CAPACITY MANAGEMENT IN HUMANITARIAN SETTINGS

by

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To Fernando,

Who always makes me smile.

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Chapter 1 - Introduction

1.1 Background

Humanitarian organizations (HOs) are facing mounting pressure to provide effective and efficient assistance to those in need, while funds are limited and needs continue to rise. In fact, there has been a 17% increase in needs from 2021 to 2022, but only around 2/3 of the necessary funds are expected to be received and distributed to the most vulnerable (OCHA, 2021; ReliefWeb, 2022). As a result, HOs are constantly striving to improve the efficiency of their operations in order to maximize the impact of funds and achieve their organizational goals while remaining true to their identities (Behl and Dutta, 2018; Scott, 2014; Audet, 2011).

One of the most effective ways for HOs to increase their efficiency is to focus on improving their capacity management (OCHA, 2021; Kasprowicz, 2020; Breman et al., 2019). To achieve this, HOs can explore a range of strategies, such as providing training and support, implementing project management best practices, and engaging with multiple stakeholders (Ika and Donnelly, 2017). However, improving capacity management is not a simple task. HOs operate in challenging and complex environments that are characterized by uncertainties and delays in needs assessment (Gonçalves, 2008; Cuervo et al., 2010), a large number of actors (US Chamber of Commerce Foundation, 2012), and external factors that can influence operations, including donor expectations, financing structures, and media effects (Balcik et al., 2010).

According to Gonçalves (2011), HOs are subject to the capability trap with two dynamics at play. First, they are pressured to provide relief and scale their capacity in the short term to provide assistance to beneficiaries. Second, HOs are pressured to build their organizational capacity in order to provide more relief in the future. Because resources are finite, HOs need to choose how to allocate resources, with more resources for relief leading to fewer resources for capacity building and vice-versa. In the long-term, focusing only on relief can erode the organizational capacity and create an unsustainable situation.

This dissertation aims to improve capacity building in humanitarian operations at different levels. It presents one chapter that focuses on the relief strategy to assist more beneficiaries in less time by HOs and two chapters that focus on the capacity building strategy to increase organizational capacity in the long run.

The second chapter of this dissertation focuses on advancing short-term capacity building, namely, how to manage a material convergence situation in disasters. The principal aim of this chapter is to more efficiently allocate capacity given all constraints and feedback mechanisms. Although solving one specific problem and offering solutions is gratifying, the multitude of challenges in the humanitarian sector necessitates a diverse array of decision-makers implementing intelligent choices. The third chapter empowers humanitarian professionals in their capacity-building journey. It presents materials provided to those enrolled in the Master in Humanitarian Logistics and Management program as support for theses methodological and research sub-processes with a deliberate practice approach. Finally, the fourth chapter provides a step-by-step guide to implement online multiplayer experiments using the specific example of examining humanitarian operations from a common-pool resource perspective. This chapter paves the way for further exploration of capacity management in the humanitarian context and holds the potential to expand research scope by supporting researchers from other fields that have traditionally relied on field experiments for data collection.

1.2 Improving Capacity Management: Donation Supply Chain

In Chapter 2, we explore capacity management associated with donation supply chain management in humanitarian relief operations. The prevalent capacity allocation and decision-making approaches employed by HOs give rise to a “second disaster” where in-kind non-priority donations disrupt the flow of essential materials from donors to beneficiaries (Fritz and Mathewson, 1957; Holguín-Veras, 2012b; Wachtendorf et al., 2013; Holguín-Veras et al., 2014). In this chapter, we identify policies and create a system dynamics model to simulate the policies’ impact on the donation flow. This model presents the mathematical theory for causal relationships that were previously described mainly qualitatively and presented in a piecemeal fashion in the literature (Organización Panamericana de la Salud, 2008; Besiou et al., 2011; Jaller, 2011; Holguín-Veras et al., 2012b; Cuervo et al., 2010; Kunz et al., 2013; Costa, 2015).

While the policies’ impact is measured in terms of time needed to assist the beneficiary population, Chapter 2 further elaborates on a variety of aspects that warrant consideration for policy implementation, thus extending the scope of the original research proposal.

Chapter 2 sheds light on the most impactful policies for managing donation flows and the underlying factors for their (un)success. The chapter provides evidence that policies that directly or indirectly reallocate human resources from handling non-priority materials to priority materials, such as admission control and donor education, yield the most favorable outcomes. Additionally, although augmenting processing capacity is often highly valued, it may not be the optimal solution when considering implementation costs.

1.3 Improving Capacity Management: Humanitarian Relief Worker Capacity Building

In Chapter 3, we focus on capacity building of humanitarian professionals in the long run. The Master in Humanitarian Logistics and Management (MASHLM) program was conceived as a capacity-building initiative aimed at transferring knowledge of management tools to humanitarian professionals (MASHLM, 2021). One significant challenge for professionals completing the master's program was the development of their thesis, which demands individual effort, familiarity with academic nuances, and proficient understanding and application of methods. With graduation rates as low as 38%, there was a clear need for improvement. Moreover, the literature emphasizes the need for materials that provide methodological support and knowledge of research sub-processes to students developing their dissertations (Van der Marel et al., 2022; Filippou et al., 2021; Ibragimova et al., 2020).

Chapter 3 outlines the development and final version of the instructional materials designed for the thesis process. These materials encompass tutorials, assignments, evaluation criteria, and additional resources that can be applied to various topics, with adaptations encouraged for specific examples. By providing these materials, supervisors can concentrate more on the thesis content, reducing the time spent on addressing academic subtleties and methods with individual students.

A comparative statistical analysis between cohorts before and after the implementation of the thesis process reveals that cohorts utilizing the thesis process experienced elevated graduation rates and higher average thesis grades.

1.4 Improving Capacity Management: Laying the Ground for Online Multiplayer Experiments Exploring Common Pool Resource Allocation Problems

In Chapter 4, we further address long-term capacity building by studying capacity allocation in synchronous decision-making cases, which require online multiplayer experiments to collect sufficient data. Despite the numerous advantages of online multiplayer experiments, such as access to larger and more diverse subject pools, reduced costs compared to field experiments, and scalability (Rezlescu et al., 2020; Hawkins, 2015; Almaatouq et al., 2021b; Poteete et al., 2010), their development presents technical difficulties. Often, this process involves programming, and there is a lack of comprehensive guidance for integrating various tools and software packages (Almaatouq et al., 2021c; Rezlescu et al., 2020; Hawkins 2015; Mason and Suri, 2012). Several research fields need synchronous multiplayer experiments for their studies (Almaatouq et al., 2021b). For instance, common-pool resources (CPRs) are characterized by multiple actors making synchronous, time-sensitive concerning specific resource types (Ostrom, 1990; Ostrom, 2000). This complexity increases when organizations have differing goals and resources. While simplifying the CPR setting facilitates the understanding of specific factors (Moxnes, 2009), examining actor interactions is crucial for advancing research in this area (Ostrom, 1992; Lindahl et al., 2015; Osborne et al., 2019; Tisdell et al., 2004).

Chapter 4 provides a detailed, step-by-step procedure for integrating system dynamics software (STELLA and isee systems) with a crowdsourcing platform (Amazon Mechanical Turk) and statistical processing software (Stata). This integration enables researchers to create online multiplayer experiments and process the collected data. By following these instructions, researchers can surmount setup and programming obstacles associated with online multiplayer experiments, allowing them to concentrate on theory and analysis.

Further, Chapter 4 offers insights into addressing worker behavior challenges associated with conducting online experiments, such as assembling workers, deterring misconduct, and maintaining engagement. Although our proposed solutions may not be the only viable options, they have proven effective in enhancing data collection for online multiplayer experiments.

Chapter 4 seeks to contribute to the research community by guiding researchers in the development of multiplayer experiments, thereby broadening the scope of research opportunities across various fields.

Chapter 2 - Policy Analysis of Material Convergence Challenges During Disasters

(with Paulo Gonçalves and Hugo Yoshida Yoshizaki)

Abstract

Material convergence, also known as unsolicited in-kind donations, poses significant challenges during disasters. The inflow of supplies and donations has both positive effects, e.g., making much-needed material available, and negative effects, e.g., jamming the supply chain. While other studies have investigated how unsolicited donations may affect humanitarian supply chains, this paper is the first to map the feedback processes influencing their overall dynamics and to offer a comprehensive analysis of how multiple policies affect the system. Therefore, it sheds light on ways to address the challenges presented by material convergence during disasters. We categorize policies into those that a) increase the amount of high priority material entering the system, b) decrease the impact of non-priority material at the disaster site, and c) increase processing and distributing efforts. We use system dynamics to build a model and explore opportunities for theoretical generalization that our in-depth empirical study offers. Our analyses show that the unintended consequences of some policies trump their intended rationality, leading to undesirable outcomes. Four policies perform consistently better regardless of disaster characteristics (dispersion and forecastability) or the loci of decisions: admission control, donor education, pre-positioning, and quantity of human resources. Directly or indirectly, these policies reallocate human resources to manage high priority material. We show that greater efforts to implement policies that address material convergence can provide more efficient relief for beneficiaries and conclude with avenues for future research.

Keywords: Material convergence, humanitarian operations, system dynamics, disaster relief

2.1 Introduction

Clothes. Tons of clothes. Even costumes. Rooms filled with mismatched shoes. Food past its expiration date. Books in a foreign language. Blankets in the summer. King-size mattresses. Poor quality tents. People. Many, many people managing all this stuff. People trying to make space. People trying to sort between useful and useless items. People working against time. People who are not sorting medications. People who are not distributing necessary food.

This description fits too many disasters. Examples begin with Fritz and Mathewson (1957) reporting on the disaster response to tornados striking Arkansas (1952), Michigan (1953), and Waco (1953) in the USA. More recently, Holguín-Veras (2012) identifies the same issues for Hurricane Andrew (1992) and Hurricane Katrina (2005) in the USA, floods in Colombia (2010), and earthquakes in Haiti (2010) and Tohoku (2011). The chaos associated with unsolicited in-kind donations not only affects natural disasters, as the Office for the Coordination of Humanitarian Affairs (OCHA) includes the man-made disasters of Iraq (2003), Lebanon (2006), Gaza (2009), and Libya (2011) in their records (Pierre Boulet-Desbareau, 2013).

The situation, as described by practitioners, is overwhelming. In response to the Indian Ocean tsunami (2004), regarding the more than 4000 tons of drugs donated, "60% were not on the national list of essential drugs, 70% were labeled in a foreign language." In Australia (2009), amid a bushfire disaster:

> "donations of in excess of 40,000 pallets of goods from across Australia took up more than 50,000 square meters of storage space. The costs for managing these donations, i.e., 3 central warehouses, 5 regional distribution points, approximately 35 paid staff, material handling equipment, and transport costs to distribute the material aid, has amounted to over eight million dollars. In addition, volunteer numbers reached 1,500

> during the first three months provided through over 40 store fronts. […] From experience, what was donated may be either unwanted or unusable and eventually has to be disposed of, causing further expenditure and possible outrage from the public" (Pierre Boulet-Desbareau, 2013).

This occurrence is referred to as material convergence, i.e., when governments, humanitarian organizations (HOs), groups, or individuals send supplies, general donations, and equipment to a disaster-affected area (Fritz and Mathewson, 1957; Holguín-Veras et al., 2012b). While it is beneficial to have materials ready to be distributed to the population in need, the overwhelming quantity of materials donated - much of it useless to beneficiaries - has several negative consequences and is sometimes described as a "second disaster" (Wachtendorf et al., 2013). In summarizing aspects reported by Fritz and Mathewson (1957), Apte (2009) and Holguín-Veras et al. (2014), material convergence drains resources to manage materials that will not be distributed, delays the distribution of critical items, occupies space that could otherwise be used for essential tasks, increases traffic congestion within and around the affected area, generates ambiguity about the source and quality of specific donations, can be detrimental to the local economy or to local production, and can create conflict between HOs or among segments of the population.

Various policy solutions have been proposed in the literature as the means to overcome the challenges associated with material convergence and make high priority (HP) material available to beneficiaries as soon as possible. Only some of these policies have been implemented in practice. Table 2.1 presents ten policies proposed in the literature, provides a brief definition of each and divides them into three categories.

Table 2.1: Policy Categories and Descriptions

Category	Policy [reference]	Description
Increase the amount of HP material entering the system	1 Pre-position material [Kunz et al. (2013)]	Make HP material available at the start of the response period to initiate distribution
	2 Material acquisition [Besiou et al. (2011)]	Increase the quantity of HP material available to organizations to support distribution
	3 Donor education [Pan American Health Organization (2008)]	Educate donors about what items to donate to receive more high-priority (HP) material
	4 Coordination [Balcik et al. (2010)]	Increase coordination between organizations to avoid material duplicates
Decrease the impact of non-priority (NP) material at the disaster site	5 Admission control [Holguín-Veras et al. (2014)]	Control receipt of donations to decrease the amount of NP reaching the disaster site
	6 Entry point control [Jaller (2011)]	Allocate human resources to the entry points of NP material to decrease the amount of NP reaching the disaster site
	7 Storage space [Holguín-Veras et al. (2014)]	Increase storage space to lessen material crowding
Increase the processing and distributing efforts	8 Quantity of human resources [Gonçalves (2008) and Jaller (2011)]	Increase human resources to accelerate the processing and distribution of HP material
	9 Network expansion Holguín-Veras et al. [(2012)]	Encourage community participation to increase the NP distribution rate
	10 Human resources allocation [Costa (2015)]	Allocate personnel according to other rules, e.g., to prioritize HP distribution over processing

In carefully examining the literature, we find that previous studies have adopted very different approaches, with some focusing only on qualitative aspects (Organización Panamericana de la Salud, 2008; Besiou et al., 2011; Jaller, 2011; Holguín-Veras et al., 2012b) and others focusing on quantitative ones (Cuervo et al., 2010; Kunz et al.,, 2013; Costa 2015). In addition, studies typically take a myopic perspective of the problem by focusing on an isolated component of a system. Most studies focus on the implementation of a single policy with the notable exception of Kunz et al. (2013) who compare two policies. Only two studies take a broader perspective of the problem and study donations (Besiou et al., 2011; Costa, 2015), yet their aim is not to solve the material convergence problem. Jaller (2011) differentiates between means of prioritizing materials at the disaster site for one instance of policy implementation. To the best of the authors' knowledge, the literature also lacks an analysis of how different disaster conditions affect the implementation of different policies.

Hence, there is a gap in the material convergence literature of studies that provide a comprehensive and quantitatively assessment of the impacts of different policies (both in isolation and in combination) on different parts of a system.

We contribute to the material convergence literature by presenting a comprehensive system dynamics model that differentiates HP and NP material flows and their dynamic effects on disaster response. The model captures key feedback loops associated with high volumes of NP material (e.g., consumption of resources and reduction of productivity due to crowding) and analyzes the unintended consequences of receiving such material. The model also captures human resources allocation rules and the specific supply chain structures involved in receiving donations and in acquiring, processing, and distributing materials. This comprehensive model framework allows us to test the reach and impact of all ten policies. Our holistic view adds to the literature on aggregate disaster response analysis and allows us to comprehend how specific policies impact aid distribution. While describing each policy's qualitative impacts is insightful, we extend previous analyses by providing a quantitative assessment and comparison of policies. To the best of our knowledge, this is the first study to provide such an analysis and comparison. Building on this, we assess the robustness of considered policies in reference to different types of disasters and decision-making processes. This approach also sets this research apart from previous studies that focus on a single type of disaster and are based on case studies without concern for generalization. The flexibility of our systems dynamic model provides results that can be generalized to other contexts.

Our analysis yields several results. First, there is a lack of quantitative studies on material convergence. The existing academic work on material convergence proposes a remarkable number of disaster policies, and while some studies test these policies, most assess policies independently without creating a comprehensive framework for comparison. Our work supports the relevance of this approach as utterly important to fully understanding the effectiveness of such policies. Second, aspects identified as negative consequences of material convergence, e.g., managing NP material that consumes human resources and occupies storage space, are to some extent necessary for a more efficient disaster response; they are the unintended consequences of receiving all types of material. Third, our analyses show that the unintended consequences of some policies trump their intended rationality, leading to undesirable outcomes, e.g., implementing the entry point control of NP items leads to less congestion at the disaster site but erodes human resource productivity, and expanding storage space leads to a lesser crowding effect, yet more material is received, which hampers the disposal of excess material, hindering processing efforts. Fourth, we identify four policies that perform consistently better regardless of the characteristics of disasters (dispersion and forecastability) or the loci of decisions: admission control, donor education, pre-positioning, and quantity of human resources. We test the policies' performance and present results based on the distribution rate of HP material during the response phase of a disaster. Finally, translating the literature into a model makes us aware of what quantitative data are available (and what information can be collected) and provides an opportunity to identify parts of the model in need of further refinement.

Following this introduction, the next section introduces material convergence in the context of humanitarian operations and defines the factors that impact it. Then, we identify the feedback loops that influence such dynamics and how some critical elements are captured in the proposed model. We then present our base case and individual policies by describing their rationality and unintended consequences and comparing their performance. This is complemented with a section on policy robustness that focuses on disaster characteristics, decision-making processes, and policy implementation. Our model's validation is then described, and the paper closes with concluding remarks.

2.2 Literature Review

2.2.1 Humanitarian Operations

A disaster event can be divided into four phases: mitigation, preparation, response, and recovery (Altay and Green, 2006). We focus on the response phase, which requires humanitarian logistics (Thomas and Mizushima, 2005) and is most affected by material convergence.

Humanitarian response operations are astonishingly complex. First, beneficiaries' needs are uncertain and must be assessed at the disaster site, usually with little preparation time (Gonçalves, 2008), which often leads to assessment delays (Cuervo et al., 2010). Following needs assessment, material is mobilized in three ways (Lima, 2014): 1) by obtaining pre-positioned material, 2) acquiring priority material, and 3) receiving donations (Jaller, 2011). Depending on the magnitude of a disaster, mobilized material can be stored at international, regional, and local levels (Lima, 2014). While pre-positioning material is usually done in the preparation phase, it is acknowledged here due to its impact on material flows during the response phase.

Receiving large quantities of material at the disaster site is referred to as "material convergence." While pre-positioned and acquired material reach the disaster site properly packaged and identified for distribution, donations undergo processing: they are sorted to clearly identify items that can be distributed to beneficiaries and then packaged to aid individuals or families for a determined time period (Long and Wood, 1995); this can occur at any of the storage levels or only upon arrival at points of distribution (PODs) in the disaster area (Jaller, 2011). The harsh conditions involved and lacking organizational planning take their toll on material human resources managing material. Human resources are assessed erroneously and not adjusted, which under stress results in high staff turnover and decreased productivity (Gonçalves, 2008) and often transportation and distribution delays (Cuervo et al., 2010).

While all of these factors can be observed within a single organization, humanitarian operations are even more complex when considering the large number of stakeholders active during disasters. While the types of stakeholders involved may not vary greatly (Besiou et al., 2011; Fontainha et al., 2014), the number of organizations of each type on-site can reach hundreds (US Chamber of Commerce Foundation, 2012). Their coordination determines the success or failure of the disaster response (Cuervo et al., 2010; Fontainha et al., 2014) and is influenced by donors' expectations and financing structures, effects of the media, and costs of coordination (Balcik et al., 2010).

2.2.2 Material Convergence

Holguín-Veras et al. (2014) define material convergence as the "flow of supplies, general donations (requested or unsolicited) and equipment that travels to the disaster site," going beyond Fritz and Mathewson's (1957) definition to include materials sent by "governments, humanitarian agencies, companies, churches, groups or individuals in the locality."

Some materials are sent before a disaster occurs. Kunz et al. (2013) explore the pre-positioning of material as a way to ensure that HP material is available from the beginning of a response. However, most material is sent after a disaster occurs when the media relay information about the magnitude of a disaster and donations pour in (Eisensee and Strömberg, 2007; Besiou et al., 2011). Thus, material convergence mainly occurs after sudden onset disasters that are heavily mediatized.

Donations may be in-kind, which create most material convergence issues (Holguín-Veras et al., 2014), or monetary, which are used to acquire material for the disaster response. Factors that influence the volume of in-kind donations are addressed by Destro and Holguín-Veras (2011), and the influence of monetary donations is discussed by Arnette and Zobel (2016).

In-kind donations are advantageous in that they create no delay in producing needed items, and beneficiaries can be assisted with less lead time (Wachtendorf et al., 2013). Disadvantages include the large proportion of nonusable items donated, including expired food, dirty clothes, and broken items (with strong evidence showing that more than 50% of donations arriving in the first few weeks of a disaster are NP items), the frequent need to repackage items, and a lack of adequate identification (e.g., several expiry dates listed on a package). Moreover, the disposal of unusable donations is a sensitive issue for HOs; the logistics chain becomes overburdened by the disaster, and HOs' reputations may suffer when donors see that their donations are not serving beneficiaries (Holguín-Veras et al., 2014). From these negative aspects, the arrival of donations is often referred to as a "second disaster" (Wachtendorf et al., 2013). To address donations of NP items, the Pan American Health Organization (2008) has adopted a donor education policy advising donors about how to donate more HP items using a booklet titled "Saber Donar" [How to Donate]. Donations are accepted while there is available storage space (Holguín-Veras et al., 2014), and in the present work we analyze a policy approach to increase storage space capacity.

Though donations relieve pressures on HOs to spend their budgets on acquiring material (Wachtendorf et al., 2013), HOs can improve responses through acquisitions: the higher the budget for acquisitions, the more beneficiaries are assisted (Besiou et al., 2011). Acquisitions, donations, and pre-positioning are the three forms of material entering the system.

2.2.2.1 Material Flow Classification

Material flows can be classified by the types of actors sending materials and by their experience with disaster responses (Quarantelli et al., 1966). This influences the proportion of a) HP items needed for immediate distribution and consumption and b) non-priority (NP) items not needed in the response phase (Holguín-Veras et al., 2014); more details on this classification are available in Appendix 2.1. The level of coordination between organizations influences the proportion of HP and NP items sent by HOs; intensifying such coordination yields a higher proportion of HP material (Balcik et al., 2010; Holguín-Veras et al., 2014).

2.2.2.2 Human Resources Allocation

Human resources are needed to process and distribute HP material and to process NP material. Gonçalves (2011) describes an organization's trade-off between allocating human resources to provide relief and investing time in building capacity, which influences the maximum human resources available to manage material in a disaster: increasing human resources increases efforts dedicated to assisting beneficiaries in need (Gonçalves, 2008; Jaller, 2011). Further, Holguín-Veras et al. (2012) propose that affected and neighboring communities can form a network of points of distribution (PODs), adding capacity to management efforts.

Human resources can be deployed following different rules. According to Holguín-Veras et al. (2014), under admission control, NP material is rejected from the start of a disaster; in turn, human resources only manage HP material.

When all material is accepted, NP material can be sorted out either at entry points to the disaster or at PODs under an entry point control policy if physical space and labor are available. Delays in HP flows decrease as NP items are diverted, giving HP items preference in allocating capacity. Control can occur at relatively few entry points for a larger disaster; smaller disasters tend to present a larger number of access routes, making it difficult to control entry points (Holguín-Veras et al., 2014). Jaller (2011) suggests that human resources should be allocated to the entry points of nonregular material flows and withhold non-priority material that would otherwise go to PODs.

When control is allocated to distribution endpoints, the NP problem moves to the disaster site. Vehicles transporting material travel on damaged infrastructure which creates congestion, and storage space is then occupied by NP material. The accumulation of material then slows processing since less space is available to maneuver material. Further, when there are instructions to deliver material "to anyone in need," material is unloaded anywhere at the scene of the disaster and "open dumps" emerge with donations rotting in plain sight (Holguín-Veras, 2012; Holguín-Veras et al., 2014).

Finally, Costa (2015) assumes that the distribution of material should take higher priority than processing, which we use as another allocation rule.

2.2.2.3 System Dynamics and Material Convergence

System dynamics is particularly useful for studying problems involving factors that interact in a circular manner (feedback loops), involving different types of delays, and with variables with nonlinear behavior (Größler, Thun and Milling, 2008). While qualitative analyses can be done, quantitative analyses provide distinct advantages. Finally, as in every simulation, hypotheses can be tested and retested in a risk-free environment (Sterman, 2000). We apply system dynamics as part of our research method, as it reflects features that correspond with problems observed in humanitarian contexts (Besiou et al., 2011; Gonçalves, 2011).

We reference four studies that use system dynamics to address material handling problems. While Besiou et al. (2011) conduct a qualitative analysis, the other three studies (Costa, 2015; Cuervo et al., 2010; and Kunz et al., 2013) apply quantitative analyses. The scope ranges from humanitarian operations to resource allocation; the first two focus on donations, while the others focus on efficient material distribution.

Besiou et al. (2011) study how in-kind donations impact the disaster response and present a causal diagram with media, beneficiary, and earmarking loops. Their causal loop diagrams are simple and qualitative and create opportunities to develop a model based on the relationships identified, add complexity to the system, and analyze quantitative outcomes. Costa (2015) analyzes coordination between actors. While he considers subsystems common to the material convergence problem, few details are provided regarding material handling activities performed and how logistical capacity is allocated. Cuervo et al. (2010) model a food supply chain from high-level distribution centers to local PODs, study material handling processes to understand inventory fluctuations, and propose planning strategies that prevent future losses. However, they account for only one external balancing loop concerning the number of donations used to assist beneficiaries that is regulated by HOs requests. Kunz et al. (2013) study humanitarian responses under two policies (with the pre-positioning of food or using more human resources during the preparation phase) and run mixed scenarios. The analysis does not consider effort duplication or coordination costs and the authors only model logistical factors.

2.2.2.4 Contributions of this Paper

In summary, the literature on material convergence in disasters identifies the following as negative consequences: the processing of excess materials, the receipt of mostly unhelpful or unusable materials, the proliferation of packages with inconsistently identified donations, increased road congestion due to vehicles transporting NP material and excess items in and around the affected area, reduced productivity due to limited processing space, and difficulties with disposing donations. Also mentioned are the diversion of human resources (Fritz and Mathewson, 1957; Apte, 2009) and the allocation of physical space (Holguín-Veras et al., 2014) to process NP material; however, it may be necessary to tolerate these issues to more efficiently handle HP material overall (Repenning and Sterman, 2002).

This research contributes to the literature by first developing the only system dynamics model that a) differentiates HP and NP material flows, b) adds feedback loops for the unintended rationality of receiving NP material, c) introduces the crowding effect, d) details human resources allocation rules, and e) operationalizes all ten identified policies. Second, it also acknowledges the dynamic interrelationships between these aspects. Third, we use a holistic approach to analyze the impact of each policy on the whole system and thus contribute to the literature on aggregate disaster response. Fourth, we compare policies proposed by the literature by testing them against the same setting. Finally, we simulate the policies under different contexts while identifying emerging subtleties and checking for robustness.

2.3 Material Convergence Feedback Loops and Structure

To translate theories presented in the above literature review into a system dynamics model, we identify the most relevant feedback loops in the studied system and clarify aspects of the model's structure.

2.3.1 Feedback Processes

When a disaster strikes, the media emphasize the *population* in need and release stories about *not assisted* people along with their hardships and resourcefulness. Individuals, churches, and whole communities are sensitive to these kinds of messages and thus send *donations* – food, clothes, hygiene kits and many other items. Donations useful to beneficiaries are labeled "high priority" (HP) material. Donations that are not useful such as torn clothing, expired food, culturally unacceptable food, and excess material are labeled "non-priority" (NP) material. Figure 2.1 shows the accumulated *received HP material* that is further processed (accumulating as *processed HP material*) and subsequently distributed (accumulating as *distributed HP material*) to meet beneficiaries' needs. As the population is assisted, HOs close the balancing "**population assistance (B1)**" loop, which captures the virtuous effects of donations in meeting the needs of beneficiaries.

HOs do not solely rely on donations to meet beneficiary needs. *Acquisitions by HOs* are based on the perceived material need and limited by an organization's financial capacity. These materials join the flow of already *processed NP and HP material* stocks, increasing the quantity of HP material made available to the population and closing another balancing "**handling the gap (B2)**" loop.

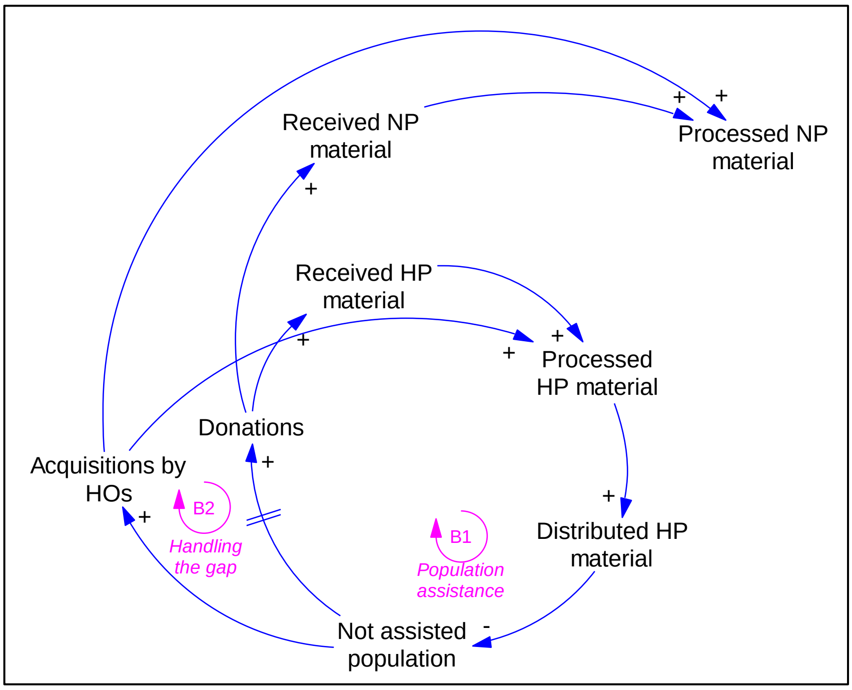

Figure 2.1: Feedback Loops B1 "Population Assistance" and B2 "Handling the Gap." The balancing feedback loops allow HOs to receive and handle material while beneficiary needs are not met.

When providing material, HOs are made aware of demand through a needs assessment, and by handling incoming material, they can calculate the material gap, which defines the "**capturing information (B3)**" balancing loop. This enables HOs to respond faster to changes in the environment by adapting their behavior (Figure 2.2). Donors believe that sending vast amounts of in-kind donations is useful; however, these donations rapidly consume space, which is a critical resource during a disaster because of its reduced availability due to competition from other activities, e.g., shelter space. *Received NP and HP material* then occupy *available storage space*, and when all storage space is occupied, *donations* are no longer accepted, which triggers the "**material acceptance regulation (B4)**" balancing loop.

According to the *perceived need of human resources (HR)*, organizations mobilize human resources (*actual HR*) and allocate them at the disaster site to handle HP (*resources allocated to HP material*) or NP material. Nevertheless, only the former will directly impact the quantity of *processed HP material* and *distributed HP material*; the more effort is dedicated to handling HP material, the smaller the quantity of the *not assisted population* and the fewer human resources needed, which closes another balancing loop: "**human resources limitation (B5)**."

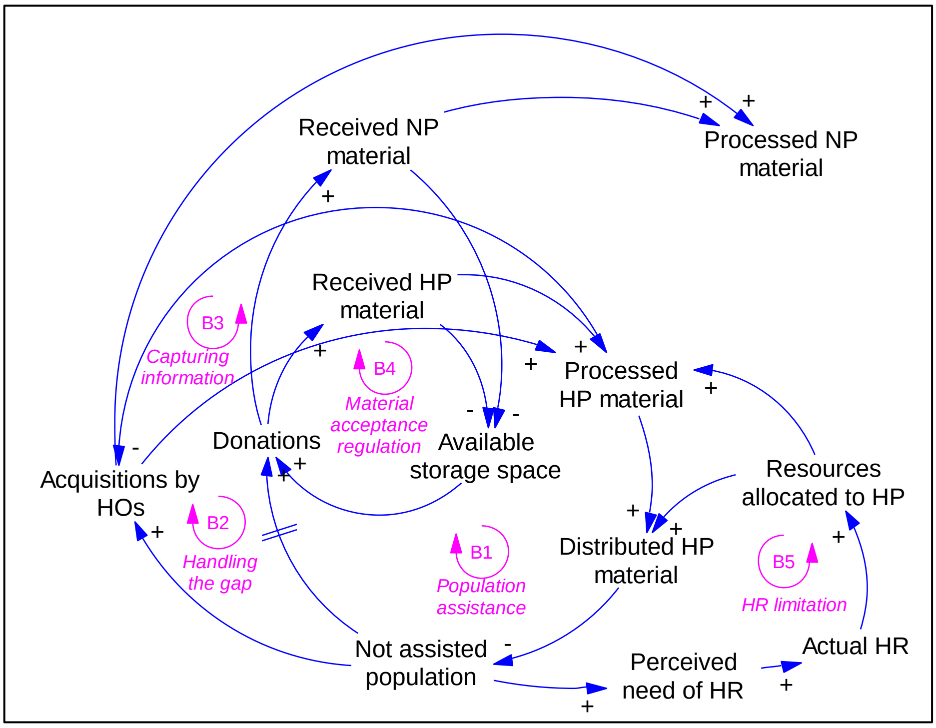

Figure 2.2: Feedback Loops B3 "Capturing Information," B4 "Material Acceptance Regulation," and B5 "HR Limitation." The additional balancing loops limit the extent to which material receipt and processing occurs.

Processing and distributing HP material directly affects the capacity of the disaster response to provide relief to the population in need. However, NP material entering the disaster site affects resources and indirectly influences HP flows (Figure 2.3).

A percentage of incoming *donations* is NP material that accumulates as *received NP material*, and as the proportion of total material (*NP fraction)* increases, space becomes limited: there is less space to place material, material must be rearranged more often, and more objects must be inspected before finding the right item. This *crowding* effect decreases the rate at which *processed HP material* and *distributed HP material* accumulates, *and as* more material is introduced, the crowding effect intensifies. This spurs the "**buried in material (R1)**" reinforcing loop.

To counter the *crowding* effect, *resources* are *allocated to NP* material to process material. As the *NP fraction* decreases, so do the difficulties with processing HP material, and in turn more *processed HP material* and *distributed HP material* accumulates. As more of the population is assisted, fewer human *resources* are *allocated to process NP material*, closing the "**making space (B6)**" balancing loop.

When allocated to the disaster site, human resources handle HP or NP material. As human resources are finite, *allocating human resources* to handle *NP material* reduces *resources allocated to HP material*, which affects the capacity to process and distribute HP material, eroding productivity in delivering HP material to the *not assisted population*. This is captured by the final major reinforcing loop: "**eroding productivity (R2)**."

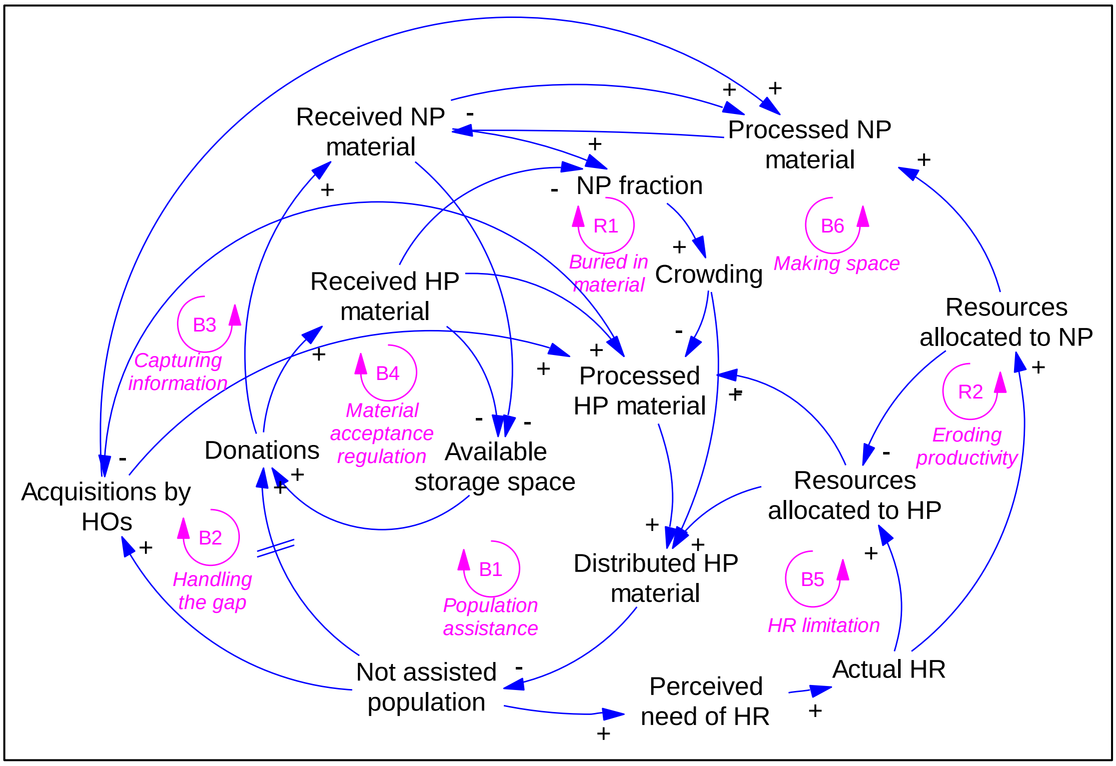

Figure 2.3: Feedback Loops B6 "Making Space," R1 "Buried in Material," and R2 "Eroding Productivity." The additional feedback loops map unintended consequences of material convergence.

2.3.2 Model Structure

We define a structure to model the logistics of material handling, the proportion of items involved in material flows, and human resource allocation rules and conclude with a bottleneck analysis.

2.3.2.1 Logistics of Material Handling

Material can enter the system in the form of donations, acquisitions or pre-positioned material. Donations are received - as a default - without differentiation between HP and NP material. They will either be processed at a warehouse outside the disaster area or at points of distribution (PODs). We make no distinction between locations and use the term "PODs" generically for the processing stage, as all material will arrive at PODs at some point; yet, the entry point control policy can only be implemented if there are warehouses in the storage network. We simplify reality by not considering the transport of material from warehouses to

PODs; thus, the case of NP material identified at a warehouse outside the disaster area and not further transported to PODs is not analyzed. Thus, storage space available for processing is the sum of storage space available in both warehouses and PODs. After processing, HP material is distributed from PODs, and NP material is stored regardless of whether it is stored in warehouses or PODs. Acquisitions are processed by suppliers, arriving ready to be distributed at the PODs. Finally, pre-positioned material is processed and can be immediately distributed.

2.3.2.2 Item Proportions in Material Flows

To determine proportions of NP and HP material entering the system, we use Quarantelli's et al. (1966) analysis of organizational structures and the flows that their activities generate. For the base case, we adopt the proportions proposed by Jaller (2011) in his studies of material convergence: 70% of HP material in regular flows generated by HOs and 30% in nonregular flows generated by donations.

2.3.2.3 Human Resources Allocation Rules

The structure of human resource allocation is also important. According to practitioners (MASHLM09 cohort, personal communication), only up to 10% of human resources in HOs are allocated to process acquisitions due to agreements with suppliers and standard operations for acquisition in emergencies that are already in place. Additionally, acquisitions are sent with correct information and packaging directly to the disaster site with no further need for processing.

When the policy of diverting human resources to a warehouse is implemented, some human resources specifically process NP material at the warehouse. The remaining human resources handle material at PODs. At PODs, human resources can process NP and HP material and distribute HP material. From discussions with practitioners, the authors infer that standard allocation is based on the proportion of each type of material in stock. A diagram with the equations for each condition is given in Appendix 2.2.

2.3.2.4 Bottleneck Analysis

Bottlenecks can form when sending donations or processing or distributing material. Sending donations forms a bottleneck early in a disaster when donations arrive in such large quantities that material convergence occurs. Bottlenecks that occur in processing and distributing material depend on the number of human resources allocated to these activities. Processing is more likely to be a bottleneck when the proportion of NP material increases and causes a crowding effect: the less space available, the more difficult material handling becomes and the lower the processing rate.

Appendix 2.3 displays the general parameters held constant under all policies and presents a multivariate sensitivity analysis.

2.4 Model Behavior and Analysis

This section quickly describes the context for the base case and then presents the model behavior and analyzes ensuing dynamics, intended rationality, and unintended consequences. Next, we analyze the individual policies considered.

To populate the parameters of the model and analyze the model's behavior, we draw on the characteristics of a disaster occurring in Brazil. In late 2009 and early 2010, the region of São Luiz do Paraitinga experienced heavy rainfall, causing the Paraíba do Sul River to overflow its banks, flooding the surrounding area and displacing 9,000 persons, i.e., 90% of the local urban population. The total loss has been estimated at R$87.3 mi (approximately $50.5 mi), and as the city economically relies on tourism, the damage to 80 of its nearly 100 historic buildings was devastating (Kawasaki et al., 2012).

The flood in São Luiz do Paraitinga is representative of a typical material convergence problem and offers an opportunity for theoretical generalization (Tsang, 2014).

It is representative due to the large quantities of material sent to the disaster site, the amount of material accumulated, and hindrances on the distribution of HP material. The case is also representative of flood disasters, of the damage they inflict (Sprissler, 2011), and of common disaster responses (Kawasaki et al., 2012; Carneiro et al., 2014). The numerous cases described in the introductory paragraphs of this work argue for the relevance of this phenomenon, and our empirical study attests that it is studied within a real-life context (Yin, 2009). For theoretical generalization, the case of São Luiz do Paraitinga allows us to explore relationships between factors identified in the literature and translate them into mathematical equations, thus developing a model of how material convergence evolves during the disaster response and of the best leverage points to counter its negative effects, i.e., to analyze the performance of policies (also identified in the literature) and explore the resulting behaviors. Other types of disasters are also analyzed to avoid limiting policy performance to a flood landscape, thus rendering the case theoretically generalizable (Tsang, 2014).

2.4.1 Base Case

Material convergence begins when large amounts of material arrive on site. As seen in Figure 2.4, NP and HP material sent through donations are accepted indiscriminately, and their quantities differ depending on the level of donor education. Receipt of NP material decreases abruptly when the threshold for this material is achieved, which is usually when it becomes clear that too much space is being occupied by useless material and that organizations will only accept further HP material (but some NP material continues to represent a proportion of donations). HP material is accepted until storage space is fully occupied; then, the media communicate that no more donations can be accepted.

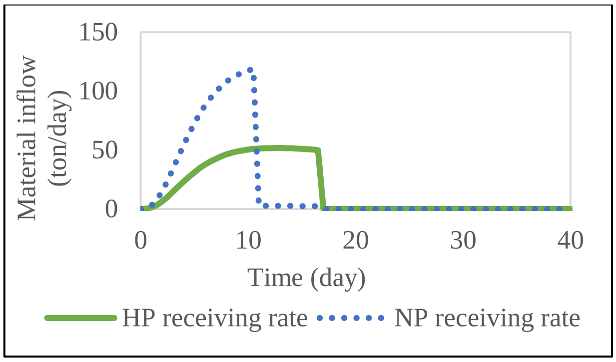

Figure 2.4: Material Receiving Rates. HP and NP material are received according to the level of donor education; once storage space becomes scarce, only HP donations continue to be accepted, though a small amount of NP material will still be present since screening at reception cannot be 100% efficient; all donations drop to zero when no more HP material is accepted.

Figure 2.5 shows the stocks of HP material. Such material rapidly accumulates at a warehouse (*Received HP*) while human resources are not yet mobilized and until no more donations are received. The stock decreases when processing and distribution begin: the stock of *processed HP* material does not rise significantly since that material gets distributed and thus accumulates in *distributed HP material*. Due to delays in the system, HP material remains in the pipeline at the point at which all beneficiaries have been assisted, and distribution stops.

In São Luiz do Paraitinga, after only one week, all storage space at the disaster site was occupied and more material was being received only at a warehouse 50 km away. Media articles describing this situation also advised on what material should be donated (Governo de SP, 2010). Nevertheless, just short of 2 weeks after the disaster, the local police requested a total end to donations as all storage space had been occupied. At this point, the number of clothes and shoes received was enough to distribute 20 items to each habitant of the city (Kawasaki et al., 2012).

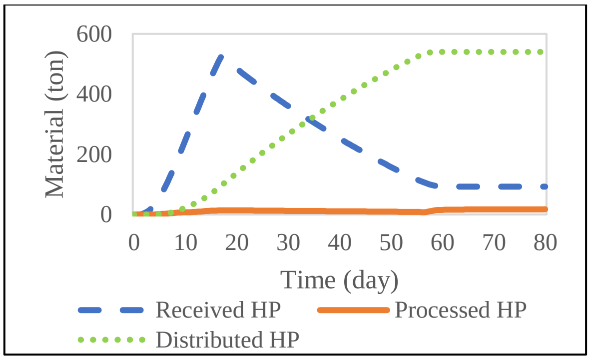

Figure 2.5: HP Material Stocks. Received HP material rapidly increases as donations pour in; material gets distributed as soon as it is processed. Thus, the stock of processed HP material does not significantly increase.

According to the civil defense coordinator in charge, the response effort continued for roughly two months after the flooding (Rodrigues, 2017). This time frame is aligned with Besiou et al. (2011) and Kunz et al. (2013), who state that the response phase typically does not surpass six months. Four years after the disaster in São Luiz do Paraitinga, clothes that had been processed but not distributed were sent to Itaóca (Brazil) when another flood struck in 2014 (Carneiro et al., 2014).

Human resources are mobilized after the first needs assessment (Figure 2.6). As the number of workers increases, capacity is allocated to PODs. The number of human resources that handle each type of material depends on the volume of each type of material received and, ultimately, on the level of donor education. Human resource allocation has the strongest effects on NP material. While these resources do not handle HP material directly, they do lessen crowding effects and indirectly enable a higher processing rate of both types of material, which has a positive effect since the processing of HP material creates a bottleneck.

The quantity of human resources decreases when need no longer exists, i.e., beneficiaries have been assisted.

Serious efforts from people processing and distributing material were observed only after the first week. Such efforts persisted for approximately two months (Rodrigues, 2017).

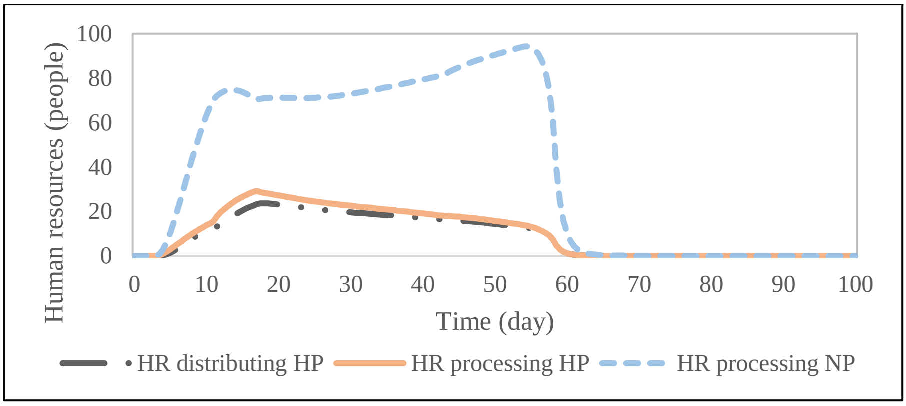

Figure 2.6: Human Resources (HR) Distribution. Human resources are allocated to different tasks according to the proportion of each material type and considering the needs of the population and the availability of material.

To compare the base case to the performance of the proposed policies, we introduce three metrics: 1) the time required for all people to be assisted, 2) the number of people assisted up to day 7 of the disaster, and 3) the assistance slope, i.e., the number of people assisted per day during the period in which 10% to 50% of the population in need are assisted.

For the base case scenario, the response phase is completed in 61 days. On day 7 of the disaster, 90 people of 9000 (1%) have been assisted, and the rate of assistance to beneficiaries is 211.8 people per day.

2.4.2 Model Validation

To determine how to validate our model, we consulted Sterman (2000) and Barlas (1996). The model is informed by a relevant case study (Sterman, 2018) and conforms to the standards of system dynamics model creation (Rahmandad and Sterman, 2012). In particular, we carry out four direct structure tests. First, structure-confirmation tests are mostly theoretical and relationships between variables are drawn from the literature, e.g., a) the sequence that material undergoes from being received to being processed to being distributed, b) the ratio of the amount of material distributed to the beneficiary assistance rate, and c) the amount of material and human resources required based on needs assessments. Second, parameter-confirmation tests are mostly empirical based on the case study and additional literature; further, interviews with practitioners support numerical estimations, as not all data points in time are available for the case study. Third, direct extreme-condition tests are performed to confirm the equations and, where appropriate, minimum and maximum functions are used to comply with extreme conditions. Finally, dimensional consistency is verified using the System Dynamics Documentation Tool (SDM-Doc) of Java Version 1.2.89.

Additionally, the model is tested using structure-oriented behavior tests (indirect extreme conditions are scrutinized in discussions with system dynamicists and researchers in the humanitarian field) and behavior sensitivity with a five multivariate analysis of different sets of variables; see Appendix 2.3.

2.4.3 Individual Policies

We test ten individual policies (Figure 2.7) proposed in the literature and complemented by practice. We classify them according to their primary intended impacts on material flows as presented in Table 2.1 of the introduction. The values of parameters for each policy are shown in Appendix 2.5. Further cost considerations are shown in Appendix 2.7.

2.4.3.1 Policies that Focus on Increasing the Amount of HP Material

Pre-positioning policy. Pre-positioning material is a very common practice in humanitarian settings (Roopanarine, 2013; UNFPA, 2019; UNHCR, 2018; UNHRD, 2019), as it ensures that HP material is available at the start of the response phase (Kunz et al., 2013). Nonetheless, the approach has disadvantages, e.g., incurring costs to maintain and store material, and the necessary analytics to correctly select the goods and store them at the appropriate place and time. When (or if) a disaster will occur is uncertain, and thus how much material should be pre-positioned is determined based on population density in a given area and the probability of a disaster and its severity (Duran et al., 2011). The pre-positioning coverage variable is set to 0 in the base case (no coverage) and is increased under this policy to 0.3 (material to cover 30% of the population in need) and priority is given to distribution over processing material.

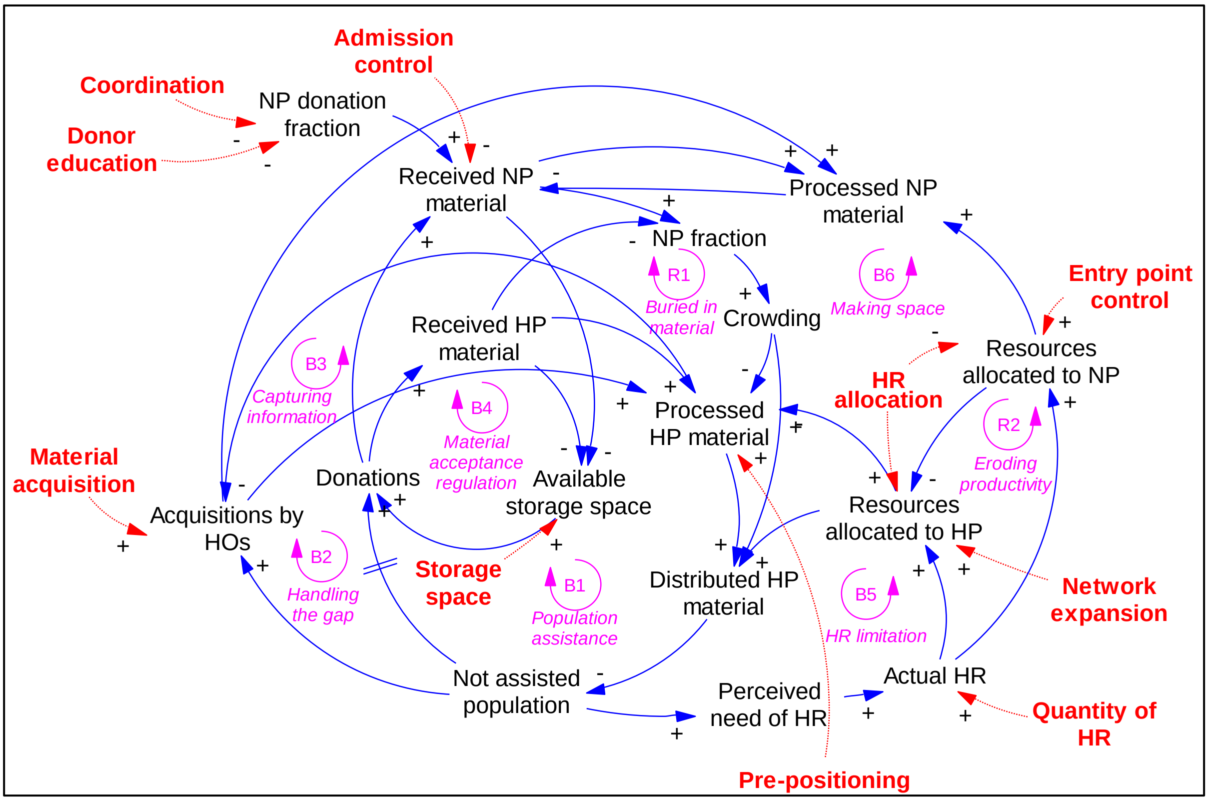

Figure 2.7: Causal Loop Diagram with Policies. Policies (in bold/red) affect the variables specified with dashed arrows, showing that policies can affect different feedback loops at different points.

The presence of pre-positioned material increases the distribution rate while pre-positioned material exists; later, the distribution rate is constrained by processing capacity until all beneficiaries have been assisted. Additionally, as the perceived need decreases much faster and as the impact of the media on donations lessens, donations are received at a decreasing rate while storage space is fully occupied; thus, even when less material is processed, the crowding effect does not impact processing more than in the base case. The response phase continues for 37 days with 835 people assisted on day 7 and an assistance slope of 360 people assisted per day.

Material acquisition policy. An HO's ability to procure specific materials directly allows it to meet beneficiaries' needs (Besiou et al., 2011), ensuring that more HP material becomes available. Although acquired material is ready to be distributed, it is subject to delays in the supply chain and especially in terms of transit time required to reach the disaster site (Holguín-Veras et al., 2007). For the base case, we assume that HOs acquire 5% of the material needed to assist beneficiaries uniformly for a period slightly shorter than the response phase (40 days). This policy doubles the materials acquired to 10%. With this policy in place, the response phase lasts 59 days. The number of people assisted on day 7 is 91 and the assistance slope is 225 people assisted per day.

Donor education policy. Educating donors about what to donate was the explicit goal of the Pan American Health Organization (2008) as stated in their booklet "Saber Donar" [How to Donate]. The booklet instructs donors, recipients of donations, and the media about what to donate to help increase the quantity of HP material donated in areas such as food, water and sanitation, medicine, and public health.

Although instructional material and educational campaigns favorably affect the quality of donated material, their efficiency is limited. First, it is unlikely for them to reach all donors. Second, even when they do, donors often forget the main messages relayed and may fall back on old habits when messages are not reinforced frequently.

The base case scenario assumes a 30% HP donation percentage (donor discernment = 0.3), and the policy increases this percentage to 65%. Thus, we assume that implementing this policy reduces the quantity of NP material by half. As the most interesting effect of this policy, the proportion of human resources allocated to each type of material changes drastically even though the allocation strategy remains the same – human resources required to process NP material decrease from approximately 70% to 35%, and human resources required to process and distribute HP material increase from approximately 13% to 30%. As a result, much less time is needed to assist all beneficiaries: 34 days or approximately 50% of the base case where 199 people have already been assisted by day 7 and the assistance slope is 450 people assisted per day.

Coordination policy. The level of coordination between organizations defines the proportion of HP and NP material that organizations acquire. Insufficient coordination results in duplication, and superfluous NP material can create delays in the distribution of HP material in the response phase (Balcik et al., 2010). Obstacles to consistent coordination have been highlighted in several studies, and in many cases not only the process used has been identified as an important influencing factor (Balcik et al., 2010) but also the personalities of those leading implementation (Stephenson Jr and Kehler, 2004).

To determine the level of coordination for the base case, we use the simplification proposed by Holguín-Veras et al. (2014) and assume that all HOs generate regular flows. Thus, we assume that 30% of acquired material is NP and 70% is HP (i.e., base case material duplication of equal to 0.3). For the coordination policy, we reduce the amount of NP material to 15% (i.e., material duplication = 0.15). This parameter change reflects a reduction in the quantity of NP material by half, similar to the donor education policy.

Increasing coordination has no significant impact, as the quantity of material in acquisitions relative to donations is very small. If the volume were larger, one could infer that a bottleneck would occur during the distribution of HP material capacity (similar to the case of pre-positioned material), that the material gap could be closed sooner and that the acquisition of material would stop earlier. Under these policy conditions, the response phase lasts 60 days, 90 people have been assisted by day 7, and the assistance slope is 211.8 people assisted per day.

2.4.3.2 Policies that Focus on Decreasing the Impact of NP Material at the Disaster Site

Admission control policy. As a default, the threshold for not accepting more NP material is reached when storage space comes to a limit. The media are then used as a means to stop donations. In practice, implementing this policy is difficult: when an organization applies it on its own, it risks losing the support of donors who send a mix of NP and HP materials and thus a share of HP material (Fessler, 2013). Thus, the coordinated implementation of this policy across several HOs who compete for the same types of donations is needed, which is not straightforward.

Under the base case scenario, when a threshold of 80% of storage space is occupied, NP donations are no longer accepted, though a small fraction of presumed HP material will still be found to be NP material after thorough processing. In applying this policy, we test the extreme case of not accepting any NP material from the start of the disaster (Holguín-Veras et al., 2014). It follows that minimum processing capacity is allocated to NP material and that storage space can be occupied almost exclusively by HP material, which occupies only a fraction of the total storage capacity.

As donations are not stopped by the media (no triggering of the regulatory feedback loop (B4)), donations cease only once all beneficiaries have been assisted. However, more HP material remains than in the base case due to the delay in donations and the time required to demobilize human resources. This policy is advantageous in that there are no negative impacts of a crowding effect and human resources are reallocated to process and distribute HP material. Under this policy, only 27 days are needed to assist all people, reflecting a 65% improvement in response time. By day 7, 215 people have been assisted, and the assistance slope reaches 600 people assisted per day.

Entry point control policy. Jaller (2011) suggests that the optimal allocation of human resources to process and control material flows maximizes the quantity of HP material distributed. This policy allocates human resources to entry points (warehouses (WHs)) of nonregular material flows (i.e., donation flows), thus withholding NP material that would otherwise reach PODs. This should reduce overall processing efforts and consequently reduce storage space occupied by NP material.

To implement this policy, entry points must be clearly identified, which is more difficult for smaller disasters since they include more entry points than larger ones (Holguín-Veras et al., 2014). Additionally, HOs require an area to process material with adequate security and infrastructure.

Under the base case, no human resources are allocated to warehouses (i.e., no items are withheld there). Under the entry point control policy, 30% of human resources (after acquisitions) are allocated to warehouses. As expected, when human resource capacity is allocated to warehouses, the NP processing rate at PODs decreases. In addition, the human resource capacity required to handle HP material diminishes in a way similar to that observed in a feedback loop (R2). When there is no more NP material in warehouses (and the unintended effects of R2 stop), human resources are free to handle HP material, increasing the distribution rate threefold and still concluding the disaster response over 46 days (23% improvement). The disadvantage of this policy lies in the fact that it takes more time to begin assisting beneficiaries in large numbers; by day 7, only 66 people have been assisted and the assistance slope is 276.9 people assisted per day.

Storage space policy. Storage space is needed to receive and process material (Holguín-Veras et al., 2014). We analyze increases in storage space, which should make more space available for processing and minimize or even prevent the crowding effect. Implementing such a policy during an ongoing disaster response can be difficult: space is a critical resource and priority is given to shelter people rather than goods; also, space must be accessible by truck and be available when donations pour in (Powell, 2017). The base case includes 1300 tons of storage space, and the implementation of this policy increases this value by the capacity of one local warehouse to 1780 tons.

Increasing the storage capacity delays the crowding effect, allowing for a higher rate of HP and NP material processing at the start of the disaster. Nevertheless, material eventually fills the extra space and the acceptance regulation feedback (B4) is triggered. As an unintended consequence of this policy, the additional received material takes more effort (the more material received, the more human resources needed) to process; since the quantity of human resources is not altered under this policy, decreasing the NP fraction that hinders processing becomes more difficult. Even though the processing rate is higher at the start of the disaster, it decreases in relation to the base case later on. By day 7, 91 people have received assistance and the assistance slope is 211 people assisted per day. All beneficiaries are assisted over 58 days.

2.4.3.3 Policies that Focus on Increasing Processing and Distributing Efforts

Quantity of human resources policy. Human resources are directly involved in handling incoming material, and having too few of such resources can create a bottleneck; thus, increasing their quantity has a positive effect on the quantity of processed and distributed material (Gonçalves, 2008; Jaller, 2011). Mobilizing enough human resources for a specific disaster is easier said than done, as resources are always finite. In addition to the cost factor, turnover rates in humanitarian work are high (Gonçalves, 2008), causing organizational learning to erode rapidly.

Under the base case scenario, the potential quantity of human resources is 150 people; under this policy, it is doubled to 300 people. Increasing the number of potential human resources directly affects the resulting bottleneck: the HP processing rate. However, as more human resources manage material, the storage space reaches 100% capacity later on, and donations are thus also stopped later; as a result, more material remains at the end of the response phase. In this case, the disaster response lasts 35 days, 157 people have been assisted by day 7, and the assistance slope is 360 people assisted per day.

Network expansion policy. Holguín-Veras et al. (2012) identify three types of point of distribution (POD) network structures: Agency Centric Efforts (ACEs), Partially Integrated Efforts (PIEs) and Collaborative Aid Networks (CANs). They suggest that the more collaborative and integrated a community is, the more the community can be utilized to process and distribute material. The base case scenario has a POD structure of 1 (on a scale of 1 to 2, where 1=ACE, 1.5=PIE, and 2=CAN); that is, the processing and distribution capacities of actual human resources are multiplied by 1 (essentially staying the same), and the policy adopts a POD structure of 2, which means that processing and distribution capacities are doubled with extra efforts from the community.

To implement this policy, decision-making structures typically need to be collaborative, and there must be strong relationships between HOs and the local population, strong network ties within the community, legitimacy and trust between actors, and a rather extensive network (Holguín-Veras et al., 2012a). Individuals must also learn how to process and distribute material, which involves community training or trial-and-error learning and which is subject to being forgotten.

Adjusting the POD structure to a more decentralized network increases the HP distribution rate, and yet this rate is still restricted by the amount of processed HP material available for distribution. In this case, the response phase lasts 37 days. By day 7, 141 people have been assisted, and the assistance slope is 360 people assisted per day.

Human resource allocation policy. Instead of allocating human resources to process incoming material, they can be allocated according to other rules. Motivated by Costa (2015), our study gives priority to distributing HP material and then to processing material. What is difficult in implementing this policy lies in managing the expectations of human resources regarding received material that is not processed. Additionally, the policy's implementation implies that there is perfect information about how much material has been processed and how much is needed (though with a delay), which is not reasonable, as many organizations work in parallel in processing material. In a more disaggregated model where agents are modeled separately, this issue can be further explored.

The base case assumes a value of 0 for "distribution priority" while this policy assumes a value of 1. Since processing creates a bottleneck, giving priority to distribution at the start of the disaster is not helpful because not enough HP material is processed and ready to be distributed. Only when the quantity of still needed and processed material matches are human resources reallocated to distribution at PODs, causing the distribution rate to spike. Initially, no material is processed, eventually causing the crowding effect to hinder processing HP material and delay distribution. With this policy in place, the response phase lasts only 49 days, representing only 80% of the base case.

2.4.3.4 Discussion of Individual Policies

Figure 2.8 presents an overall comparison of assisted populations and distribution rates for each policy.

We summarize the performance metrics for each of the 10 individual policies in Table 2.2 and rank them by the amount of time required to assist all beneficiaries from shortest to longest. There is a clear relationship between policies that assist 10% of people over 11 days and those that take up to 15 days to assist all beneficiaries: the former assist all beneficiaries in less than 37 days while the latter take at least another 9 days. The assistance slope echoes this pattern where policies that assist more than 350 people per day perform significantly better than the others, which assist up to 280 people per day.

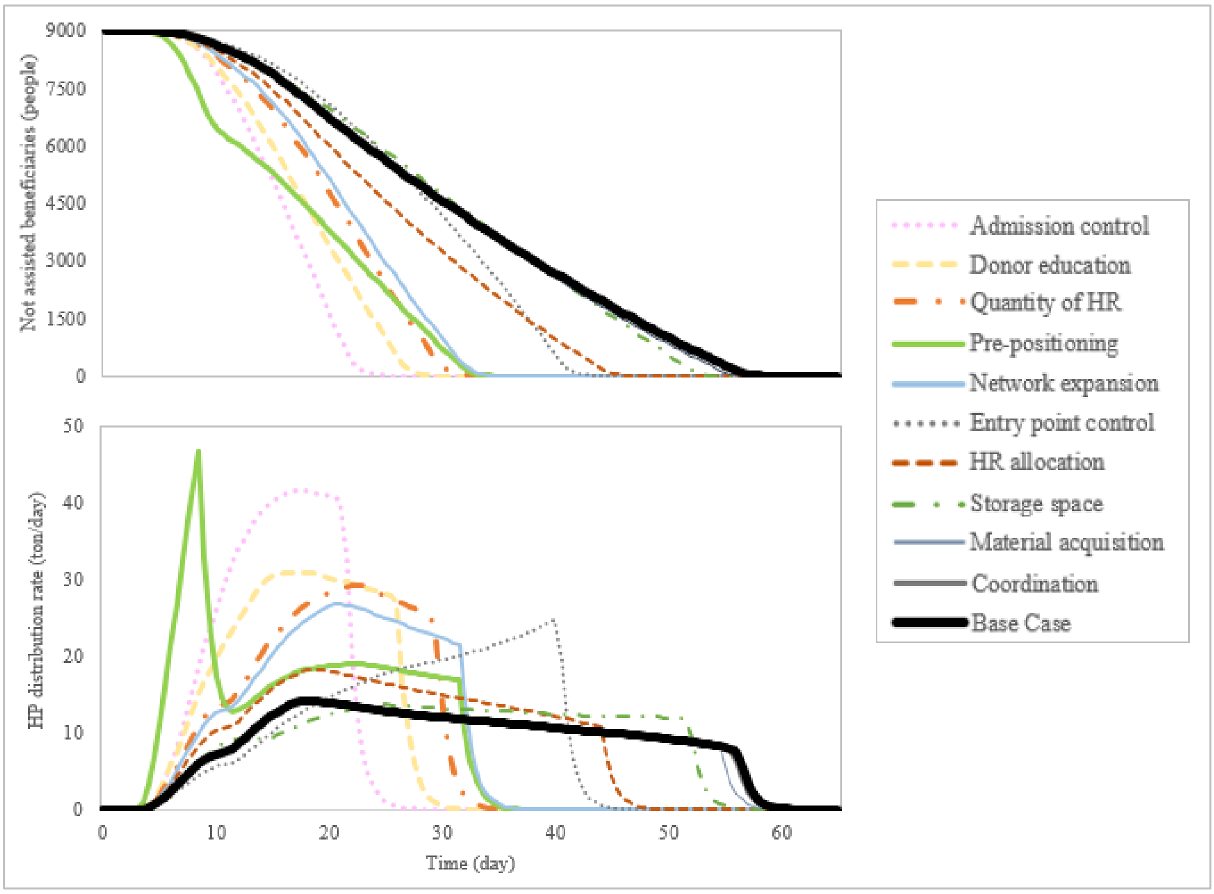

Figure 2.8: Comparison of Individual Policies. The upper figure shows the number of not assisted beneficiaries over time while the lower one shows the HP distribution rate, which directly impacts the stock shown in the upper figure.

The best performing policy (admission control) performs 55% better than the base case, and the worst performing policy (coordination) saves only one day of response time relative to the base case. Donor education, the quantity of human resources, pre-positioning, and network expansion perform similarly, as all of them affect the capacity to process and distribute material; yet, their assistance slope is not as high as for the admission control policy since NP material still enters the system. These four have a common feature: they directly or indirectly reallocate human resources to manage HP material. While the human resource allocation policy affects part of the response effort, it does not greatly impact the processing effort and therefore lags behind. Storage space, material acquisition, and coordination policies perform very similarly to the base case, suggesting that they do not focus on bottlenecks; surprisingly, coordination and material acquisition that only introduce more material even when it is HP material do not perform significantly better than the base case, since in a material convergence setting there is more HP material than is required to assist beneficiaries. In the middle of this spectrum remains the entry point control and human resource allocation policies: they indirectly affect the bottleneck (processing of HP material).

Table 2.2: Performance Metrics of Individual Policies. Policies are ordered by the time required to assist 100% of beneficiaries in days with fewer days denoting better disaster response performance.

Policy	Time required to assist [days]			Slope [people/day]	Cumulative # assisted by day 7 [people]
	10% p	50% p	100% p		
Admission control	9	15	27	600.0	215
Donor education	10	18	34	450.0	199
Quantity of human resources	10	20	35	360.0	157
Pre-positioning	7	17	37	360.0	835
Network expansion	11	21	37	360.0	141
Entry point control	15	28	46	276.9	66
Human resource allocation	12	25	49	276.9	118
Storage space	13	30	58	211.8	91
Material acquisition	13	29	59	225.0	91
Coordination	13	30	60	211.8	90
Base Case	*13*	*30*	*61*	211.8	*90*

It is particularly important to acknowledge the role of delays and nonlinearities in the material convergence problem, as they increase system complexity. Delays impact the system at several stages, e.g., during needs assessment, material processing and material distribution, and are present under many policies, e.g., the time required for acquisitions to be received, for human resources to be (de)mobilized and for the crowding effect to kick in with increased storage space. Such delays affect the effectiveness of different policies as bottlenecks shift and as the allocation of human resources changes.

Nonlinearities also characterize the material convergence problem. The existence of stocks in the system allows for accumulations, which form in diverse and nonlinear ways depending on inflows and outflows. Additionally, interactions between variables of multiplications or divisions create nonlinearities as well. Finally, specific equations are nonlinear, e.g., the allocation of human resources to distribution depends on the availability of processed material and acceptance of donations depends on having available storage space, and this can abruptly change the rules a system is subject to. The overall outcome will typically present nonlinear behavior as can be observed from the lower chart shown in Figure 2.8.

As we show in this paper, the negative effects of material convergence can be mitigated when disaster responders implement exogenous policies that affect critical variables of the system. As an alternative, policies can be triggered from within the system during the disaster response and thus be made endogenous.

We identify and apply the partial endogeneity of the admission control policy. The crowding effect can also trigger three policies: the storage space, entry point control, and human resource allocation policies. Information on the ratio of HP and NP material can trigger both the coordination and donor education policies. However, not all policies can be triggered within the timeframe of one disaster. The pre-positioning policy must be implemented before a disaster occurs and the network expansion policy is unlikely to develop during a disaster.

2.5 Considerations for Policy Robustness

To generalize the insights of the proposed framework and determine whether the proposed policies are robust, we conduct an in-depth analysis of the environments in which policy implementation occur considering disaster characteristics, overarching decision-making processes, and implementation.

2.5.1 Disaster Characteristics

The disaster management literature identifies five important characteristics of disasters: onset (Apte, 2009), intensity (UNISDR, 2009), frequency (Albala-Bertrand, 2000), dispersion (Apte, 2009), and forecastability (Albala-Bertrand, 2000; Thévenaz and Resodihardjo, 2010).

In this study, we consider only sudden-onset disasters since it is widespread media attention and consequential donations en masse that set the stage for material convergence. The effect of having a more intense disaster or a more vulnerable population at a particular location is the same, as both increase the need for assistance; this can be analyzed through a sensitivity analysis. In this work, we consider only a single-time occurrence without considering frequency. Finally, we discuss issues of dispersion and forecastability.

Dispersion (Apte, 2009) is defined as the density of people affected in a disaster area. In concentrated disasters, beneficiaries are positioned physically close to one another (e.g., the 2018 flood in Venezia: roughly 3240 people/km^2); however, in dispersed disasters, beneficiaries are located far apart (e.g., the 2010 earthquake in Haiti and the Dominican Republic: roughly 340 people/km^2 with local variations)[1]. Dispersion affects the effectiveness of disaster response policies. For instance, it decreases the effectiveness of communication and coordination efforts, reduces the robustness of POD structures in a community, and increases costs of distributing pre-positioned materials. In contrast, the number of entry points decreases when larger areas are affected, and this policy can in turn be implemented more easily (Holguín-Veras et al., 2012b).

Forecasting a disaster entails predicting the precise date and time, location, and magnitude of a disaster (USGS, 2018). In our work, "forecastability" encompasses the use of forecasts and monitoring devices despite time preparation availability differences (Wilkinson

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[1] These metrics were calculated using the Population Explorer tool available at https://www.populationexplorer.com.

et al., 2018). Not all disasters are forecastable, including those caused by earthquakes (USGS, 2018), mass movements (Sassa et al., 2009; Anders, 2013), and tornados (NOAA, 2017). Forecastability allows decision-makers to overcome some delays that otherwise impact the disaster response by, e.g., pre-positioning material or mobilizing human resources. With a predictability of at least a couple hours that allows for mitigating measures, forecastable disasters include hurricanes (AMS, 2007), extreme temperature events (Wilkinson et al., 2018), floods (Parker et al., 2009; Wilkinson et al, 2018), and volcanic activity (Sparks, 2003).

According to a report involving several climate centers and research institutes, forecasting has led to several preparedness actions such as pre-positioning material, identifying storage facilities, preparing to receive materials, coordinating response activities among organizations, and integrating finance and planning processes that allow for material and human resource mobilization (Wilkinson et al., 2018).

We consider the impact of dispersion and forecastability together (Table 2.3) to analyze the effectiveness of disaster response policies. Concentrated and forecastable disasters benefit from a broader and more effective set of preparedness policies. That is, these disasters are easier to plan and prepare for and their responses are smoother when policies have been implemented; dispersed and nonforecastable disasters struggle with limited and ineffective preparedness policies. That is, these disasters are more challenging to plan and prepare for, and their responses are more complex.

Table 2.3: Dispersion and Forecastability Matrix for the Four Cases of Interaction

Dispersion/Forecastability	Forecastable	Nonforecastable
Concentrated	Concentrated and Forecastable (e.g., flood)	Concentrated and Nonforecastable (e.g., mass movement)
Dispersed	Dispersed and Forecastable (e.g., hurricane)	Dispersed and Nonforecastable (e.g., earthquake)

We measure the impacts of different policies for all four cases and analyze the first one (C&F) in detail in Appendix 2.4. We present a summary of the results in Figure 2.9.

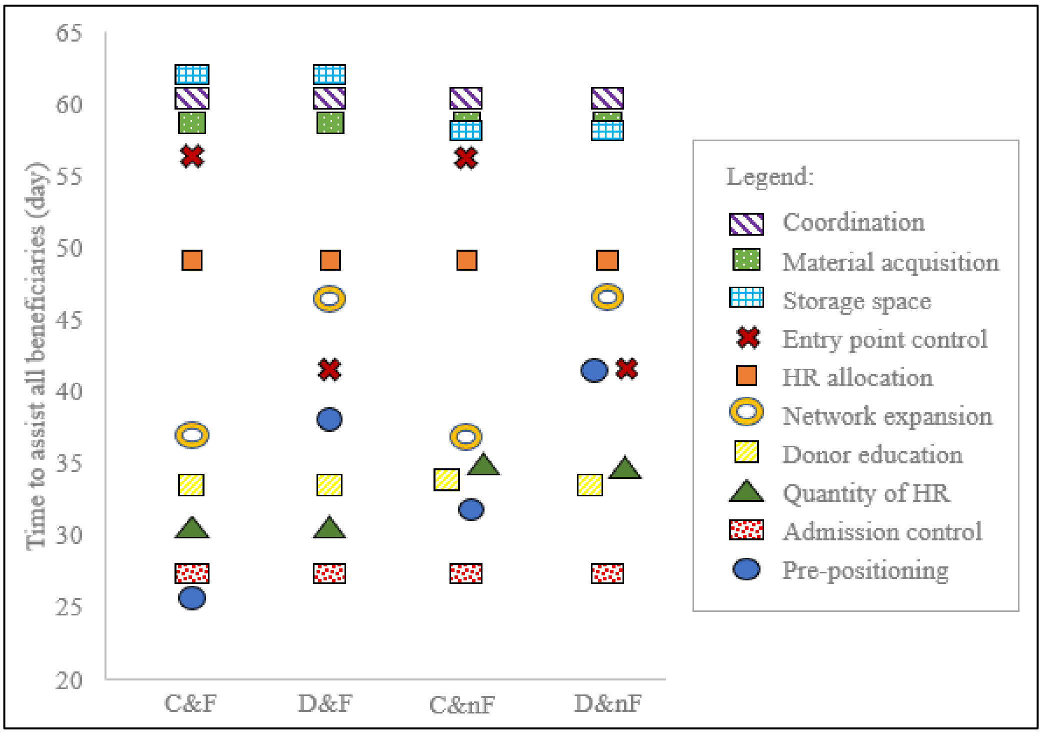

Figure 2.9: Policy Performance According to Disaster-Specific Characteristics. Policies listed closer to the bottom of the figure perform better, as they take less time to assist all beneficiaries.

To be conservative, we assume a relatively strong impact (50%) of forecastability and dispersion on the policies and assess their robustness. Of the ten individual policies considered, disaster characteristics influence eight; of these, only four policies are impacted to the extent that response efficiency is altered, i.e., the amount of time required to assist all beneficiaries is affected. These policies are the pre-positioning, entry point control, network expansion, and quantity of human resources policies.

Disaster characteristics have the most positive impact on pre-positioning policy, which by making nearly enough HP material available to all beneficiaries bypass the processing bottleneck, as a forecasted disaster allows for enhanced preparation regarding types and quantities of material needed, information on vulnerable populations, best locations to position material, and distribution planning. The entry point control policy is also positively affected, but predominantly because dispersion favors fewer entry points and processing efforts are more focused. The network expansion policy is most negatively affected, as dispersion hinders the development and maintenance of ties between people living far apart, leaving fewer opportunities for joint processing and material distribution. Disaster characteristics affect outcomes of the quantity of human resources policy somewhat, as the response still depends on the rate of donation receipt and thus on the processing and distribution of HP material.

It is useful to know the history of disasters in a given region when determining policies that perform best under the identified conditions; yet, when there is no such information or different types of disasters occur, the best performing policies are consistently the pre-positioning, admission control, quantity of human resources, and donor education policies. This means that these policies are generally robust, though forecastability and concentration significantly promote the value of pre-positioning. It is thus no wonder that pre-positioning receives so much attention from HOs and captures a significant fraction of preparedness policies.

2.5.2 Decision-making Processes

Lindenberg and Bryant (2001) characterize five types of organizational structures of HOs, and Thévenaz and Resodihardjo (2010) simplify this classification by identifying two types of decision-making processes. Centralized and decentralized decision-processes influence the managerial decisions of HOs contacting other HOs in the wake of a disaster, though complexity is significantly amplified (Lindenberg and Bryant, 2001). When an organization adopts a centralized decision-making process, it achieves more coordination, it utilizes human resources more efficiently since they can be allocated strategically, it pre-positions items more effectively and on a larger scale, it controls the admission of materials more effectively and consistently in collaboration with different organizations, and it faces reduced efficiency in its POD structures due to limited adaptability to local needs. An organization that adopts a decentralized decision-making process influences the policies mentioned above in the opposite manner.

Computationally, we assume that centralized and decentralized decision-making processes influence the effectiveness of each response policy by 20%.

While coordination impacts the system locally (organizations send a higher percentage of HP material), it does not affect the bottleneck (processing of material); thus, no differences in the overall disaster response are observed under centralized or decentralized decision making. Admission control policy is not impacted either while the other policies are impacted: decentralization reduces the performance of the quantity of human resources (15%), pre-positioning (5%), and network expansion (30%) policies; with centralization, better performance is achieved by the quantity of human resources (9%) and pre-positioning (6%) policies while the network expansion policy performs as it does in the neutral case.

This means that policies are generally robust when considering centralized and decentralized decision-making processes. The resulting impact on policies is mild and only three of the policies (the quantity of human resources, pre-positioning, and network expansion policies) under which the decision-making process affects bottlenecks are affected.

2.5.3 Policy Implementation

Majone (1989) states that only the political process can resolve disagreements regarding the evaluative criteria of policies, yet he adds that "analysts can contribute to societal learning by refining the standards of appraisal and by encouraging a more sophisticated understanding of public policies than is possible from a single perspective." While we identified the distribution rate as a worthwhile criterion for measuring the effectiveness of policy implementation and encourage a more sophisticated understanding of material convergence dynamics, we agree that implementation viability assessment must take into account further aspects.

The project literature clearly states that time, cost, and scope must guide implementation (The World Bank, 2006; INTERact, 2015). Other guidelines add factors such as agreement and the number of interested parties to this list (BIS, 2010). In believing that powerful insights can be gained from an initial assessment of these factors and that they can stir interesting discussions, we objectively consider 1) costs and subjectively consider 2) time required to implement, 3) time required to achieve results, 4) the number of actors, and 5) institutional barriers in subsequent discussions. The basis for the cost consideration is presented in Appendix 2.7. The other four factors are informed by typical humanitarian response concerns as described before under each individual policy given in section 4.3. and are not based on simulations.

The number of actors involved can include only one organization to up to several organizations or even active engagement from the community. Institutional barriers consider policy acceptance within HOs: admission control, network expansion, and human resource allocation policies are expected to encounter the most opposition due to their need for coordination across HOs and incipient discussions among HOs on these policies. Time required to implement rests on the number of decision-makers that must agree on a given policy and the frequency of decision reassessment. Implementation costs depend on the type of object obtained: material and human resources are the most expensive, recurrent information and space are next, and one-time information is the least expensive. Time required to achieve results hinges on the causes of delays: transporting material usually presents few obstacles, reallocating human resources is more demanding, and both disseminating information and delaying the forgetting process are the most complex (Table 2.4).

Table 2.4: Additional Factors Affecting Policy Implementation

Policy	Number of actors	Institutional barriers	Time to implement	Cost of implementation	Time to achieve results
Pre-positioning	■■		◑	$$	◔
Material acquisition	■		◔	$	◔
Donor education	■■■		◑	$$$	◕
Coordination	■■		◕	$$	◕
Admission control	■■■■		●	$	◑
Entry point control	■■		◑	$$	◑
Storage space	■		◔	$$	◔
Quantity of human resources	■		◔	$$$	◑
Network expansion	■■■■		●	$	◕
Human resource allocation	■■■		◕	$	◑

Next, we classify the policies by overall implementation difficulty. Storage space and material acquisition policies are easy to implement. Institutional barriers are low for this group, possibly reflecting the minimal cognitive demands of such policies and demonstrating that results are achieved rapidly. Of moderate difficulty are the entry point control, quantity of human resource, pre-positioning, and human resource allocation policies. As the average number of actors increases, the time needed to implement and achieve results increases; the cost of implementation is, on average, higher than it is for the first group. The most difficult to implement are donor education, coordination, admission control, and network expansion. Although attempts have been made to implement some of these policies, they face strong institutional barriers (except for donor education) and require active effort from society (except for coordination), which still translates into more time for implementation; yet, the costs of implementation are not particularly different from those of the second group, making them potential alternatives for managing material flows in future disasters.

2.6 Conclusion

Material convergence is a common and disruptive problem during disasters. It is also a complex dynamic problem involving multiple actors, fragmented decisions, significant delays, and densely connected feedback mechanisms. The present research emphasizes that each of these aspects affects flows of high-priority (HP) and non-priority (NP) materials differently, leading to a significant influence on the effectiveness of the humanitarian response. We shed light on the mechanisms that cause material convergence by detailing eight feedback loops that affect the flow of HP materials (five directly and three indirectly). Our analysis suggests that a significant fraction of resources is allocated to manage NP material and cannot therefore be used to actively assist people. This result illustrates how humanitarian response suffers when management does not consider the dynamics involved in material flows.

Several studies have proposed policies that can avert the negative effects of material convergence. Our study goes further by comparing ten different policies using three different performance metrics and by providing a comprehensive framework to study the individual impacts of each considered policy on the system and potential unintended consequences.

Depending on the metric used, the ranking differs; this prevents us from claiming that there is a single best policy that beats all others. However, some policies display positive attributes that are clearly evident. For instance, policies that focus on reallocating human resources allow for a shorter response phase. Overall, the admission control, donor education, quantity of human resource, and pre-positioning policies perform better than the others.

In addition, we consider two aspects of disasters that impact policies aimed at mitigating material convergence: dispersion and forecastability. Forecastable and concentrated disasters increase the effectiveness of almost all policies. However, in many cases the change in policy effectiveness is only mild. An exception is observed for the pre-positioning policy, whose effectiveness is strongest in the midst of forecastable and concentrated disasters. This result supports HOs' overwhelming focus on this policy for disaster preparedness.

The results obtained from analyzing decision-making processes indicate that decentralized decision-making is utterly negative and should be avoided by instituting a central command for disaster response. Nevertheless, instituting one central command is not necessarily desirable for HOs with different mandates; alternatives as a "humanitarian social network of action" based on the empowerment of lower ranks and facilitated communication channels exist (Stephenson Jr and Kehler, 2004).

We divide the individual policies into three groups by implementation difficulty. Of the best performing and most robust policies, those easiest to implement are the pre-positioning and quantity of human resources policies. Both policies encounter fewer barriers and delays in producing visible results. Accordingly, they are more frequently used in practice[2]. Donor education is more difficult to implement as the time required to achieve results increases and the goal to reach all donors might require too much effort. Attempts to implement this policy result in varied outcomes[3]. Admission control is difficult to implement due to institutional barriers and a need to integrate several actors. Not surprisingly, there have only been discussions on this approach and no implementation in practice[4].

We also combined policies as shown in Appendix 2.6. We conclude that focusing efforts on more than one feedback loop at a time can result in more efficient material handling and greater assistance to beneficiaries. In particular, combining the admission control and quantity of human resources policies results in a disaster response that is almost as efficient as combining all ten policies in a single effort.

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[2] A search on reliefweb (https://reliefweb.int), a well-recognized media outlet on humanitarian operations, returns thousands of results related to pre-positioning material and increasing the number of relief workers.
[3] A search on reliefweb returns a few dozen results related to educating donors.
[4] A search on reliefweb returns no results related to material control in disasters.

In an extended version of our model, more aspects could be considered: 1) transportation capacity and jams, 2) customs procedures, 3) closing the feedback loop between donations and an organization's acquisitions through monetary donations, 4) donor and media agendas, and 5) cultural aspects, institutional aspects, and legislation. It is also important to acknowledge that a prioritization system may not be static; HP material can become NP material as conditions on the ground evolve (Holguín-Veras et al., 2014).

Future research can expand in several directions based on our study. Other human resource allocation rules can be implemented, and the proportion of human resources allocated to processing and distributing HP material can in turn be fine-tuned. The crowding effect can be studied under different human resource conditions and operations research can be used in conjunction with system dynamics to analyze the ensuing behavior (Ghaffarzadegan and Larson, 2018). Further, data could be collected to fully calibrate the proposed model (Kapmeier and Gonçalves, 2018). Changes in human resource productivity could also account for difficulties such as those of last-mile distribution. Finally, the implementation of admission control could be pursued.

Appendix 2.1: Material Flow Classification

To better understand how donations become obstacles, we analyze the composition of material flows. One classification of material flows considers priorities: a) high priority (HP) items are those needed for immediate distribution and consumption and b) nonpriority (NP) items are those that are not needed in the disaster response phase. These donations cannot be distributed because they are culturally inappropriate or perishable products past their expiration date among other reasons. NP items are generally not properly packaged for distribution, thus consuming more resources for proper processing (Holguín-Veras et al., 2014).

Another classification of material flows considers the organizations that request material. According to Quarantelli et al. (1966), organization structures can be either regular or irregular, and their activities can be old or new. The possible combinations of these factors define the classification of organizational structures shown in Table 2.5. Established organizations already exist and perform routine activities; organizations in the process of extension, although already existing, take on new activities; organizations in expansion are new and carry out activities previously performed by some individuals; and emergent organizations are also new and carry out new activities.

Table 2.5: Classification of Organizational Structures

Structure/Activity	Regular	Irregular
Old	Established	Extending
New	Expanding	Emergent

Source: adapted from Quarantelli et al. (1966)

Classifying organizations is necessary to identify which types of flows arrive at the disaster site. Holguín-Veras et al. (2014) propose that established or expanding organizations generate material flows with a higher percentage of HP items, as they can use knowledge gained from past experiences. Organizations in the process of extension or emergence are more likely to generate flows with more NP materials.

While we have described the type of material (HP or NP) as a given, prioritizing materials may not be a static factor. For example, an HP item may, due to its urgency, be acquired by several actors, which suddenly leads supply to exceed demand and the HP material to be classified as NP material (Holguín-Veras et al., 2014). Such dynamism can also occur by changing the objectives of humanitarian operation in different phases of the disaster cycle; for instance, the initial goal could be responsiveness and then change to efficiency. Identifying a change in objectives is vital to successfully managing the humanitarian supply chain and mitigating the negative effects of material convergence (Day et al., 2012).

Appendix 2.2: Human Resource Distribution at PODs

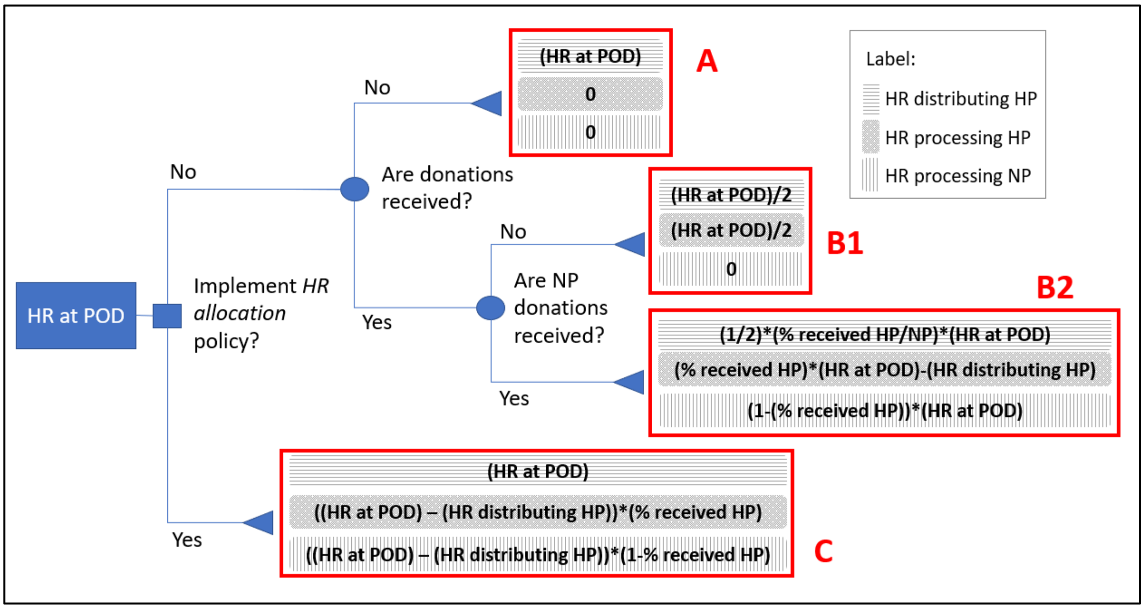

Figure 2.10: Distribution of Human Resources (HR) at PODs. Equations shown in the red boxes translate allocation decisions into mathematical rules.

Figure 2.10 shows the equations for the number of human resources accomplishing three activities performed at PODs: distributing HP material, processing HP material, and processing NP material. In Part A, no donations are received; in Part B, human resources are allocated to the task according to the percentage of HP and NP material; and in Part C, the human resource allocation policy is implemented.

Appendix 2.3: Multivariate Sensitivity Analysis

Five multivariate sensitivity analyses (MSA) help us understand the impact of different sets of variables on the distribution rate of the base case (Table 2.6). MSA 1 focuses on society, MSA 2 focuses on the organization, MSA 3 focuses on productivity, MSA 4 focuses on human resources, and MS5 focuses on NP singularities.

Table 2.6: Multivariate Sensitivity Values

Parameter	Value	Unit	MSA 1	MSA 2	MSA 3	MSA 4	MSA 5
Time for society to mobilize	5	Day	[2-10]				
Impact factor of NAB on donations	0.02	Dimensionless	[0.01-0.05]				
Assessment time	3	Day		[2-7]			
Average productivity	0.07	Ton/People/Hour			[0.04-0.09]		
Effect of emergency on productivity	0.75	Dimensionless			[0.6-0.9]		
Warehouse hours/day	8	Hour/Day			[7-9]		
Emergency Hours/day	14	Hour/Day			[10-15]		
Estimated productivity	0.05	Ton/People/Hour			[0.02-0.07]		
Estimated Hours/day	10	Hours/Day			[8-12]		
Time to mobilize HR	5	Day				[3-10]	
Time to demobilize HR	21	Day				[14-28]	
% of leaking NP material	0.05	Dimensionless					[0.01-0.10]
NP processing difficulty	0.825	Dimensionless					[0.7-0.9]
Volume reduction of processing	0.9	Dimensionless					[0.8-0.95]

Changing the parameters of MS 1, MS 2, and MS 5 has a very minor effect on the distribution rate; thus, the model is not particularly sensitive to these parameters. As expected, changing parameters associated with productivity affects the distribution rate; yet the base case’s behavior is still observed for 50% of the cases (Figure 2.11). Changing the human resource mobilization and demobilization parameters also impacts the distribution rate, but on a smaller scale (Figure 2.12). The model is sensitive to these parameters.

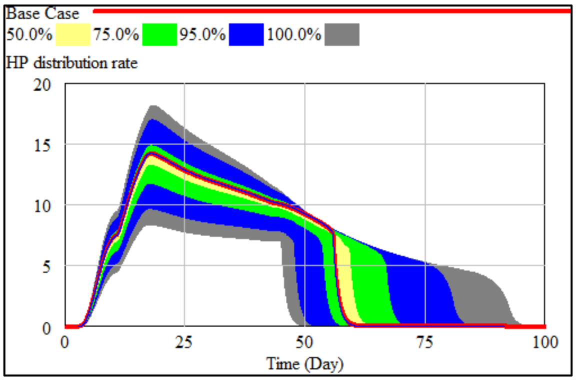

Figure 2.11: Distribution Rate for MSA 3

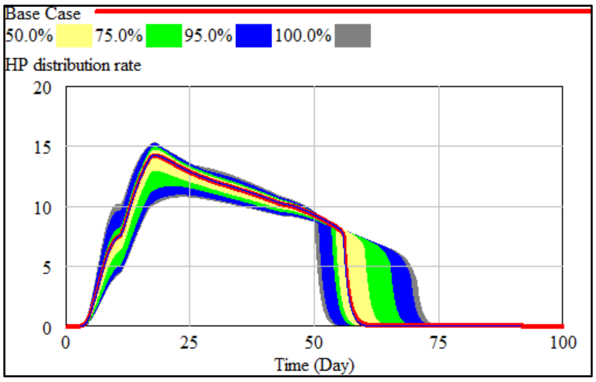

Figure 2.12: Distribution Rate for MSA 4

Appendix 2.4: Disaster-Specific Characteristics – Analysis of the Four Cases

Table 2.3 presents four combinations of disaster characteristics. Next, we analyze each case in detail. The results are used to create Figure 2.9.

Case 1: Concentrated and forecastable disaster

We incorporate the impact of "concentrated and forecastable" disasters into the model while changing the affected policy parameters. To assess the influence of a concentrated and forecastable disaster on the policy results, we compare it to policies applied to the base case setting. In Table 2.7, the parameters are the values of corresponding policy variables. The policies are ranked in order of time required to assist all beneficiaries from shortest to longest.

Table 2.7: Impact of Concentrated and Forecastable (C&F) Disasters on Policy Performance

Policy	Policy parameters			Time required to assist 100% of people [days]		Cumulative # assisted by day 7 [people]	
	C&F	Base Case	Unit	C&F	Base Case	C&F	Base Case
Pre-positioning	0.67/1	(0.3/1)	Dmnl	26	(37)	812	(835)
Admission control	0	(0)	Dmnl	27	(27)	215	(215)
Quantity of human resources	450	(300)	People	30	(35)	193	(157)
Donor education	0.65	(0.65)	Dmnl	34	(34)	199	(199)
Network expansion	2	(2)	Dmnl	37	(37)	141	(141)
Human resource allocation	1	(1)	Dmnl	49	(49)	118	(118)
Entry point control	0.15	(0.3)	Dmnl	56	(46)	66	(66)
Material acquisition	0.15	(0.10)	Dmnl	58	(59)	93	(91)
Coordination	0.04	(0.15)	Dmnl	60	(60)	90	(90)
Storage space	2670	(1780)	Ton	62	(58)	92	(91)

The parameters of the following three policies do not change: admission control, donor education, and human resource allocation. Pre-positioning more than doubles the parameter value, as it is positively influenced by the forecastable and concentrated nature of a disaster and is the most efficient disaster response, assisting all beneficiaries in less time than even the admission control policy. The number of beneficiaries assisted by day 7 is marginally less than it is for the neutral case since human resource mobilization efforts are less intense given that there is available information on how much less material must be processed due to the presence of large amounts of pre-positioned material. While the number of human resources can be increased under forecastability conditions, the network cannot be expanded to a structure superior to that of CANs. Coordination and material acquisition policies perform similarly to their responses without forecastability. Entry point control and storage space policies perform worse than in the base case, as efforts required to avoid the crowding effect are decreased in a concentrated disaster.

Case 2: Dispersed and Forecastable Disaster

Table 2.8: Impact of Dispersed and Forecastable Disasters on Policy Performance

Policy	Policy parameters			Time required to assist 100% of people [days]		Cumulative # assisted by day 7 [people]	
	D&F	Base Case	Unit	D&F	Base Case	D&F	Base Case
Admission control	0	(0)	Dmnl	27	(27)	215	(215
Quantity of human resources	450	(300)	Dmnl	30	(35)	193	(157)
Donor education	0.65	(0.65)	People	34	(34)	199	(199)
Pre-positioning	(0.23/1)	(0.3/1)	Dmnl	39	(37)	836	(835)
Entry point control	0.45	(0.30)	Dmnl	42	(46)	67	(66)
Network expansion	1.5	(2)	Dmnl	46	(37)	114	(141)
Human resource allocation	1	(1)	Dmnl	49	(49)	118	(118)
Material acquisition	0.15	(0.10)	Dmnl	58	(59)	93	(91)
Coordination	0.11	(0.15)	Dmnl	60	(60)	90	(90)
Storage space	2670	(1780)	Ton	62	(58)	92	(91)

An example of a dispersed and forecastable disaster is a hurricane (Table 2.8).

The parameters of the three following policies do not change: admission control, donor education, and human resource allocation. While parameters for the quantity of human resources, storage space, entry point control, and material acquisition increase, those for pre-positioning, entry point control, network expansion, and coordination decrease for a dispersed disaster.

The admission control policy leads to the most efficient response under these conditions. Both the quantity of human resources and entry point control policies perform better in a dispersed disaster, as they influence the processing and distribution capacity, taking 15% and 9% less time to assist all beneficiaries, respectively; network expansion takes 25% more time. While material acquisition and coordination are positively impacted, the difference in the assistance effort is marginal.

Case 3: Concentrated and Nonforecastable Disaster

Table 2.9: Impact of Concentrated and Nonforecastable Disasters on Policy Performance

Policy	Policy parameters			Time to assist 100% of people [days]		Cumulative # assisted by day 7 [people]	
	C&nF	Base Case	Unit	C&nF	Base Case	C&nF	Base Case
Admission control	0	(0)	Dmnl	27	(27)	215	(215)
Pre-positioning	(0.45/1)	(0.3/1)	People	32	(37)	830	(835)
Donor education	0.65	(0.65)	Dmnl	34	(34)	199	(199)
Quantity of human resources	300	(300)	Dmnl	35	(35)	157	(157)
Network expansion	2	(2)	Dmnl	37	(37)	141	(141)
Human resource allocation	1	(1)	Dmnl	49	(49)	118	(118)
Entry point control	0.15	(0.3)	Dmnl	56	(46)	66	(66)
Storage space	2670	(1780)	Ton	57	(58)	91	(91)
Material acquisition	0.10	(0.10)	Dmnl	59	(59)	91	(91)
Coordination	0.08	(0.15)	Dmnl	60	(60)	90	(90)

An example of a concentrated and nonforecastable disaster is a mass movement (Table 2.9).

The only disaster response that is significantly positively impacted in a concentrated and nonforecastable disaster is pre-positioning; in 15% less time, all beneficiaries are assisted. Although the level of material duplication is the lowest for this scenario (coordination policy), it still does not have a major impact on the disaster response.

Case 4: Dispersed and Nonforecastable Disaster

Table 2.10: Impact of Dispersed and Nonforecastable (D&nF) Disasters on Policy Performance

Policy	Policy parameters			Time to assist 100% of people [days]		Cumulative # assisted by day 7 [people]	
	D&nF	Base Case	Unit	D&nF	Base Case	D&nF	Base Case
Admission control	0	(0)	Dmnl	27	(27)	215	(215)
Donor education	0.65	(0.65)	Dmnl	34	(34)	199	(199)
Quantity of human resources	300	(300)	People	35	(35)	157	(157)
Pre-positioning	(0.15/1)	(0.3/1)	Dmnl	42	(37)	836	(835)
Entry point control	0.45	(0.3)	Dmnl	42	(46)	67	(66)
Network expansion	1.5	(2)	Dmnl	46	(37)	114	(141)
Human resource allocation	1	(1)	Dmnl	49	(49)	118	(118)
Storage space	2670	(1780)	Ton	57	(58)	91	(91)
Material acquisition	0.10	(0.10)	Dmnl	59	(59)	91	(91)
Coordination	0.15	(0.15)	Dmnl	60	(60)	90	(90)

An example of a dispersed and nonforecastable disaster is an earthquake (Table 2.10). Again, as in case 2, the policies most affected in a dispersed disaster are pre-positioning and network expansion. The other policies are not affected by dispersed conditions and nonforecastability hampers the diffusion of information, which may be useful for the disaster response.

Appendix 2.5: Specific Parameters for Individual and Combined Policies

Table 2.11 shows the changed parameters for each policy (highlighted). Five policies rely on percentages: pre-positioned and acquired material are calculated as a fraction of material needed to assist all beneficiaries; donor discernment is calculated as the proportion of HP donated material; admission control is calculated as the threshold percentage of occupied space that triggers the policy; and entry point control is calculated as the fraction of human resources diverted to control material outside the disaster area. Two policies rely on absolute numbers: since the proportion of HP and NP material received affects the storage space required, and the crowding effect influences the ideal quantity of human resources, and neither of these policies can be calculated as percentages. Furthermore, two policies function as switches: network expansion and human resources allocation can either be implemented or not during the disaster response. Only one policy changes two parameters at once: the pre-positioning policy increases the amount of material and implies that human resource allocation will prioritize the distribution effort.

Table 2.11: Specific Parameters – Individual Policies

Parameter/Policy	Base case	Pre-positioning	Material acquisition	Donor education	Coordina-tion	Admission control	Entry point control	Storage space	Quantity of HR	Network expansion	HR allocation	Unit
Pre-positioning coverage	**0**	**0.30**	0	0	0	0	0	0	0	0	0	Dmnl
Acquisition coverage	**0.05**	0.05	**0.10**	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	Dmnl
Donor discernment	**0.30**	0.30	0.30	**0.65**	0.30	0.30	0.30	0.30	0.30	0.30	0.30	Dmnl
Material duplication	**0.30**	0.30	0.30	0.30	**0.15**	0.30	0.30	0.30	0.30	0.30	0.30	Dmnl
Threshold for NP acceptance	**0.80**	0.80	0.80	0.80	0.80	**0**	0.80	0.80	0.80	0.80	0.80	Dmnl
Control at warehouse	**0**	0	0	0	0	0	**0.30**	0	0	0	0	Dmnl
Storage capacity	**1300**	1300	1300	1300	1300	1300	1300	**1780**	1300	1300	1300	Ton
Potential human resources	**150**	150	150	150	150	150	150	150	**300**	150	150	People
POD structure	**1**	1	1	1	1	1	1	1	1	**2**	1	Dmnl
Distribution priority	**0**	**1**	0	0	0	0	0	0	0	0	**1**	Dmnl

Appendix 2.6: Combined Policies

The combined policies are an attempt to address material convergence with a comprehensive approach. Motivated by the extant literature, we group individual policies into five combined ones with parameter changes captured in Table 2.12.

First, we analyze three combined policies that shed light on improvements recurrently suggested or requirements for an efficient response phase (Jha et al. 2012):

1) A *resource centered* policy that addresses limited funding (using the quantity of human resources, material acquisition, and pre-positioning policies): “prepare resource inventories, identifying how much is available locally and how much is needed from outside; plan resource mobilization” (Jha et al., 2012:376);

2) A *planning centered* policy that addresses the challenges HOs face in effectively coordinating their efforts with other organizations and allocating resources (using the coordination, human resources allocation, and admission control policies): “participatory planning for emergency situations can help build trust and confidence among stakeholders, enhance cooperation, facilitate information sharing and encourage regular communication” (Jha et al., 2012:374); and

3) A *society centered* policy that addresses the difficulties that communities affected by a disaster experience in proactively joining the relief effort (using the donor education and network expansion policies): “implement public awareness activities; be pro-active; educate the public on what to do, and what not to do” (Jha et al., 2012:376).

Taking into consideration that the best individual policies reallocate human resources and the goal of the disaster response is to process and distribute HP material, we propose another combined policy that affects the system at distinct stages:

4) A *relief centered* policy that maximizes the distribution of HP material (using the quantity of human resources and admission control policies).

Finally, we propose a policy that can be seen as the upper boundary of disaster responses: 5) A *global effort* policy that simulates the most comprehensive effort possible (including all policies).

Table 2.12: Specific Parameters – Combined Policies

Parameter/Policy	Base case	Planning Centered	Society Centered	Resource Centered	Relief Centered	Global Effort	Unit
Material duplication	**0.30**	**0.15**	0.30	0.30	0.30	**0.15**	Dmnl
Distribution priority	**0**	**1**	0	0	0	**1**	Dmnl
Threshold for admission control	**0.80**	**0**	0.80	0.80	**0**	**0**	Dmnl
Donor discernment	**0.30**	0.30	**0.65**	0.30	0.30	**0.65**	Dmnl
POD structure	**1**	1	**2**	1	1	**2**	Dmnl
Acquisition coverage	**0.05**	0.05	0.05	**0.10**	0.05	**0.10**	Dmnl
Pre-positioning coverage	**0**	0	0	**0.30**	0	**0.30**	Dmnl
Potential human resources	**150**	150	150	**300**	**300**	**300**	People
Control at warehouse	**0**	0	0	0	0	**0.30**	Dmnl
Storage capacity	**1300**	1300	1300	1300	1300	**1780**	Ton

Figure 2.13 shows that these combined policies impact the rate at which beneficiaries are assisted, and in all cases the response phase ends significantly earlier than it does for the base case. It is not clear whether this impact is the result of only one of the policies or all of them; thus, we analyze each combined policy individually. The metrics are summarized in Table 2.13.

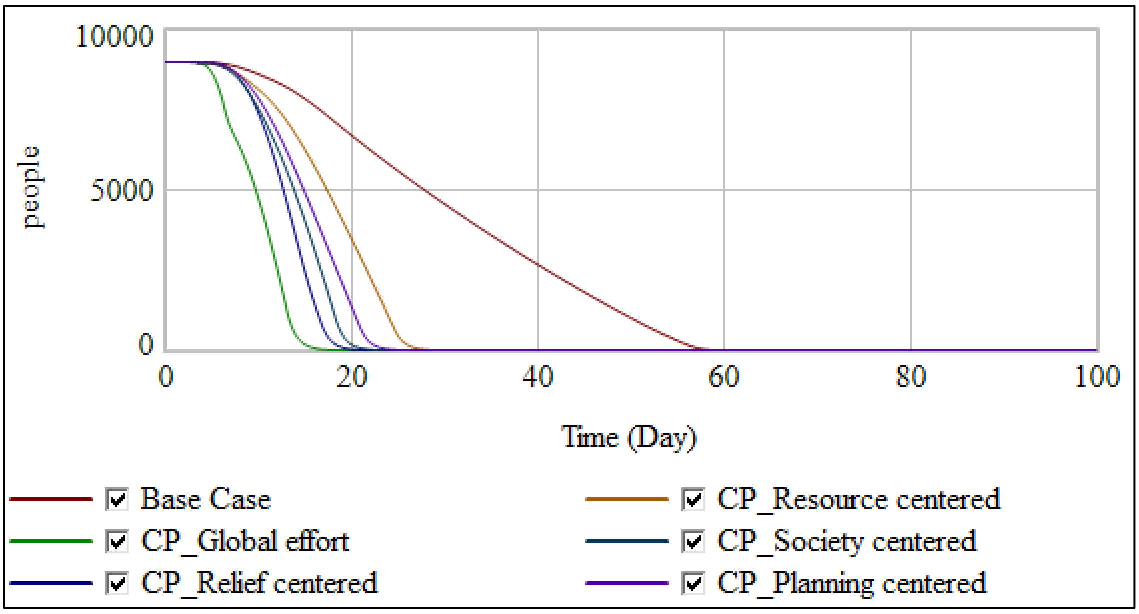

Figure 2.13: Not Assisted Beneficiaries - Combined Policies. Policies that in fewer days help all beneficiaries perform better.

Organizations' lack of planning can be addressed by increasing coordination between HOs, implementing a different human resource allocation method, and establishing admission control of NP items. This *planning centered* policy performs better than the base case, especially due to the admission control policy, but the resulting improved coordination also makes the HP material slightly more available. The overall resulting behavior is the same as that of the individual admission control policy.

A *passive society* can be made more active by increasing the level of donor education and developing POD structures. This *society centered* policy is still restricted by HP processing capacity, but both policies contribute to a combined policy that is better than either one is alone.

The reaction to *limited funds* involves increasing the number of human resources, pre-positioning material and having organizations acquire material. Even though this *resource centered* policy performs better than the base case, its outcome is not as good as the quantity of human resources policy on its own. Adding more acquisition capacity erodes human resources at PODs, and as a result, the HP distribution rate does not increase as rapidly.

Under the *relief centered* policy, the quantity of human resources increases and the admission control policy is implemented. Not even 20% of storage space is occupied since processing and distributing efforts are significant.

Under the *global effort* policy, all policies already used under the other combined policies are considered at once. All beneficiaries are assisted in 21 days, which is only 35% of the time needed in the base case. To compare policies to the global effort is interesting for several reasons: it is the optimum that can be achieved within the boundaries of the parameters and processes depicted in the model, and it shows how efficient other combined policies that only combine up to 3 policies at a time are in relation to this optimum.

We summarize the metrics for each of the combined policies in Table 2.13. Every combined policy performs at least 45% better than the base case and the global effort policy performs best of all. Even though the assistance slope of the global effort is the same as those of the relief centered and society centered policies, the period in which this assistance rate occurs is slightly different. The global effort policy assists 10% of the population in need by day 6, whereas the other two policies only reach this threshold on day 8; yet, the final amount of time required to assist all beneficiaries differs by only 9% or three days. For the combined policies, at least twice, up to nearly 23 times the number of people are assisted by day 7 of the disaster than in the base case.

Table 2.13: Metrics - Combined Policies

Policy	Time required to assist [days] 10% p	50% p	100% p	Slope [people/day]	Cumulative # assisted by day 7 [people]
Global effort	6	11	21	720.0	2098
Relief centered	8	13	24	720.0	245
Society centered	8	14	25	600.0	313
Planning centered	9	15	28	600.0	219
Resource centered	10	18	31	450.0	243
Base Case	*13*	*30*	*61*	*211.8*	*90*

Appendix 2.7: Policy Costs

When deciding which material convergence policies to implement, Humanitarian Organizations (HOs) and governments must consider multiple dimensions. Different policies present varying implementation costs, implementation timeframes, numbers of actors involved, and expected benefits.

A common tool used to assess policies is the cost-benefit analysis approach (European Commission, 2017). The definition of costs, though, is not straightforward: some policymakers only consider direct implementation costs, others consider opportunity costs, others consider costs incurred due to delayed outcomes, and others even consider the costs of unintended consequences. In humanitarian settings, the usual approach involves considering only direct implementation costs (both due to limited time available to assess other costs during emergencies and due to a lack of analysis or data on unintended consequences). Hence, to explicitly incorporate costs into the decision-making processes of humanitarian actors addressing material convergence policies, we base our analyses on direct implementation costs.

We followed two steps to estimate direct implementation costs: 1) we identified cost types, and 2) we calculated cost values for each policy. The cost types are generalizable across different types of disasters and disaster locations. The cost values are specific to the Brazilian flood disaster context (our case study) and thus are not generalizable.

After calculating the direct costs associated with implementing each policy, we discuss some of the caveats to a cost-based policy comparison and then proceed to detail how we dealt with them to reach our insights.

At the end of this appendix, we present an expanded cost analysis that includes the costs of some unintended consequences of the material convergence problem since the simulation allows us to quantify them.

a) Cost Types

First, we present the different types of costs that may be incurred with the implementation of different policies. Each policy may incur only one. Here, we categorize and present the different types of costs. We identify nine types of costs incurred by different policies, which may include: warehouse rentals, warehouse managers, office setup, material purchases, transportation, human resources, volunteers, training, and advertising campaigns. Below, we categorize these into fixed and variable costs. We also include a section on cost increases during emergencies.[5]

a.1) Fixed Costs

Fixed costs include warehouse rentals and office setup. The cost associated with renting a warehouse depends on its storage capacity (measured in m^2). However, once the capacity is established, the rental cost is fixed; it does not depend on the amount of materials stored. A warehouse of 250 m^2 capacity in Taubaté can be rented for US$1,966.00 per month (Imovelweb, 2019). As part of establishing operations in a warehouse, HOs must also establish an office. The minimum cost associated with

[5] As mentioned previously, the cost values are specific to the Brazilian flood disaster context. We calculate them in Brazilian currency (Brazilian Reais (R$)) and converted them into US dollars (1 US$ = R$ 1,78) for this paper. The average exchange rate in January 2010 is available at: http://www.acinh.com.br/servicos/cotacao-dolar.

setting up an office is US$4,944.00 (Brito Jr, I., personal communication, October 22, 2019), which includes the purchasing of a desk, a chair, and a computer.

a.2) Variable Costs

Variable costs include people, material, transportation, and advertisement campaigns.

a.2.1) People

The variable costs associated with people relate to warehouse managers, HO human resources, volunteers, and trainers. A warehouse manager controls access to a warehouse and its goods. However, there are situations when a part-time warehouse keeper suffices. A full-time warehouse manager receives a monthly allowance of US$1,685.00/month (Brito Jr, I., personal communication, October 22, 2019). The costs associated with HOs' human resources are attributable to employees' monthly allowances. These costs vary across locations and functions. We calculate these costs based on the monthly allowance of a civil defense agent in the state of São Paulo: US$1,573.00/month (Vunesp, 2019).

Volunteers do not receive payment, but they receive lodging and meals. HOs spend an average of US$28.00 per volunteer per day for such expenses. Finally, volunteers need training to correctly process and distribute material. Training sessions take two hours and can be offered to groups of 30 volunteers (Brito Jr, I., personal communication, October 22, 2019). The training cost associated with trainer payment is US$117.00 per session (Unifesp, 2019).

a.2.2) Material

Materials handled during the disaster response include 17 items: jackets, shoes, shirts, raincoats, boots, blankets, mattresses, bedsheets, food containers, hygiene kits, cleaning kits, vests, insulation tape, plastic canvas, gloves, helmets, and pluviometers.

Considering the mix of materials needed, the average cost is US$14.96 per ton of material (Brito Jr, 2015).

a.2.3) Transportation

Transportation costs depend on the distance to be traveled. According to the Brazilian National Transport Association (2001), for distances of up to 50 km, the cost per km-ton is US$0,49 per km and ton, and for distances of greater than 50 km, the cost is US$0,12 per km and ton. For the pre-positioning policy, we consider that material is transported 1) from suppliers in São Paulo to the warehouse in Taubaté, representing a distance of 133 km; and 2) from the warehouse in Taubaté to the disaster-affected area in São Luiz do Paraitinga, representing a distance of 46 km. For the material acquisition policy, we assume that material is transported directly from São Paulo to São Luiz do Paraitinga, covering a distance of 175 km.

a.2.4) Advertisement campaign

Advertisement campaigns are needed to create societal awareness about which materials to donate or which materials HOs are accepting. The minimum audience to be reached is the state's population. A 6-month campaign costs US$252,809.00 (Sinapro, 2017; Eboli, M.B., personal communication, November 7, 2019).

a.2.5) Costs during emergencies

During emergencies, costs associated with the provision of goods and services increase due to higher demand that is not matched by an equally rapid increase in supply, greater risks faced by carriers during transportation, and longer transit times (Spelic, 2018). We assume a 50% increase in costs for warehouse rentals, material purchases, and transportation under this condition.

However, an increase in costs does not necessarily translate into an increase in prices. During emergencies, government interference and societal pressure maintain prices at nonemergency levels (Reinsdorf et al., 2014). Given our operational focus, we do not consider price variations in our analysis.

b) Cost Values

To calculate cost values, we first identify which costs the ten policies incur and in which amounts. Then, we multiply the amounts by the unit cost as presented in the previous section. Table 2.14 presents a summary of the total policy costs. Below we describe which types of costs each policy incurs.

The **pre-positioning policy** incurs six types of costs. A warehouse rental is needed for the seasonal pre-positioning period (6 months) along with a warehouse manager (25%) and one-time office setup. The material to be pre-positioned is purchased according to the population coverage. Moreover, the cost of transportation includes the cost of the transport of material from suppliers to the warehouse at normal costs and the cost of transportation from the warehouse to the disaster-affected area at inflated costs. Finally, this policy enables the allocation of human resources to prioritize the distribution of HP material over NP material at a human resource cost of 2 FTE during the period of the disaster response.

The **acquisition policy** cost includes costs of purchasing material under high demand and costs of transportation from suppliers to the disaster-affected area at inflated costs.

The **coordination policy** cost involves the hiring of additional people. Human resources from different organizations are needed to plan and communicate joint actions of buying complementary materials as needed. For the São Luiz do Paraitinga disaster, we assume that 5 FTE (full-time equivalent) staff are needed throughout the disaster response (approximately 2 months).

The **human resources allocation policy** cost is also related to human resources. For the correct allocation of human resources, 2 FTE staff are needed during the period of the disaster response.

Both the **entry point control policy** and **storage space policy** costs are related to the warehouse: a rental period, a warehouse manager (100%) and one-time office setup. In both cases, the warehouse is only utilized during the disaster response (2 months).

The **donor education policy** incurs two costs. First, a contract is forged with an advertising agency that can create a statewide donor education campaign and implement it over the preparation period of 6 months. Second, two civil defense personnel (each at 20%) are needed to establish guidelines for the campaign and to steer discussions with the advertising agency.

The **admission control policy** cost is similar to the cost of donor education. The difference lies in the time period involved. Rather, the advertising campaign occurs only during the disaster response period, and the quantity of human resources is adjusted to four people (each at 50%) to enforce compliance with the admission control policy rules.

The **quantity of human resources policy** cost covers accommodation and food for volunteers throughout the disaster, training sessions for volunteers on how to adequately sort and efficiently distribute material, and two FTE staff coordinating the volunteers.

The **network expansion policy** cost includes the hiring of one staff member (50%) over 6 months to engage with the community and organize training sessions over the same time period.

Table 2.14: Types of Costs and Implementation Costs for Each Policy

Policy	Pre-position material	Material acquisition	Donor education	Coordination	Admission control	Entry point control	Storage space	Quantity of human resources	Network expansion	Human resource allocation
Types of costs	Warehouse manager	Material	Human resources	Human resources	Human resources	Warehouse manager	Warehouse manager	Human resources	Human resources	Human resources
	Warehouse rental	Transportation	Advertising campaign		Advertising campaign	Warehouse rental	Warehouse rental	Volunteers	Training	
	Office setup					Office setup	Office setup	Training		
	Material									
	Transportation									
Implementation costs (US$)	36,000.00	1,400.00	256,600.00	15,700.00	96,900.00	14,200.00	14,200.00	259,700.00	8,200.00	6,300.00

c) Policy Comparison

To compare different policies with respect to costs, we calculate the implementation costs of each policy. Although using a monetary indicator allows for an objective measurement, other factors make this comparison challenging. First, some of the costs considered above are discrete while others are continuous. Their appropriate comparison requires some assumptions. Fixed costs (warehouse rental and office setup costs) are calculated based on an integer number of units (warehouses), which is discontinuously influenced by the quantity of material to be stored. Additionally, two policy parameters are only computed in discrete form: network expansion (1, 1.5 or 2)[6] and human resource allocation (0 or 1)[7].

Second, the cost range for different policies may vary significantly. For instance, the human resource allocation policy costs up to US$6,300.00 whereas the donor education policy may cost up to US$256,600.00. Another difficulty concerns the minimum expenditures required to implement a policy (i.e., a cost threshold). For example, the entry point control policy requires at least one warehouse with an associated cost of US$14,200.00 to be implemented.

Before detailing the challenges associated with the above-listed factors, we consider a budget constraint. We assume that the same budget constraint for the implementation of any policy would allow us to compare policies on equal grounds.

Both value discreteness and value range pose several challenges when comparing the ten policies with a budget constraint. First, as some types of costs are only defined for discrete values, considering a budget that does not equal the cost for those specific parameter values results in an outcome with reduced (or no) meaning.

[6] Processing and distributing capacities increase by 50% with a network expansion value of 1.5 and by 100% with a network expansion value of 2.

[7] Human resources are allocated according to material proportions with the parameter set to 0; distribution is prioritized over processing with the parameter set to 1.

Second, as the relationship between policies' costs is nonlinear, comparing policies considering different budgets may result in an altered ranking of best policies during cost-benefit analysis. Third, when the cost range of policies does not overlap, there is no real parameter value for a given budget. Fourth, the minimum expenditure puts a lower limit on possible parameters for policy implementation. Rather, any values that translate into lower expenditures result in unfeasible policy implementation.

Additionally, the relationship between value parameters and costs is not always linear. For instance, increasing the budget to provide more donor education has a stronger impact on donor discernment while not many people are aware of appropriate material donation standards; once most people have been reached, the marginal cost of reaching outliers increases exponentially.

In acknowledging the evident difficulty of pursuing a cost-based comparison of policies, we realize that there is not one budget over which we could reasonably compare all ten policies. We can, though, compare policies according to the number of reduced response days in reference to the cost (US$/reduced days) each policy makes possible.

Depending on the available budget, some policies can be attempted and others cannot with varying benefits. Table 2.15 (columns 3 and 4) shows the possible minimum and maximum expenditures for each policy. The minimum amount is an estimate of the minimum infrastructure or effort necessary for the policy to be initiated. The maximum amount is the value at which an increase in budget would not increase the related parameter any longer. Estimating the maximum amount is not straightforward: 1) relationships between increases in budgets and parameters can be nonlinear; 2) the policy might be constrained by available warehouses or volunteers, which can be indefinitely increased by introducing assets or people from outside the disaster area; and 3) it might depend on the number of people affected.

Thus, we compare policies according to the number of reduced response days in reference to the cost (1000 US$/reduced days). Overall, policies that rank higher present low costs but also have less impact. Table 2.15 summarizes, for each policy, cost limits, the number of reduced days considering the parameters defined in Appendix 2.5, and the metric used to compare policies.

Table 2.15: Policy Cost Limitations and Comparison Metrics

Policy	Implementation cost (US$)	Min	Max	Reduced days	1000 US$/reduced day
Admission control	$ 96,900.00	$ 96,900.00	$ 96,900.00	34	2.85
Donor education	$ 256,600.00	$ 85,500.00	Nonlinear	27	9.50
Quantity of human resources	$ 259,700.00	$ 28,500.00	∞	26	9.99
Pre-positioning material	$ 36,000.00	$ 19,300.00	100% coverage	24	1.50
Network expansion	$ 8,200.00	$ 5,100.00	∞	24	0.34
Entry point control	$ 14,200.00	$ 14,200.00	Number of HR	15	0.95
Human resource allocation	$ 6,300.00	$ 6,300.00	$ 6,300.00	12	0.52
Storage space	$ 14,200.00	$ 14,200.00	Number of WHs	3	4.74
Material acquisition	$ 1,400.00	$ -	100% coverage	2	0.72
Coordination	$ 15,700.00	$ -	Nonlinear	1	15.73

d) Expanded Cost Analysis

The typical decision-making approach only takes into account costs for supplying or coordinating resources to having them delivered to beneficiaries, e.g., costs of procuring material, transporting material to the disaster site or training volunteers. However, this is a narrow view of policy implementation. A significant proportion of costs is only managed once beneficiaries' needs have been met: the costs of disposing of NP material and forwarding HP material. These costs are mostly underestimated (if not ignored) during the decision-making process.

They do, though, significantly impact the total policy implementation cost. As the policies impact different variables in the system and generate distinct behavior, material accumulated in HP and NP pipelines at the end of the response varies. This material must be disposed of or forwarded to organizations that can reuse it (where the remaining alternative would be to indefinitely store this material and incur the costs associated with this option).

The cost of disposing material can vary widely depending on the type of material and location involved. In Australia (Bainbridge and Timms, 2018), common donation disposal processes have been reported to cost US$217.00 per ton; during the 92-96 conflict in Bosnia-Herzegovina, costs were estimated at US$2,000.00 per ton; and after the 2004 tsunami, costs for drug disposal were estimated at US$5,229.00 per ton (Pharmaciens Sans Frontieres, 2005). To be conservative, we consider a cost of US$217.00 per ton.

The cost of forwarding material is more easily estimated for the Brazilian context. Material must be transported from the disaster-affected area to a location where it can be reused. In our case, this trajectory could run from São Luiz do Paraitinga to São Paulo, which could absorb and reuse leftover HP material. This results in a cost of US$20.65 per ton. We do not consider storage costs before transportation occurs, which results in a conservative analysis. Rather, leftover material costs are presumed to have an even greater impact on the total cost of policies.

Table 2.16 presents the quantity of material in material pipelines to be disposed of or forwarded for each policy and the associated cost of this leftover material.

The policies with the highest quantities of leftover material are the storage space, quantity of human resources, and donor education policies. For the latter two policies, quantities of leftover material are related to delays in the system. When efficient information flows can be implemented, less leftover material may result.

We also observe that two policies (donor education and admission control) incur high costs the first time they are implemented as a result of advertising campaigns. However, once the community has been made aware of the minimum standards for donations, further campaigns can be shorter and less extensive, significantly reducing policy costs.

While the metric used to compare policies favors the least expensive policies in the first analysis, in the expanded analysis the order is modified.

The best-performing policies identified in the robustness analysis (environmental features) are among the most efficient policies in terms of US$/reduced days: the pre-positioning (2.93), admission control (3.21), donor education (10.87), and quantity of human resources (13.13) policies.

Finally, in Figure 2.14 we plot the relationship between total costs and by how many days a response period can be reduced for the implementation of all policies. Admission control emerges as the policy with clearest benefits and with costs just slightly above average. The donor education and quality of HR policies also involve significantly fewer days of implementation, but at the expense of particularly high costs. In terms of lower costs, the pre-positioning and network expansion policies rank first followed by the entry point control, human resource allocation, storage space, material acquisition, and coordination policies, respectively.

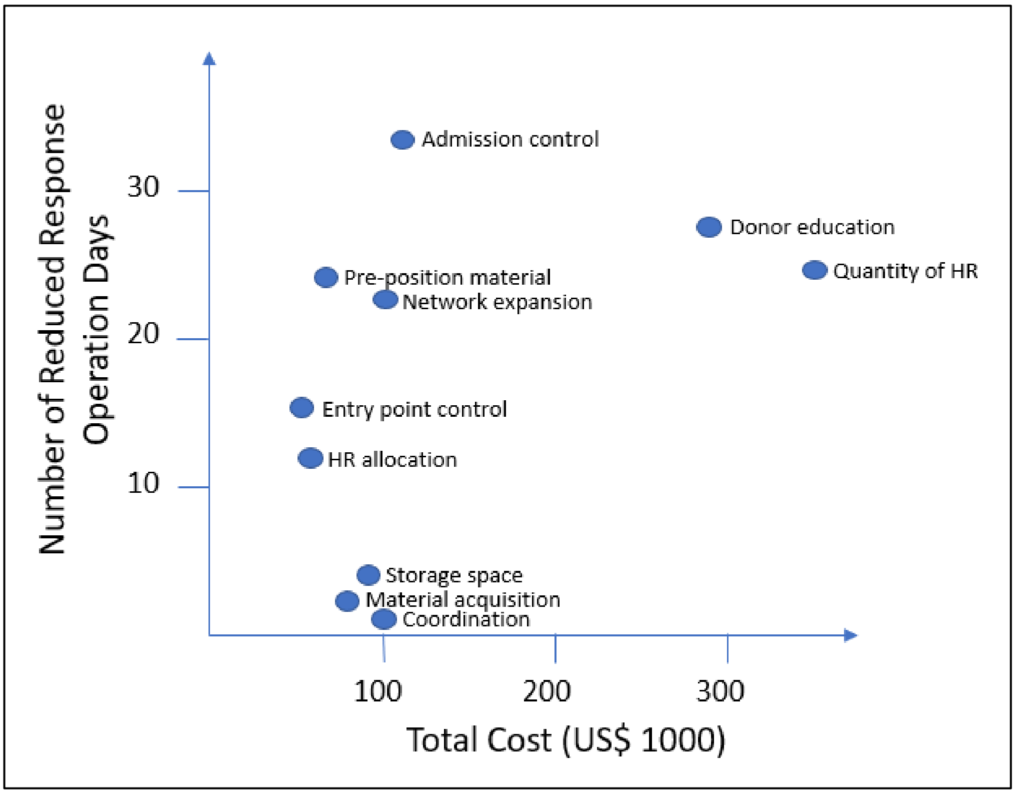

Figure 2.14: Relationships Between the Number of Fewer Response Operation Days and Total Cost.

Table 2.16: Summarized Policy Costs for Expanded Analysis

Policy	Implementation cost (US$)	Quantity of NP material (ton)	Quantity of HP material (ton)	Leftover material cost (US$)	Leftover impact on total costs	Total cost (US$)	1000 US$/reduced day
Quantity of human resources	$ 259,700.00	348	307	$ 81,800.00	24%	$ 341,500.00	$ 13.13
Donor education	$ 256,600.00	121	515	$ 37,000.00	13%	$ 293,500.00	$ 10.87
Admission control	$ 96,900.00	27	303	$ 12,100.00	11%	$ 109,000.00	$ 3.21
Coordination	$ 15,700.00	369	114	$ 82,400.00	84%	$ 98,100.00	$ 98.14
Network expansion	$ 8,200.00	392	232	$ 89,800.00	92%	$ 98,000.00	$ 4.08
Storage space	$ 14,200.00	328	362	$ 78,500.00	85%	$ 92,700.00	$ 30.92
Material acquisition	$ 1,400.00	375	127	$ 84,000.00	98%	$ 85,300.00	$ 42.68
Pre-positioning material	$ 36,000.00	121	383	$ 34,200.00	49%	$ 70,300.00	$ 2.93
Human resource allocation	$ 6,300.00	227	145	$ 52,300.00	89%	$ 58,600.00	$ 4.89
Entry point control	$ 14,200.00	125	476	$ 37,100.00	72%	$ 51,300.00	$ 3.42

Chapter 3 - Capacity-building in Humanitarian Organizations: Master Thesis Process

(with Carol Switzer)

Abstract

Humanitarian organizations face increasing challenges to assist beneficiaries as funding dwindles with economic recessions while needs increase, sparked by global warming and wars that also disrupt already fragile supply chains and increase costs. Building relief worker capacity is a powerful way to enhance the impact of organizations leading to more efficient and effective operations and countering environmental challenges. This study presents the instructional design process followed to develop learning activities to guide the students enrolled in the Master in Humanitarian Logistics and Management program to successfully deliver their master's theses. The output includes instructional materials for a set of nine tutorials, related assignments, and structured evaluation criteria. The summative evaluation shows that implementation of the thesis learning activities led to statistically significant higher graduation rates as well as an increase in the number of outstanding theses. The developed learning activities and materials provide methodological support and knowledge on research sub-processes for students to develop their theses using the deliberate practice approach, also allowing supervisors to invest their supervision time in content rather than in the explanation of academic rules. This significantly improves the quality of the research output on top of improving the work's presentation.

Keywords: capacity-building, humanitarian operations, master's degree, instructional design

3.1 Introduction

OCHA estimates that the need for humanitarian intervention will rise by 17% to 274 million people in need in 2022 from 235 million in 2021. Drivers for the rising need consist of an aggravating climate crisis affecting those most vulnerable and conflicts leading to a rise in extreme poverty (OCHA, 2021).

Humanitarian organizations (HOs) can only assist a portion of this increased need. In 2022, the target includes 183 million people (67% of people in need) at an estimated cost of USD 41 billion. In 2021, only 70% of the funds needed for the 174 million target population were provided (OCHA, 2021). As of 31 August 2022, approximately 31% of needed funding for the year has been received (similar to the 2021 status at that point), leaving a gap of USD 25 billion to cover the 2022 target population (ReliefWeb, 2022).

To cover the increasing need and maximize the impact of funds, HOs strive to improve their efficiency (Behl and Dutta, 2018; Scott, 2014; Audet, 2011). A range of strategies from process upgrading to increased local engagement and enhanced data analysis are employed in this quest. Permeating and laying the foundation for several of these strategies is the need to invest in capacity-building (OCHA, 2021; Kasprowicz et al., 2020; Breman et al., 2019; Gonçalves, 2011; Ferris, 2005). The European Commission alone is investing EUR 19.8 million in capacity-building in 2022 (ECHO, 2022).

In line with this goal, the Master in Humanitarian Logistics and Management (MASHLM) offered by Università della Svizzera italiana (USI) has been developed as a capacity-building program for humanitarian professionals (MASHLM, 2021). It provides graduates with practical and theoretical knowledge of managerial tools, providing them with technical and transversal skills and enhancing their leadership capability to improve their organizations' strategies and processes. It also improves career prospects and advancement.

The culminating academic experience of the master's program is the master's thesis that follows university standards and presents their research results. Students have struggled with various components of the thesis and in some cases do not finish it, therefore not receiving their master's degree. The difficulty in fulfilling academic requirements, such as organizing their work in well-defined chapters, distinguishing methods and their data sources, and aligning their work with the findings, also precludes students in elaborating high-quality work. It is crucial to emphasize that while students engage in specialized methodological courses and complete related project assignments before starting the thesis, they often struggle to apply this acquired knowledge when developing a thesis without a predefined research question and solution approach.

To help students navigate the thesis development, the authors developed a structured thesis process, consisting of instructional materials designed using the Dick, Carey, and Carey (2009) model. To the best of the authors' knowledge, this is a novel application of the model. A summative evaluation of the thesis process shows that cohorts that use it obtain higher graduation rates as well as higher average thesis grades.

This paper contributes to the humanitarian literature by presenting instructional materials that build the capacity of humanitarian professionals. It also adds to the literature on education and academic capacity filling a thesis development literature gap by providing methodological support and knowledge of research sub-processes to guide students in developing their theses using the deliberate practice approach.

The paper is organized as follows. The context section provides a capacity-building overview in the humanitarian sector and identifies gaps related to thesis development in the literature. The methods section introduces the Dick, Carey, and

Carey (2009) framework for creating instructional materials. The results section presents the MASHLM thesis process instructional materials and development steps. The conclusion reflects on the thesis process and touches upon some outcomes outside of the classroom.

3.2 Context

This section is divided into two parts: first, it introduces capacity-building in the humanitarian relief setting; second, it identifies the literature gaps related to thesis development materials.

3.2.1 Capacity-building in Humanitarian Relief

Simmons et al. (2011) analyze a range of capacity-building definitions and how they have been used interchangeably with capacity development. They identify three common features to these definitions: capacity-building is a process, it encompasses several domains such as characteristics, aspects, capabilities, or dimensions, and it specifies some motivation or a desired result.

Consistent with these features, the United Nations Office for Disaster Risk Reduction (2009) defines capacity development as "the process by which people, organizations, and society systematically stimulate and develop their capacities over time to achieve social and economic goals, including through improvement of knowledge, skills, systems, and institutions."

Vallejo and Wehn (2016) categorize capacity-building initiatives by process and expertise. Capacity-building projects may range from training and support to project management to multistakeholder engagement and dialogue (Ika and Donnelly, 2017).

Successful capacity-building initiatives consider the context, the people, and the needs (De Lannoy, 2022; Drain et al., 2017; Hagelsteen and Becker, 2013; Brinkerhoff and Morgan, 2010). In their eagerness for progress, HOs, at times, try to fit all problems into the same capacity-building framework and replicate it throughout the world or just replace rather than build local capacity (Iizuka, 2020; Eade, 2007). Even when well-designed, capacity-building initiatives are not always monitored after completion to assess their efficacy, since the allocated budget may not include the resources to do so (Vallejo and Wehn, 2016). It can also be difficult to correctly and completely evaluate capacity-building initiatives because quantitative and qualitative aspects are under consideration at individual, group, and organizational levels (Labin et al., 2012).

Finally, organizations face the tradeoff between investing in capacity-building or providing more immediate relief and recovery capacity. The ideal resource allocation leads to adequate short-term operational capacity and development (instead of erosion) of organizational capacity in the long term (Gonçalves, 2011).

3.2.2 Thesis Development

Extant literature covers several aspects of supporting thesis development. The main audience for this literature is students (Denscombe, 2019; Roberts and Hyatt, 2019; Bui, 2019, Bitchener, 2010). Roberts and Hyatt (2019) and Bitchener (2010) detail the chapter structure but do not dive into research questions or how to align the problem with the method and results. They approach the problem considering a completed work that only needs to be described in a thesis format. Bui (2019) takes it a step further by providing exercises to describe sections but also lacks the alignment of chapters and presents paragraph descriptions which might seem very rigid to some students. Denscombe's (2019) framework offers valuable insights on how to align the thesis components, but it lacks guidance on how students can engage in deliberate practice.

Ericsson's (2008) deliberate practice approach is an effective method for improving skills by focusing on repetition and receiving feedback. Incorporating deliberate practice into the framework would enhance students' ability to develop high quality theses.

Bitchener (2018) provides supervisors with guidance on how to direct students to overcome writing challenges (e.g., writer's block) and how to manage progress on their thesis. Other work addressing students also focuses on the same topics, with emphasis on academic writing (Murray, 2017; Single, 2010; Bolker, 1998).

Ibragimova et al. (2020) point out the shortcomings in methodological support for master's research such as hypothesis validity, connection with the subject of study, and use of a reliable method. This gap in written materials for guiding students in their thesis development process is supposed to be bridged by supervisors. Van der Marel et al. (2022) emphasize that supervisors usually share their knowledge of research sub-processes such as (1) formulating a research question, (2) searching for and using of theory, (3) developing the research design, and (4) gathering and analyzing data. Filippou et al. (2021) list many practices supervisors may adopt to support students, e.g., setting deadlines, showing what the process is like, and how to get materials. Nonetheless, supervisors' practices can differ dramatically even in the same institution (Filippou et al., 2021), and sharing knowledge of research sub-processes is a significantly time-intensive exercise if done properly (Van der Marel et al., 2022).

Thus, this paper presents the process of developing a structured set of instructional materials that share the knowledge of research sub-processes and provide methodological support for master's students to develop their theses with a deliberate practice approach. Much of this knowledge transfer can be organized for groups of students, therefore optimizing supervisors' time to focus on content instead of processes.

3.3 Methods

The instructional materials have been developed based on Dick, Carey and Carey's (2009) instructional design model (Figure 3.1), a highly-regarded standard, system-oriented approach in the industry. The model stands out for encompassing a large number of elements in a structured way, using several documents to keep track of the process, and providing validation and backward feedback among the various steps (Botturi, 2003). It surpasses classroom-oriented instructional design methods, such as ADDIE (IEEE, 2001), ASSURE (Heinich et al., 1993), and product-oriented methods like LOM (LTSC 2001). While alternative approaches offer unique perspectives on the Dick, Carey and Carey model, such as Smith and Ragan's (1993) focus on differentiating learning objectives and Greer's (1992) emphasis on project management, the original model effectively addresses the current needs.

The model consists of ten steps that assist the design of learning initiatives and are executed iteratively:

(1) **Identify instructional goal:** identify the higher-level goal for the instruction.

(2) **Conduct instructional analysis:** identify relevant steps for achieving a goal, subordinate skills, and entry point skills.

(3) **Analyze learners and contexts:** identify characteristics of learners and their context and explore how to utilize this information in the classroom.

(4) **Write performance objectives:** identify the action, the condition, and the result related to each step.

(5) **Develop assessment instruments:** identify types of tests and evaluation criteria and align them with instructional materials and desired learning outcomes in a logical manner.

(6) **Develop instructional strategy:** sequence and cluster content defining the learning components for each cluster.

(7) **Develop and select instructional materials:** create the materials that envelop and transmit the content and are aligned with the target learning outcomes.

(8) **Design and conduct formative evaluation of instruction:** test the materials, ideally with a subset of the target audience, to identify areas for improvement.

(9) **Revise instruction:** analyze data collected during the formative evaluation and implement changes.

(10) **Design and conduct summative evaluation:** compare the final form of the instruction with other similar forms of instruction in terms of learning outcomes.

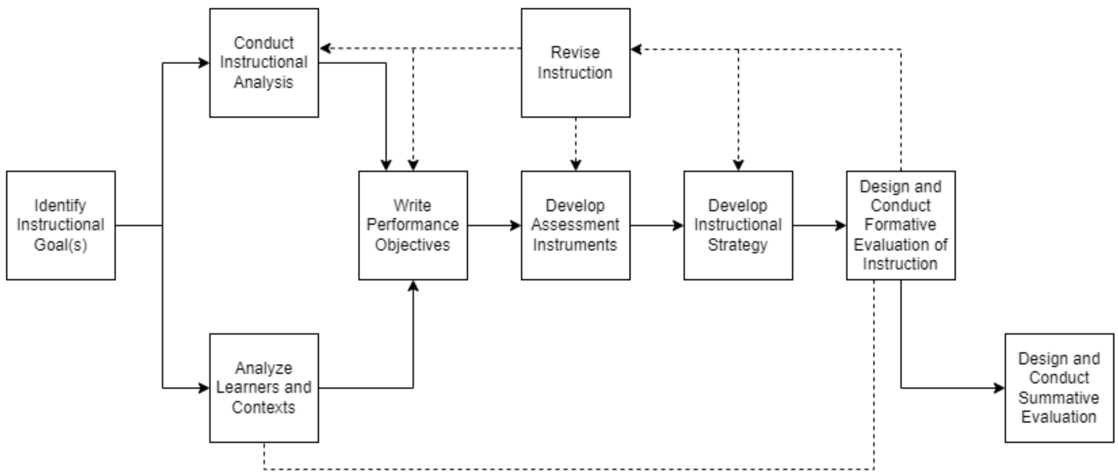

Figure 3.1: Instructional design model adapted from Dick, Carey and Carey (2009)

Records about student performance for MASHLM cohorts 1 through 10 (henceforth called MASHLM01 through MASHLM10) provided thesis grades and graduation rates. The authors also observed students in class and supervised a subset of students in their thesis effort for those in MASHLM08 onwards. Teachers' reports of interactions with students from MASHLM01 to MASHLM07 also offered insights into the student learning experience.

While the instructional materials were largely developed for MASHLM09, feedback from students was used to improve the materials used with MASHLM10. The Results section and the Appendices present the final version of the instructional materials.

3.4 Results

This section presents the materials developed according to each phase of the Dick, Carey and Carey (2009) instructional design model.

3.4.1 Identify instructional goal

Administrative regulations clearly identify the instructional goal. The master's program guidelines require that "the Master's student will develop a minimum 50-page essay applying a certain methodology or approach to the analysis of a given problem and arguing a reasonably original hypothesis" and that the thesis be "presented orally (viva examination) before a panel."

3.4.2 Conduct instructional analysis

Humanitarian topics are often not straightforward, and solutions may result in unintended consequences elsewhere. This complexity means that the instructional analysis needs to be applied to an intellectual skill domain with an ill-structured problem, i.e., the goal, nature, and data required for a solution are not clearly identified or available.

The skills and subordinate skills outline considers several entry-level skills. Students are interviewed before acceptance to the master's program to assess that their current job is related to the humanitarian logistics context and that they are motivated to take on a two-year study program. They must also present a bachelor’s diploma and show appropriate reasoning skills.

The 9 steps and subordinate skills required to perform the goal are presented in Figure 3.2 and Figure 3.3. As suggested by Dick et al. (2009), the steps and subordinate skills mapping is guided by the question of what students need to know to do the outlined steps.

For step 1 “Place different parts of information in the thesis sections,” students must understand that their work output has to be structured according to academic standards. Merton’s fragments (1987) allow them to describe problems aligned with what is expected of thesis chapters’ content where “establishing the phenomenon aligns with the introduction chapter, “specifying ignorance” aligns with the literature review chapter, and “using strategic research materials” aligns with the methodology chapter. Highlighting to students that they need to think about the methodology when choosing a problem helps keep them focused on a topic that they have information on instead of choosing a topic that might seem interesting but over which they have no data control.

Step 2 “define a context” is set by the students’ experiences and current jobs. Further, it is limited by the MASHLM courses as the thesis must cover at least one of the topics presented during the program.

Step 3 “articulate a research question” involves a number of subskills. Students should brainstorm different research questions which can be elicited from identifying challenges and opportunities in their environment and recognizing past thesis topics. Davis’s (1971) factors help students evaluate if their research question is interesting by engaging the audience’s attention, denying an old truth and adding to the story, providing utility, and stating the implications. Further, students are prompted to use logical categories (Davis, 1971) to practice articulating research questions. And, finally, they are presented with reasons to write a thesis in an effort to internalize their motivation to write the thesis.

In Step 4 “conduct a literature review,” students identify the article structure reinforcing their understanding of standard academic structure. They also learn how to use databases to find relevant articles and are then prompted to summarize articles using the standard structure so as to conduct the literature review.

In Step 5 “define and implement a research methodology and a data collection method,” students reinforce their understanding on how to use several methods to which they have been introduced in the mandatory methods classes of the master’s program. Students are not expected to master all methods after just a few classes, so this step extensively reviews the main methods, compares them to clarify their differences in terms of data collection and results, and presents examples to demonstrate how to select an appropriate methodology for a given research question. At the end of this step, students select the appropriate methodology for their thesis.

Step 6 “report on collected data and analyze the results” enables students to present their data in figures, tables, and graphs according to best practices. Detailed information on how to describe results for each method is presented in the specific methods classes.

In Step 7 “summarize research findings and how they contribute to society and academia,” students retrieve the original research question and answer it based on the thesis findings. They also look back at the literature review to fill the research gaps first identified.

Step 8 “cite and reference sources” enables students to use a reference manager and correctly cite sources. It also clarifies the process of paraphrasing.

Finally, in step 9 “present the thesis to an expert board,” students organize their presentation summarizing the thesis content, and get ready to present it to an expert board.

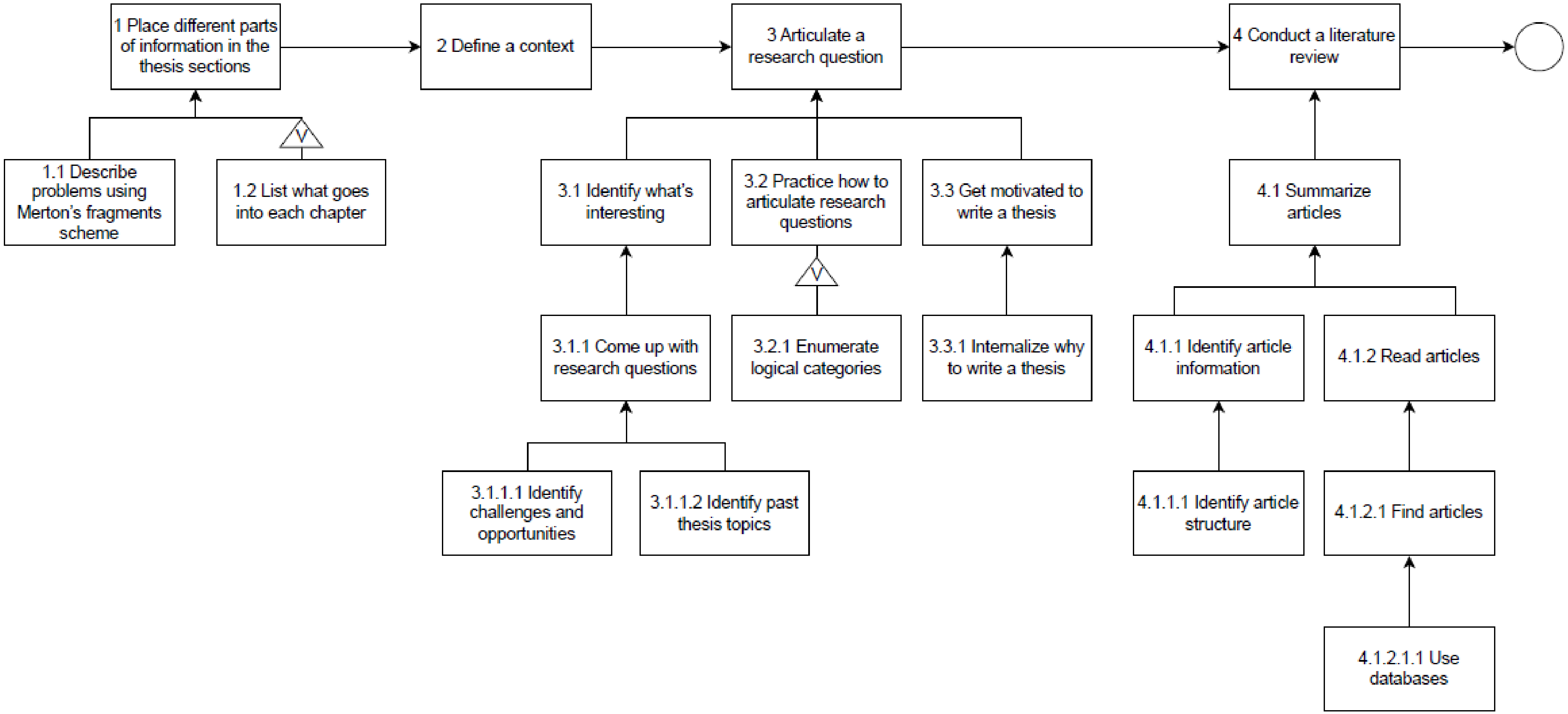

Figure 3.2: Instructional Analysis – Steps 1 through 4

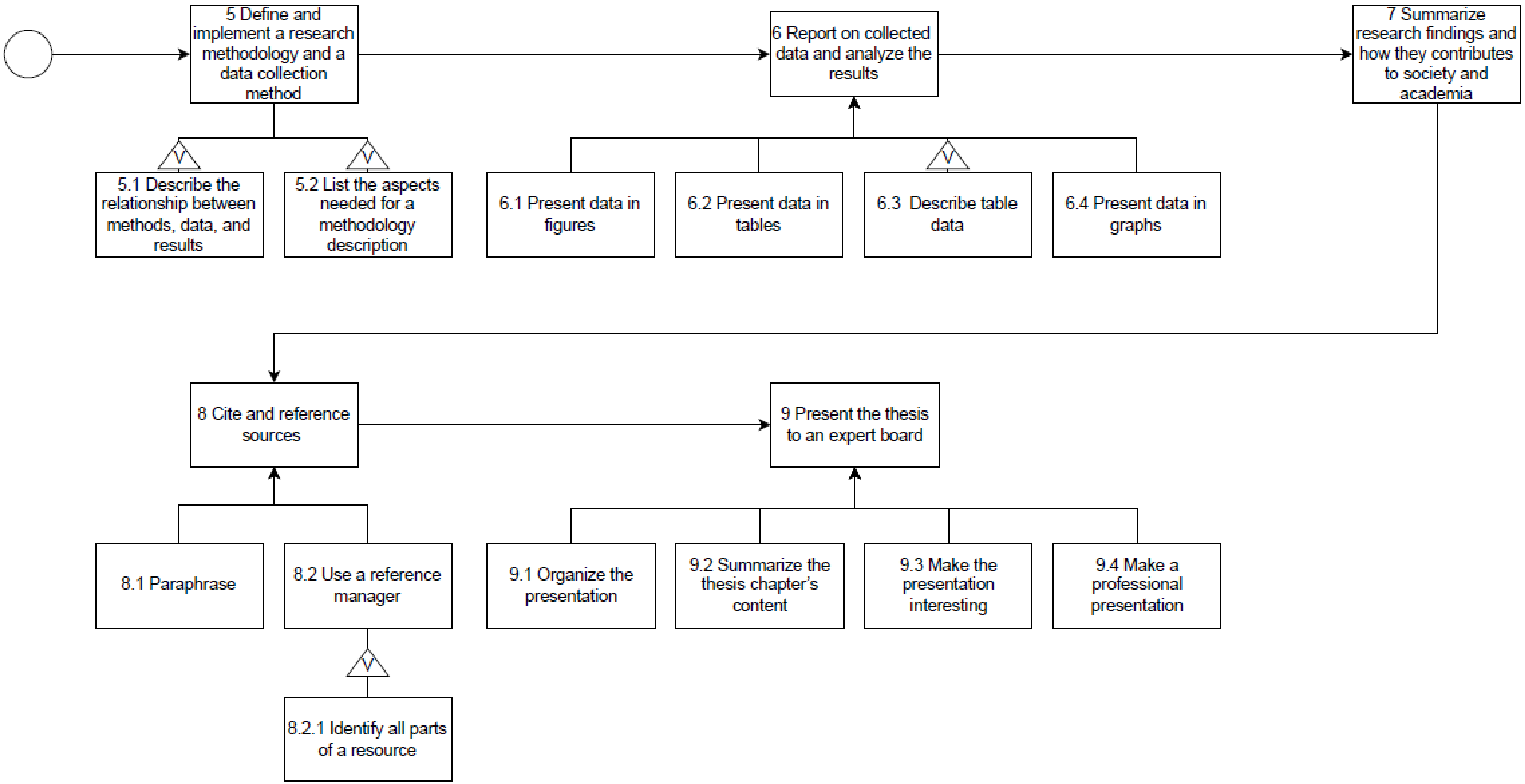

Figure 3.3: Instructional Analysis – Steps 5 through 9

3.4.3 Analyze learners and contexts

To develop materials that are aligned with student needs and experience, students and their individual contexts are taken into consideration.

Humanitarian professionals are usually drawn to the MASHLM program by word-of-mouth dissemination from alumni, and their general attitude toward the teaching organization is positive. Enrolled students are typically mid-level managers with at least five years of experience in humanitarian operations. Most come from developing countries in the Middle East and Africa, and English is their second language. The level of academic preparation can be highly diverse, with many students lacking high-quality teaching in their formative years. Thus, there is a need to provide extra teaching guidance, paced lectures, and a breakdown of complex steps for better understanding.

Students' work experience tends to be practically oriented and assumes group work. Writing a thesis, on the other hand, is an individual effort and demands knowledge of academic subtleties. This does not mean that students' theses are not useful in the field: students successfully design new processes, products, and more as part of their theses and often implement these in the field. They demonstrate their academic aptitude while providing an output that is useful to their employers and advances their careers.

3.4.4 Write performance objectives

Considering the necessary skills and the student's profile, the performance objectives for the thesis process are:

- Correctly place different parts of information in the appropriate thesis sections to present the work in a clear and organized manner.

- Define a context using concrete facts and numbers to establish the relevance of the thesis topic.
- Given the context, articulate a research question that, when answered, provides insights into the underlying problem.
- Conduct a literature review to accurately position the research in its field, considering the thesis boundaries.
- Define and implement a research methodology and data collection method that answer the research question within time and resource constraints.
- Given the data, report on data collected and analyze the results to answer the research question.
- Correctly cite and reference sources according to the referencing style required by the university to ensure academic validity.
- During the viva, present the thesis to an expert board for evaluation.

3.4.5 Develop assessment instruments

Assessment instruments include assignments in the form of practice tests, and post-tests. Directions for completing these tests are found in Appendix 3.1.

The first practice tests are:

- Assignment 0.1 Define the Context
- Assignment 0.2 Digging Deeper
- Assignment 0.3 Exploring Research Methods

Based on the deliberate practice approach, these practice tests guide students in preparing the introduction (Define the Context), literature review (Digging Deeper), and methodology chapters (Exploring Research Methods) on a smaller scale. It allows them to explore different topics without having to commit to a specific one. Further, students are still just beginning their master’s studies and are yet to learn about many methodologies, so this series sets them up to absorb this knowledge when presented. Practice test 0.1 is evaluated by completion; students receive individual feedback for practice tests 0.2 and 0.3.

Additional practice tests are:

- Assignment 1 Thesis Scope Sheet
- Assignment 2 Extended Chapter Outline

Assignments 1 and 2 require students to commit to a topic. In the Thesis Scope Sheet, students present the problem they would like to work on, its relevance, methods for data collection and analysis, and expected results. They receive extensive feedback on the alignment of all these parts. They are asked to resubmit Assignment 1 as needed, as it is critical for a successful thesis. The Extended Chapter Outline is a natural development with additional bullet points for each topic previously outlined. Assignment 2 is reviewed lightly, and students receive individual feedback.

The post-tests directly follow the structure of the thesis:

- Assignment 3 Introduction
- Assignment 4 Literature Review
- Assignment 5 Methodology
- Assignment 6 Results
- Assignment 7 Conclusion
- Assignment 8 Abstract
- Assignment 9 Executive Summary
- Assignment 10 Presentation

Assignments 3 through 10 guide the full development of the thesis parts and viva presentation. The evaluation criteria for the main thesis chapters are presented in Appendix 3.2 as checklists with weighted scoring by criteria. The scoring is normreferenced, i.e., it uses a group comparison method. The comparison is vis-à-vis the thesis output expected from an executive master's program, not to other students in the cohort. The individual thesis supervisor gives feedback on the development of Assignments 3 through 9 and the Results Chapter (for which there are no specific instructions as it naturally develops from the remainder of the thesis).

3.4.6 Develop instructional strategy

The instructional strategy considers the delivery system, content sequencing, and content clustering.

The organization strategy mandates that an instructor teach a group of students in a classroom, thus the main delivery system for the instructional materials follows the traditional model. In-person activities are set to occur during 10 sessions of 1 hour each. Thus, skills are developed according to a scheme of 10 tutorials. Table 3.1 and Table 3.2 present the learning components for each tutorial.

Additionally, a thesis supervisor is assigned to each student to closely guide them on their specific topic of interest as the budget permits it. Students are matched to supervisors whose research interests are aligned with the student's choice of research topic to provide an opportunity for following up with further research or a publication. This maximizes the motivation of the supervisor and the student.

Figure 3.4 outlines the assignment timeline in weeks starting from the Thesis Scope Sheet assignment as implemented for MASHLM10.

Table 3.1: Learning Components Part 1

LEARNING COMPONENTS		Tutorial									
		Research Question (1)	Thesis Process (2)	Literature review (3)	Article Summary (4)	Academic Writing (5)	Method Alignment (6)	Quantitative Methods & TSS Workshop (7)	Data Collection & Analysis (8)	Presentation (9)	Presentation practice (10)
Preinstructional activities	Gain attention and motivate learners	Start with something funny (e.g., a cartoon) to create a relaxing environment and have them laugh (class starts at 6pm after a full day of teaching). Ask about class expectations so as to align their hopes with the instruction and try to overcome psychological barriers (especially in methods focused classes 6 through 8)									
	Describe objectives	Set the agenda									
	Describe and promote recall of prerequisite skills	Focus on students' work environment	-	-	Tutorial 3	-	Methods classes	Methods classes, Tutorial 2	Methods classes	Tutorial 2	Tutorial 9
Content	Skills	3	1, 2	4, 4.1.2, 7	4.1.1, 8.2	6, 8.1	1, 5	5	5	9	-
Learner participation	Practice in class	Create and structure research questions	Identify Merton's fragments and Thesis content per chapter	Use references with a reference manager software	Summarize articles	Identify good description of elements and paraphrase	Identify Method's chapter elements and needed information	Provide feedback to one peer's TSS	-	-	Present once and provide feedback to one peer's presentation
Assessment	Pretest	-	-	-	-	-	-	Thesis Scope Sheet	-	-	-
	Posttest	Define the context		Digging deeper		Exploring research methods		Extended chapter outline Introduction Literature review	Methodology Results Conclusion Abstract Executive summary	Presentation	
	Feedback	-		Teacher's aggregated light feedback		Teacher's aggregated light feedback		TSS: peer feedback, teacher's individual feedback Chapters: supervisor feedback	Supervisor feedback	Peer feedback	
	Final Evaluation	-	-	-	-	-	-	Master's defense committee			

Table 3.2: Learning Components Part 2

LEARNING COMPONENTS		Tutorial									
		Research Question (1)	Thesis Process (2)	Literature review (3)	Article Summary (4)	Academic Writing (5)	Method Alignment (6)	Quantitative Methods & TSS Workshop (7)	Data Collection & Analysis (8)	Presentation (9)	Presentation practice (10)
Follow-through	Memory aids for retention	Assignment instructions with checklist, content slides at disposal									
	Transfer considerations	Every single possible time recall examples of their work environment									

MASHLM Thesis Timeline				Week																												
	Assignment	Start	Finish	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
0.1	Define the context	01/out	11/nov																													
0.2	Digging deeper	20/nov	31/dez																													
0.3	Exploring research meth	07/jan	27/fev																													
1	Thesis Scope Sheet	17/fev	14/mar	Thesis Scope Sheet																												
2	Extended Chapter Outlir	17/mar	30/mar					Ext Ch Outline																								
	Assigning supervisors	31/mar	06/abr																													
3	Introduction Chapter	07/abr	20/abr								Intro																					
4	Literature Review Chapte	21/abr	18/mai										Lit Review																			
5	Methodology Chapter	19/mai	15/jun														Methodology															
6	Results Chapter	16/jun	27/jul																		Results											
7	Conclusion Chapter	21/jul	10/ago																							Conclusion						
8	Final Thesis	02/ago	22/ago																									Final Thesis				
9	Exec Summary	23/ago	28/ago																												Ex Sum	
10	Presentation	23/ago	28/ago																												Pres	
	Defense	02/set	03/set																													DEFENSE

Figure 3.4: Thesis Gantt Chart

3.4.7 Develop and select instructional materials

The instructional materials developed for in-class instruction are presented in full in Appendix 3.3.

The materials were carefully developed to consider the motivational aspects and not overwhelm students with extra content. Further, materials were developed focusing on the deliberate approach so as to enable consistent practice and feedback. Tracking mechanisms were implemented so students can follow the class progress and be aware of how much they have already learned.

Special attention is given to immediately transferring methodological knowledge to the work environment setting of humanitarian operations. Examples and exercises aim to bridge the gap between theory and practice and make the tutorials clearly relevant to students.

3.4.8 Design and conduct formative evaluation of instruction

The thesis process was developed concurrent with MASHLM09 classes. This precluded the instructional designer to collect student feedback in three phases (one-to-one, small-group, and field trial). To ensure the quality of the overall process, materials, and assessments, the master's program director reviewed instructions and provided invaluable insights based on his extensive experience with previous theses and the target audience.

The instructional designer revised the instructional materials for MASHLM10 based on feedback from MASHLM09 students and from supervising students one-on-one, which deepened the instructional designer's understanding about the challenges and constraints students face when writing their thesis. The next section presents the changes made from MAHSLM09 to MASHLM10.

3.4.9 Revise instruction

The instructional materials were updated based on feedback from the experience of students, supervisors, and administrative staff during MASHLM09. Changes are as follows:

First, students still struggled to choose their thesis topic. This presented a problem in itself and hindered them from advancing to subsequent thesis assignments. Thus, the objective "to articulate a research question" was added, and, to support this objective, tutorial 2 "Thesis Process" was introduced. This tutorial presents a framework and examples of identifying a gap in research or need in an operative process and walks through examples of strategies for choosing a topic.

Second, students found it difficult to write adequate abstracts and executive summaries. Based on their questions, they wrestled with understanding the differences between the two. Thus, two assignments were created to differentiate them and detailed instructions with examples to further distinguish them.

Further, students were still choosing more qualitative than quantitative methods even though theses utilizing quantitative methods delivered higher quality theses. To nudge students to use quantitative methods, the first part of Tutorial 7 was changed to focus on quantitative methods.

Finally, the original assignment timeline added stress and did not improve quality as expected. MASHLM09 students were required to deliver a preliminary thesis chapter outline, a partial literature review, and a partial methodology chapter to keep them on track in between distant deadlines. As the expected effect was not observed, these intermediary deliveries were excluded from the final instructional materials.

3.4.10 Design and conduct summative evaluation

The summative evaluation compares outcomes between cohorts that experienced the thesis process, MASHLM09 and MASHLM10, and those that did not, MASHLM08 and earlier. Additionally, it shows how a “rescue operation” enabled some students from earlier cohorts to successfully finish their theses using the new thesis process. The evaluation outcome is based on two quantitative aspects: graduation rates and thesis grades. There was no lead time for additional expert judgment or field trials to conduct the summative evaluation.

From MASHLM01 to MASHLM08, students were given a rudimentary version of the thesis scope sheet, a chapter outline, and a rudimentary extended chapter outline. Although these were the basis for the thesis process, early cohorts did not benefit from the group-level tutorials delivered to the group, and the program director was burdened with managing the process alone, which presented a capacity problem. Many students could not handle mostly solo effort of developing their theses, resulting in many not defending their theses, thereby not completing the program and not earning their degree. Of course, other roadblocks exist as MASHLM students work full-time for humanitarian organizations (e.g., IOM, MSF, ICRC) and are often living or on mission in developing countries in conflict or disaster settings due to the nature of their work. Students did not complete their theses for reasons that ranged from losing family in conflicts to bombing of offices that prevented them from leaving the country to attend MASHLM classes. These factors understandably also affected their ability to pay for the program, which was still an issue in MASHLM09 but became a weaker factor for MASHLM10 students as the enrolment policy was changed to require advance payment.

A “rescue operation” was set up to recover as many MASHLM08 and earlier cohort students as possible for the two-fold effect of improving the completion ratio for the program and enhancing career prospects for students who had not completed the program. The operation was planned at a policy, institutional, and individual level. At a policy level, the university has strict rules about the maximum time a student can take to finish the degree (two years), after which they would no longer be eligible to complete any program in the faculty anywhere in Switzerland. A meeting with university leadership was called to lobby for an exception for MASHLM students since their profile differed significantly from the students that this particular policy targeted. Due to the extenuating circumstances surrounding many of the students' situations, the university agreed to grant an exception for MASHLM students to return to finish their degree, enrolling in an "additional" semester and joining the current cohort in the thesis process.

At an instructional level, "rescue" students were invited to attend classes and the corresponding tutorial sessions with the current MASHLM cohort. Due to financial and time constraints, many chose to follow the thesis process online. Once enrolled, they were included in the current cohort of students and monitored by the research group.

At an individual level, "rescue" students required additional supervision and monitoring to support them in finishing. Doctoral candidates played a key role in this process as the link between the official supervisor of record and the student, stepping in more closely than a supervisor would be able to do. This also provided experience to PhD students in supervision which "gives forward" placing them and their future students at an advantage. The administrative staff also supported students a great deal. The involvement of the entire staff, from administration, master's students, PhD students, to the professors created a strong and supportive team environment, which resulted in motivation for everyone to work towards the common goal of improved completion rates.

Thesis grades improved markedly after the thesis process was implemented (Figure 3.5). MASHLM10 delivered the highest cohort grade average at 8.70, and both

MASHLM09 and MASHLM10 produced a significantly higher number of outstanding theses with more than 35% of defended theses achieving grades nine or higher (out of a maximum of 10). Running a Welch's t-test on grades 9 or higher comparing cohorts 1 to 8 and 9 to 10, leads us to accept the alternative hypothesis that the means of the two populations are significantly different (test statistic 6.076 > critical t value 3.182).

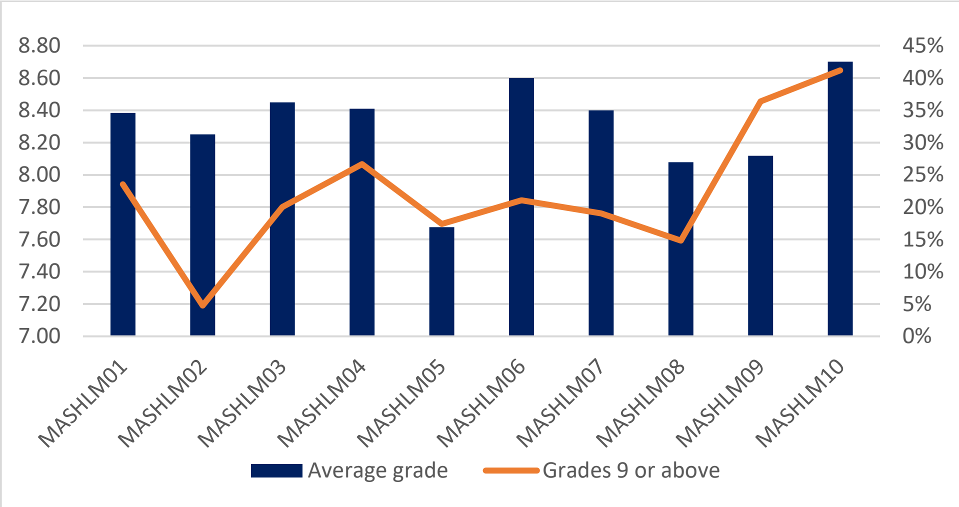

Figure 3.5: Thesis grades average and percentage above nine (out of 10) per cohort.

Further, Figure 3.6 shows that completion rates ranged from as low as 38% to 81% in cohorts MASHLM08 and earlier before the rescue operation and increased up to 91% for MASHLM09 after the thesis process implementation. The completion rates for MASHLM09 and MASHLM10 are the highest of the program without extra time extensions for students. The rescue operation was responsible for increasing the completion rates by 8.2% on average. Running a Welch's t-test on completion rates before the rescue operation comparing cohorts 1 to 8 and 9 to 10, leads us to accept the alternative hypothesis that the means of the two populations are significantly different (test statistic 5.813 > critical t value 2.306).

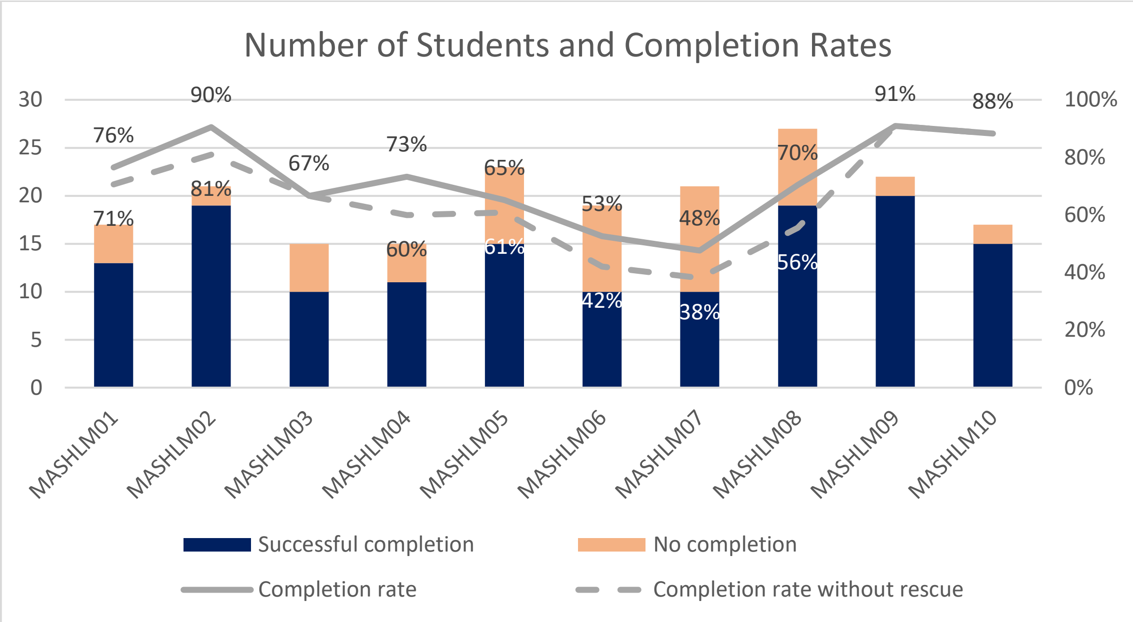

Figure 3.6: Number of students that completed the MASHLM program (with and without rescue operation) and completion rate per cohort.

3.5 Conclusion

This paper shows a novel application of the Dick, Carey, and Carey (2009) method to developing instructional materials for supporting students in their thesis development. It is especially well aligned with the humanitarian setting that emphasizes the need to consider the context, the people, and the needs (De Lannoy, 2022; Drain et al., 2017) in all phases of capacity building.

This paper, and the thesis process it describes, empowers supervisors (and saves them time) by providing instructional materials providing methodological support and knowledge of research sub-processes for students to develop quality theses using the deliberate practice approach, thus filling an important thesis development literature gap. It adds to the education literature by addressing supervisors, instead of students, and providing a framework to address all the important aspects of a thesis and how to ensure it is a coherent piece that answers the desired research question. It also expands the literature by providing concrete guidance aligning the methods' data collection and analysis with the overall research using the deliberate practice approach.

The thesis process effectively illustrates the method of deconstructing and organizing complex issues into discrete components for problem-solving. This comprehensive approach exemplifies the identification of a recurring challenge, such as subpar thesis quality, and presents a step-by-step solution. Such a skill is vital for relief workers operating in complex environments, as they need to discern patterns and execute systematic resolutions to these issues. One repetitive problem has been material convergence during disasters, and creating a training program based on the approach presented in this work could potentially provide a much more efficient solution to the problem (Fritz and Matthewson, 1957). Moreover, the method provides HOs with how to engage relief workers who have been away from academic settings for extended periods, often over 20 years – a typical scenario within the humanitarian context. Ultimately, grounded in the deliberate practice approach, the method demonstrates how consistent practice can enhance the abilities of humanitarian relief workers.

It is important mentioning that supervisors play an essential role in guiding students (Bazrafkan et al., 2019) and will continue to do so regardless of the best materials. With the thesis process though, supervisors are more capable of eliciting the best student work as they focus on the humanitarian content instead of spending time explaining academic rules, basic research methods, writing strategies, and general moral support in supervision sessions.

The instructional materials that were developed to assist students with their theses successfully built capacity in humanitarian professionals. MASHLM09 and MASHLM10 students who went through the thesis process achieved a higher graduation rate and presented more outstanding theses in comparison to earlier cohorts.

The latest cohort (MASHLM10) also achieved the highest average grade for all cohorts, and several students from earlier cohorts completed the master’s program with help of the “rescue operation” powered by the thesis process.

Examples of the outstanding research developed as part of a MASHLM thesis that directly impact the field with various levels of implementation include the following. Yao (2020) proposed the design of mobile laboratory technology to support early response to Ebola, measles, and COVID-19 epidemics in South Sudan. He also redesigned the process resulting in a turnaround time of eight hours instead of days. Ponweera (2018) used Lean Six Sigma to improve the Aga Kahn Foundation’s recruitment process in Afghanistan, decreasing the process time by 60% from 107 days to 42 days and controlling the variance of the process. Satary (2018) improved the ICRC transportation network of food items sent to Yemen and found that transportation and storage costs (reaching billions in expenditure) could be decreased by 30% in 2017 and 2018. Jones (2018) presented an optimized version of the light vehicle fleet of two major international humanitarian organizations resulting in a potential 6.2% cost savings. El Homsi (2020) calculated the net present value for different options of procuring and leasing real estate by a large HO in Lebanon. The best option halves the needed investment in acquired properties, while the current leasing strategy is more costly and does not return any assets.

The thesis process materials have been implemented in a structured and organized way using iCorsi, an eLearning platform for university courses. As a result, other master's programs at Università della Svizzera italiana (USI) have been able to adopt parts of the instructional materials, starting with the thesis scope sheet. However, the implementation of the entire process is not possible without a facilitator. While the thesis process has been successful in diverse contexts outside the humanitarian setting at

USI, some programs may struggle to relate to the examples provided and may prefer to incorporate more relevant domain examples into the materials. Ultimately, ongoing improvements to the process and its implementation are necessary.

Appendix 3.1: Assignment Instructions

a) Assignment 0.1: Define the Context

Describe what your organization or project is all about. The following question can guide you in this endeavor.

- What is the objective of your organization or project? Who are the beneficiaries and how does the organization or project support them?
- Make use of numbers. How many people were assisted in the last period? What was the volume of "things" you managed? What is your final target?
- What are your responsibilities? What is the scope of what you can achieve?
- What are the challenges? What are the opportunities?

Observation: if you are not currently in the field or you are new to your job, you may write about a project you worked on before and know very well.

Maximum 2 pages.

b) Assignment 0.2: Digging Deeper

To expand your knowledge on how a particular problem has been approached by other people and analyze it critically, it is necessary to search for studies related with the research question and structure the relevant information. State your research question (it is ok if this changes once you really begin your thesis) and search for 5 articles that approach this problem. Then, summarize the main information.

Insert the citation (Author, Year) using a reference manager (e.g., Mendeley, Zotero…). At the end of the assignment, insert the complete reference.

RESEARCH QUESTION:

ARTICLE 1

Title:
Citation:
Problem/Topic:
Main Idea:

Findings:
Data:
Method(s):

(Replicate scheme for 5 articles)

c) Assignment 0.3: Exploring Research Methods

Instructions:

1) Describe the context of your problem (max 1/2 page)
2) List a minimum of 5 methods that could be used to address your problem
3) Define the data needed for each method
4) State the expected results for each approach

CONTEXT:

#	METHOD	DATA	EXPECTED RESULTS
1			

(Replicate table for 5 methods)

d) Assignment 1: Thesis Scope Sheet

The scope sheet describes your proposed thesis subject, the research scope, the research question, and how you plan to answer your research question. This is an important first step in the thesis process and requires the approval of the HumanOps team and Program Director.

Your master's thesis is an opportunity to:

- put into practice theories and concepts learned in the program
- study a particular topic in depth
- show evidence of independent investigation
- show evidence of ability to plan and manage a project within deadlines

The table below outlines the information required for this scope sheet. Please complete the table answering all the questions posed. Be specific.

Title	• Working title ○ What is the topic of your research? Add the “place”; it may be an organization or a country (or both). Be specific (but not too long – max 12 words!)
Research question	• What problem(s) will the thesis address? ○ Try to concentrate on one or, maximum, two research questions
Thesis objective	• If the thesis is successful, what would happen differently? ○ Make sure your objectives lead to answering your research question(s).

Project Description	• What is the project all about?
	  ○ What is the current situation? Why is it not acceptable or how can it be improved?
	  ○ Who is involved? Where does it take place?
	  ○ What are the challenges and opportunities?

Methodology	• What method will be used to collect data?
	  ○ Some of the methods seen in class are: interviews, survey/questionnaire, observations, reports/academic literature.
	• What method will be used to analyze data?
	  ○ Focus on using one or two methods at most for a deeper understanding of the issue than a large variety of methods.
	  ○ Some of the methods seen in class are: optimization, system dynamics, risk analysis, project management, CPR/PERT, lean six sigma, statistics, scenario planning, strategic planning, focus group discussion, case study.

Data sources/types	• What type of data will be used? How will data be obtained?
	  ○ What are your sources? Do you have access?
	  ○ Will you collect the data or is it part of a process that, for example, your team carries out?
	  ○ Is the data quantitative, qualitative or both? Describe.
	  ○ What is the time span of the data?

Expected results	• Given the applied methodology, available data and set objectives, what are the expected results? ○ Reminder: you may propose a change in the system, but in general implementation should not be part of the thesis scope.

e) Assignment 2: Extended Chapter Outline

The table below describes each section of the thesis. For this assignment, expand your ideas from the thesis scope sheet into an outline of at least 10 to 12 pages, providing details that support your outline. Clearly, you cannot know what the results will be at this stage. Focus on the introduction, literature review and methodology chapters, with a brief overview of your expectations for the remaining chapters.

Please start your extended chapter outline after the table within the headings provided. Make sure to add the references using a reference manager.

	Description	Outline
1	**Introduction**	Introduces the main problem (context and background), its consequences and shortcomings of current managerial policies. The introduction advances the main questions that will be investigated and defines measurable goals, which will be achieved through the applied thesis.
2	**Literature Review**	Reviews previous relevant academic research that is useful to the thesis work. Depending on the topic, it can include references to manuals, guidelines, reports, documentations and policies from organizations.
3	**Methodology**	The methodology describes the data sources, data types and the methods. A clear distinction can be drawn between the method(s) used to collect data and the method(s) used to analyze data.
4	**Results and Analysis**	Describes the results obtained from data and methods used. These findings often include tables, graphs, charts, and sometimes quotations. It analyses the results' meaning and outcomes for the specific problem(s) and situation(s).
5	**Conclusion**	Discusses the managerial implications/consequences of the work and specific findings. Provides limitations to the work (scope, areas of application, etc.) Describes the contribution of the thesis and recommendations based on the analysis. Suggests future research.
6	**References / Bibliography**	List of references used, please apply the Harvard citation style: See http://guides.is.uwa.edu.au/harvard for an introduction and follow the MASHLM Thesis guidelines.
7	**Appendix**	Additional materials developed (survey description, mathematical derivations, simulation models, datasets, interview protocols, additional results (not included in the thesis scope), etc.

1. **Introduction**
   4 to 5 bullets describing major topics in this chapter.
   4 or 5 bullets of subtopics for each major topic. For example:
   Problem context and background
      Description of the problem
      Description of the context
   Current managerial policies and shortcomings
      Managerial policy 1: description, challenges and results
      Managerial policy 2: …
   Main questions investigated
      Question 1: motivation for the question
      Question 2: …
   Definition measurable goals achieved
      Definition of Measurable goal 1
      Details about measurement
      …
2. **Literature Review**
   Definitions and theory on the topic
   Articles (reports, theses…) addressing the same topic
   Articles (reports, theses…) using the same methodology
   Shortcomings of this material
   What gap will be addressed in your thesis

3. **Methodology**
   Data collection method
      Description of the method
      Justification for using the method
      Expected data obtained
   Data analysis method
      Description of the method
      Justification for using the method
      Expected results

4. **Results and Analysis**
   Expected outcomes (hypothesis)

5. **Conclusion**
   Managerial implications
   Limitations

6. **References / Bibliography**

7. **Appendix**

f) Assignment 3: Introduction

The introduction section of your thesis provides a quick trip through your whole project. It presents the main questions that will be investigated and defines measurable goals, which will be achieved through the applied thesis. It is important that you understand that your thesis *can* be explained in a short form, without all the depth that you will provide later in the paper. Your introduction is an opportunity for you to come to a much better understanding of what you are trying to say.

A good introduction responds to the needs of the reader, rather than the demands of the material. The reader shouldn't have to wait to hear your guiding problem until they have the full context to that problem. You have to find a way of giving them the big picture before the deep context.

Use the structure below to write an introduction:

Context

- state the general topic and give background
    - what your reader needs to know to understand the problem
- outline the current situation
- evaluate the current situation (advantages/ disadvantages) and identify the gap

Problem and significance

- identify the importance of the proposed research - how does it address the gap?
- state the research problem/ questions
- state the research aims and/or research objectives
- state the hypotheses

Response

1. outline the methodology used
2. outline the order of information in the thesis – a roadmap

Maximum 2500 words.

g) Assignment 4: Literature Review

The literature review helps to position your work, demonstrating to the reader what is known on the subject (can reference your context, methodology, or underlying question), what are the gaps, and what your work adds or why it is necessary. It consists of a critical analysis of published sources, or literature, on your thesis topic. It is an assessment of the literature and provides a summary, classification, comparison and evaluation.

Follow these steps to write your literature review:

- Define the subject you are interested in (research question)
- Make a preliminary analysis of the literature
- Gather the information
    - Which database? What types of documents? Which keywords?
    - Limitations: Time frame
    - Process: review of abstracts, review of full papers, snowball method

- Outcome: a collection of references (articles and books!) on which you will base your thesis.

When you write your Literature Review, summarize articles in your own words with an in-text citation to the source. Identify elements of the article that are relevant to your topic, describe them, explain how it is related, and how you intend to use this, or what you can do beyond what your source has done.

Refer back to the Literature Review Tutorial for detailed guidance on how to conduct your literature review.

Minimum 2500 words.

Add your literature review to the file you have already started for the Introduction and check the percentage of similarity on **Turnitin**. If the overall percentage is higher than 10%, review the Turnitin report to see where your text needs to be rewritten. This is mainly an independent exercise, i.e., you are responsible for this work on your own, however, if you have difficulty, discuss the Turnitin report with your supervisor.

h) Assignment 5: Methodology

The methodology section of a research paper answers two main questions:

1. How was the data collected or generated?
2. Which methodology was used to analyze it?

In writing the methodology chapter, explain the methodology you are using and *why* you chose it. Your reader needs to know the method you used to get your data because it effects your findings, and how you interpret your findings. It can be helpful to think of this piece as a "manual" – write so that someone can pick up your paper and do the same work you have done. Be direct and precise.

Your methodology is crucial to the quality of your research. It is important that the methodology is appropriate and your reasons for selecting it are clear. You should follow accepted practices; there is no need to re-invent a method. Your literature review can help you determine the method to use.

Work closely with your supervisor on your methodology chapter, as s/he has valuable experience in working through research questions using best practices and appropriate methodologies.

Do not wait to contact your supervisor until the deadline. Get in touch with them early on to be sure you are on the right path. At the deadline, your methodology chapter should be complete, and you can go straight into the analysis and results section.

Refer back to the Tutorial on Methods for tips on what to include and what not to include.

Add your methodology chapter to your draft thesis working document, with what you have written so far: your introduction, literature review, and references. At any point now, you can begin using the Thesis template according to the style guidelines (in iCorsi).

i) Assignment 7: Conclusion

The conclusion summarizes your work. To evaluate if they want to read a work, scholars first check the introduction (where you proposed a relevant problem) and then the conclusion (where it is clear what you achieved). There are no new analyses in the conclusion, but you can discuss the most relevant aspects of your results.

A conclusion includes:

- A summary of your work
- Resuming the research question and explicitly answering it
- The practical and/or academic contributions of your work (check the last part of your literature review where you addressed the research gaps)
- Limitations
- Future research

j) Assignment 8: Abstract

An abstract is a short statement (max 250 words) that describes your thesis, including the scope, purpose, results, and contents of your work. It is neutral statement with no evaluation or assessment of the work. It contains key words from the thesis, however it is not an exact copy of part of the thesis.

An abstract includes:

- The importance of your research
- A clear problem statement
- The main claim you are making (include scope)
- Type of method or evidence used
- Results
- Implications; have you added to the body of knowledge on your subject?

What not to do

- Copy paste from your thesis
- Reference other work
- Define terms

Keywords

After the text, add 3 to 6 keywords to the abstract page. These keywords are used to categorize work, in search engines they are used to identify relevant work, etc. Make sure one of the words refers to the topic of the thesis and another to the data analysis method. One keyword does not necessarily mean 1 word. E.g., “material convergence, system dynamics” are 4 words, but only 2 keywords.

k) Assignment 9: Executive Summary

The executive summary is a separate stand-alone overview of your thesis that summarizes key points for your readers, permitting them to quickly understand your study's overall content. You write the executive summary last since it needs to capture all the elements of your study. Executive summaries are typically used in business environments and are not academic in nature. Think of it as a pitch, where you are proposing your work to an organization as a solution to a specific problem. Keep it simple. Keep it short, 2-3 pages. Your language should be less academic and more powerful than your master’s thesis, which is why this is kept separate from the thesis.

Difference between the executive summary and the abstract
Both summarize the contents of a research study, however, the abstract is much shorter, is part of the academic study (used for reference purposes), and does not include recommendations due to its academic nature.

The audience
Your executive summary will be printed and given to the thesis defense committee for their reference during the defense. A well-written executive summary will help them understand your work and where to go to find more detailed information.

Your executive summary could also be made available on the MASHLM website to share with our network.

An executive summary includes:

- An opening statement, with brief background information
- The purpose of research study
- Your research method and analysis (briefly)
    - Include where you got your data and the method you used for gathering it
- Overview of findings
- A description of each recommendation accompanied by a justification.

What not to do:

- Copy paste sections of your thesis
- Copy your abstract
- Make the executive summary an outline of your thesis
- Spend too little time on the results and recommendations

l) Assignment 10: Presentation

The thesis defence is an academic oral examination and you need to demonstrate your unique research and results to the professors to show that you have applied concepts learned during your studies. There is no template for the presentation; it is open for you to decide on the structure. There is no limit to the number of slides, however, you must complete your presentation in 15 minutes. The presentation is an opportunity for you to explain your research and how it contributes to academic literature or how it adds value to a particular problem in the field.

A common error in the defence is to spend too much time on the background description of the project – this is easy to do since projects are often very interesting. However, the defence committee has read your thesis already so there is no need to go into detail on background info; it is better to spend most of your time on your results and recommendations.

Things to keep in mind:

- The first slide should contain the information indicated on iCorsi – this is important for our records and archive
- Focus on results, implications, and recommendations
- Tie in the academic aspect (briefly) by stating your research question and whether your study confirmed or contradicted it
- Tell a story – why you picked your topic, why you chose the methodology you used, and what you learned
- Use your time wisely – your time is limited and you risk cutting off your presentation if you spend too much time on background.
- Keep your slides simple with as little text as possible; use images to help relay your message.
- Practice delivering your presentation – do not read from your slides, remember what you want to say, do not go too fast or too slowly, modulate your voice
- Speak clearly and directly to the professors about your research, watch their reaction to be sure they understand you, pause between points

Appendix 3.2: Evaluation Criteria

a) Introduction Chapter

INTRODUCTION CHAPTER: EVALUATION CRITERIA		Score 0-10	Comments
Context			
Oultines the current situation	10%		
Evaluates the current situation	20%		
Identifies the gap	10%		
Problem and relevance			
Identifies the importance of the research - how well does it address the gap?	20%		
States the research question(s)	20%		
States the thesis aims and/or objectives	10%		
Thesis overview			
Identifies used methodology	5%		
Outlines thesis chapters	5%		
Final Grade	100%	0	

b) Literature Review Chapter

LITERATURE REVIEW CHAPTER: EVALUATION CRITERIA		Score 0-10	Comments
Theory			
Defines relevant terms	10%		
Identify the proper literature stream	20%		
Describes references that addresses the topic	10%		
Describes publication that addresses the selected methodology	20%		
Benchmarking			
Explores how other authors addressed similar problems	10%		
Identify contribution relative to prior work	10%		
Gap identification			
Identifies the literature gap(s)	20%		
Final Grade	100%	0	

c) Methodology Chapter

METHODOLOGY CHAPTER: EVALUATION CRITERIA		Score 0-10	Comments
Data Collection Method			
Clearly identifies method used to collect data, e.g., interviews, survey/questionnaire, observations, reports/academic literature, data mining	10%		
Explains why this data collection method was chosen	10%		
Thoroughly describes data collection process: •Describes type of data •Includes a sample of data collection tool (if applicable) •Presents relevant and well-written questions (if applicable: interview, survey) •Identifies the data source, and how access was obtained •Describes who collected the data and how, e.g., individually or in teams •Names the timeframe to which the data refers	10%		
Data Analysis Method			
Clearly identifies method used to analyze data, e.g., optimization, system dynamics, risk analysis, project management, CPR/PERT, lean six sigma, statistics, scenario planning, strategic planning, focus group discussion, case study	10%		
Explains why this analytical method was chosen	10%		
Explains what part of the collected data will serve as input for each stage of the analysis method	10%		
Articulates expected results	10%		
Overall Assessment of Research Methodology			
Appropriateness of data collection method for the research question	10%		
Suitability of the analytical method with respect to the research question	10%		
Overall clarity of the methodology presented	10%		
Final Grade	100%	-	

d) Results Chapter

RESULTS CHAPTER: EVALUATION CRITERIA		Score 0-10	Comments
Data			
Clearly and appropriately presents data (tables/charts/description)	10%		
Uses descriptive statistics correctly (Mean, Media, Max, Min...) (if relevant)	10%		
Provides narrative description of data showing relevance to research questions	10%		
Analysis			
Conducts an analysis that corresponds to data collected and described	10%		
Follows through on stated methodology accurately	10%		
Clearly presents results from analysis	20%		
Consistency of Recommendations			
Develops recommendations that answer the research questions	20%		
Ties recommendations to results of analyses (not on general knowledge of topic)	10%		
Final Grade	100%	-	

e) Conclusion Chapter

CONCLUSION CHAPTER: EVALUATION CRITERIA		Score 0-10	Comments
Opening			
Summarizes main points of the thesis	20%		
Restates the research question and explicitly answers it	20%		
Synthesizes implications of the research	10%		
Significance of the Research			
Describes practical contributions, if any	10%		
Discusses academic contributions, e.g., gaps identified in the Lit Review	20%		
Ending			
Identifies limitations of the research	10%		
Explores potential for future research	10%		
Final Grade	100%	0	

Appendix 3.3: Instructional Materials

a) Tutorial 1: Research Question

Tutorial 1: Research Question

1

MASHLM - TUTORIAL 1 2

2

Agenda

- Why write a thesis?
- Research questions from topics
- Research questions from logical categories
- That's interesting!
- How many research questions?
- Tips
- References

MASHLM - TUTORIAL 1 3

3

Why write a thesis?

- A proposition
  - solve a problem
  - increase organizational capacity
  - reduce organizational costs
- An opportunity
  - study something interesting
  - apply what you have learned
  - develop skills
- A test
  - to earn the Master of Advanced Studies MAS degree
  - to get a promotion
- ...

Image: HLM09 graduation September 2018

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4

Challenges and Opportunities

- What are the C/O in your **work environment**?
- What are C/O of **humanitarian operations in general**?

Come up with at least 5 ideas!

5

Research Topics from previous years

Business plan

Predicting Violence through Social Media

Uses and barriers to ICT systems

Staff turnover

Fundraising

Cash Based Transfer

Gender equality of workers

International Staff Recruitment

Organizational management

Communication, complaint handling and feedback as success factors

Leadership effect in hostage negotiation

Type of information and learning styles

Partnership

Transition from response to recovery

Scenario evaluation for Disarmament, Demobilisation and Reintegration

Generating Innovation

6

Research Topics from previous years

Cost structure and evolution

Assessment of a vaccine supply chain

Improving waste management

Civil-Military collaboration

Assessment of the supply chain

TB drugs

Centralized-decentralized decision analysis

Outsourcing 3PL

Supply chain management

Processes in Humanitarian organizations

Procurement process design

Inventory and transportation of war kits

Delays in Customs Clearance

Relationship between training and performance

E-procurement

Public policy for the supply chain of potato

Corruption as waste in process

Standards Compliance

Construction and hygiene products

Humanitarian Supply Chain Risk

7

Research Topics from previous years

Transportation of food items

Distribution methods

Pre-position of non-food items in global warehouses

Proposition of a new warehouse

Health supplies

Operations cost

Transportation and Infrastructure

Air transport

Light Vehicle Fleet Profile

Efficiency of passengers transport

Road safety training

Food distribution in landlocked countries

Relief Commodity distribution

Reverse logistics of tires

Planning a mitigation project

Organization policy

8

Research Topics from previous years

Missing people after several years after a disaster
Special Needs Education
Disease Prevention
Dead body management
Maternal Care
Policy Design for HIV/AIDS Programs
Avian Flu
Security and resilience
Impact of education program
Return to original country
Personal Protective Equipment for Ebola
Drone Delivery of Medical Aid
Drought Preparedness & Response
Health financing mechanisms
Reasons to migrate
Indigenous knowledge for sustainable food production
Immunization Activities
Integration in new community
Vulnerable population
Adaption Techniques
Strategies to minimize the effects of climate change
Artificial insemination in Cattle
Psychosocial support of IDP and local victims
Factors that affect the decision to relocate population for DRR
Family Planning

Social aspects & others

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Challenges and Opportunities

- What are the C/O in your **work environment**?
- What are C/O of **humanitarian operations in general**?

Can you add more ideas?

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Research questions from topics

- Begin with **Why** or **How**
  - Process
  - Causality

Transform 2 topics into research questions!

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Logical categories

A. Single Phenomenon

i. Organization: Organized <--> Disorganized or Structured <--> Unstructured
ii. Composition: Single <--> Multiple or Simple <--> Complex
iii. Abstraction: Individual <--> Holistic or Atomistic <--> Collectivistic
iv. Generalization: Local <--> General or Specific <--> Broad
v. Stabilization: Stable <--> Changing or Unchanging <--> Dynamic
vi. Function: Ineffective <--> Effective or Manifest <--> Latent
vii. Evaluation: Good <--> Bad or Relative <--> Absolute

B. Multiple Phenomena

i. Co-Relation: Unrelated <--> Correlated or Independent <--> Interdependent
ii. Co-Existence: Co-Exist <--> Do Not Co-Exist or Compatible <--> Incompatible
iii. Co-Variation: Positive <--> Negative or Linear <--> Non-linear
iv. Opposition: Similar <--> Opposite or Same <--> Different
v. Causation: Dependent <--> Independent or Cause <--> Effect

Source: Davis (1971), Chris Rider slides (2019)

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Research questions from logical categories

What seems to be…		… is in reality…	
	organized		disorganized
	ineffective		effective
	local		general
	unstable		stable
	dependent		independent

Think of something that could be described like this!

- Begin with **Why** or **How**

Transform it into a research question!

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That's interesting!

- **Engages the attention** of the audience
- Denies an old truth and **adds to the story**
- Provides **utility**
- What are the **implications**?
  - Generalizability
  - New horizons for humanitarian operations
  - New ways of making business

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Agenda

- Why write a thesis?
- Research questions from topics
- Research questions from logical categories
- That's interesting!
- How many research questions?
- Tips
- References

15

How many research questions?

Only 1 (max 2!)

Factors to consider:
Time limitation, thesis scope, clarity, in-depth vs. shallow analysis, …

Image: Malat-webspace.royalroads.ca (2019)

16

Tips to come up with research questions

Create a word file or get a notebook

Keep it open during classes / work time

Write down every idea

Write down everything that annoys you

Only select an idea at the very end

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References

Lave, C. A. & J. G. March. 1993(1975). "An introduction to speculation." Chapter 2 in *An Introduction to Models in the Social Sciences*. New York: University Press of America.

Davis, M. S. (1971). "That's Interesting!: Towards a Phenomenology of Sociology and a Sociology of Phenomenology." *Philosophy of the Social Sciences*, 1(2): 309–344. [*Read pp. 309-326*]

Makadok, R., R. Burton & J. Barney. (2018). "A practical guide for making theory contributions in strategic management." *Strategic Management Journal*, 39: 1530–1545. [*Read pp. 1530-1539*]

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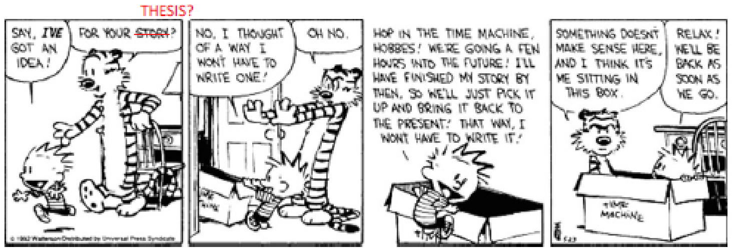
b) Tutorial 2: Thesis Process

Tutorial 2: Thesis Process

1



MASHLM - TUTORIAL 2 2

2

Agenda

- Merton's fragments
- Example
- Try it yourself!

- Thesis structure
- Examples

- Thesis Process
- Assignment 1

3

Merton's fragments

- Establishing the phenomenon
  - Establish that the phenomenon actually exists, that it is enough of a regularity to require and to allow explanation.
- Specifying ignorance
  - The express recognition of what is not yet known but needs to be known in order to lay the foundation for more knowledge; no vague admissions of ultimate ignorance.
- Using strategic research materials
  - The material that exhibits the phenomena to be explained or interpreted to such advantage and in such accessible form that it enables the fruitful investigation of previously stubborn problems.

4

Example: Kamara's thesis

- Establishing the phenomenon
  - Evidence that delays in the clearing process at the freeport of Monrovia negatively impact business.
  - Validation using the questionnaire.
- Specifying ignorance
  - There are many reasons for delays, each case is different
- Using strategic research materials
  - Conducting a desk review for generic knowledge
  - Conducting interviews for in-depth knowledge of the specific case
  - Developing the questionnaire with feedback from the supervisor
  - Knowing the population, calculating the sample size
  - Testing the questionnaire for validity and reliability
  - Distributing the questionnaire

5

Try it yourself!

- Research question: ....

- Establishing the phenomenon
- Specifying ignorance
- Using strategic research materials

6

Agenda

- Merton's fragments
- Example
- Try it yourself!

- Thesis structure
- Examples

- Thesis Process
- Assignment 1

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Thesis structure

Abstract	✓ Big picture of the thesis
Introduction	Establishing the phenomenon
Literature Review	Specifying ignorance
Methodology	Using strategic research materials
Results	✓ Presents results generated from the study
Conclusion	✓ Summary + what the authors infer from their research
References	✓ Bibliography; list of cited works

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Example: Satary's thesis

- Introduction
- Literature Review
- Methodology
- Results
- Conclusion

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9

Example: Tahmasbi's thesis

- Introduction
- Literature Review
- Methodology
- Results
- Conclusion

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10

Slides 9 and 10: presentation of shortened and edited excerpts (approximately 10 pages) of Satary's and Tahmasbi's theses.

Agenda

- Merton's fragments
- Example
- Try it yourself!

- Thesis structure
- Examples

- Thesis Process
- Assignment 1

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11

Thesis Process

Deadlines

Tutorial schedule

Extra activities (H5P)

Pre-thesis assignments, feedback

Supervisor

iCorsi

Turnitin – Plagiarism

Grades

Conditions to schedule a defense (coursework...)

Conditions to extend the deadline

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12

References

Merton, R. K. (1987). "Three Fragments From a Sociologist's Notebooks: Establishing the Phenomenon, Specified Ignorance, and Strategic Research Materials." *Annual Review of Sociology*, 13(1): 1-29.

Tahmasbi, D. G. (2016). "Health financing mechanisms for refugees in the urban context. A case study of UNHCR insurance project for refugees residing in Iran." Master Thesis, Università della Svizzera italiana.

Satary, R. (2018). "Optimization of Transport Network of Food Supplies for International Committee of the Red Cross (ICRC), Yemen Delegation." Master Thesis, Università della Svizzera italiana.

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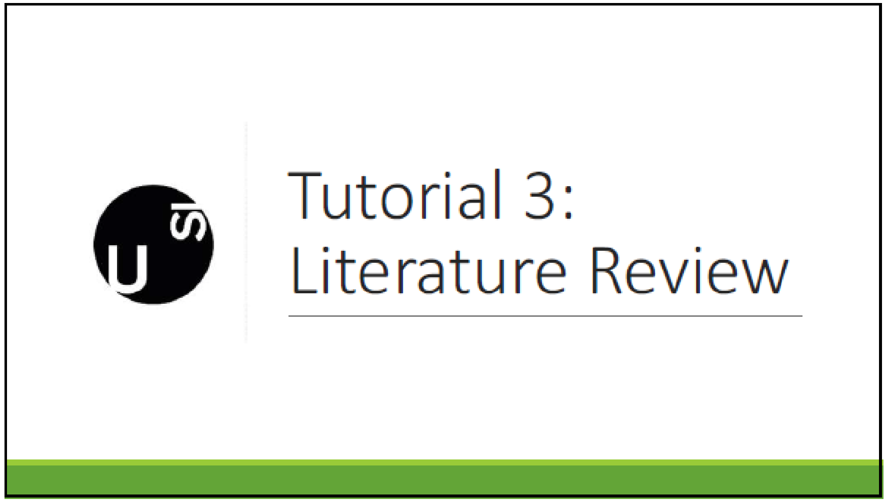
13

c) Tutorial 3: Literature Review



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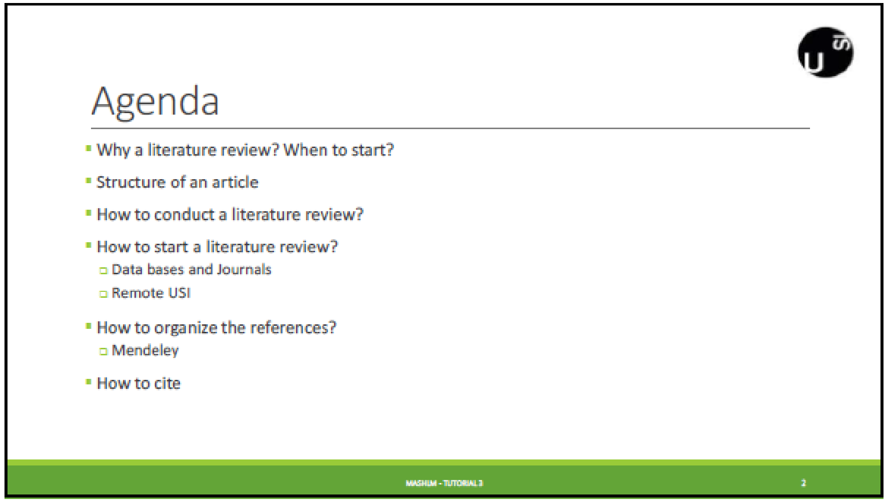

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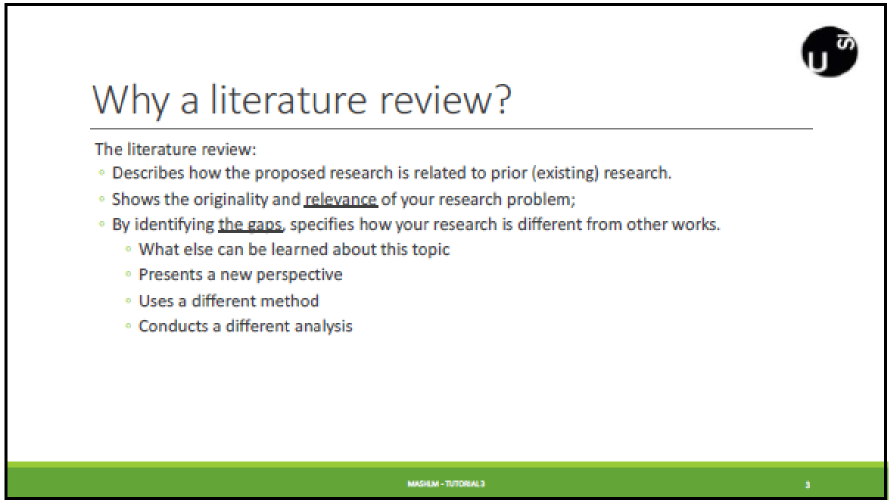

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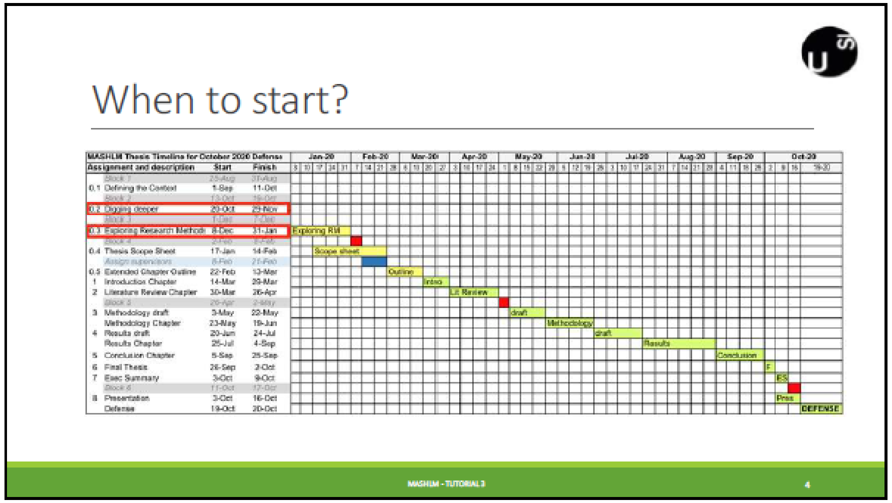

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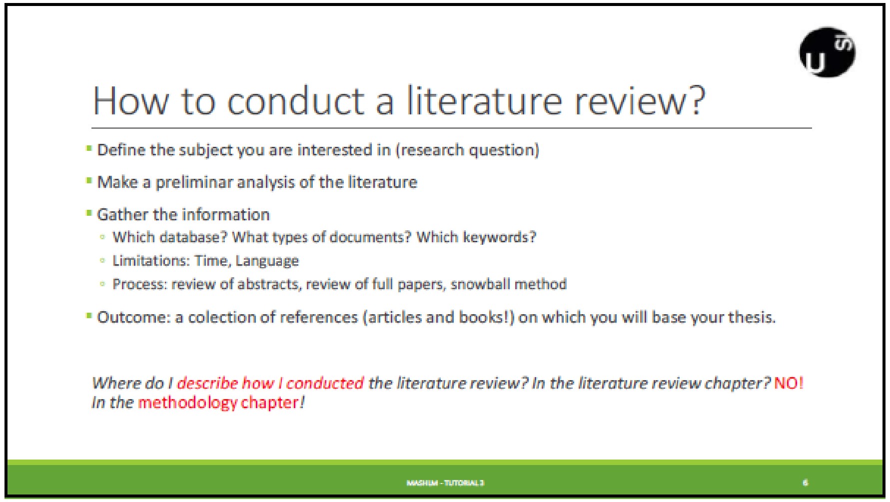

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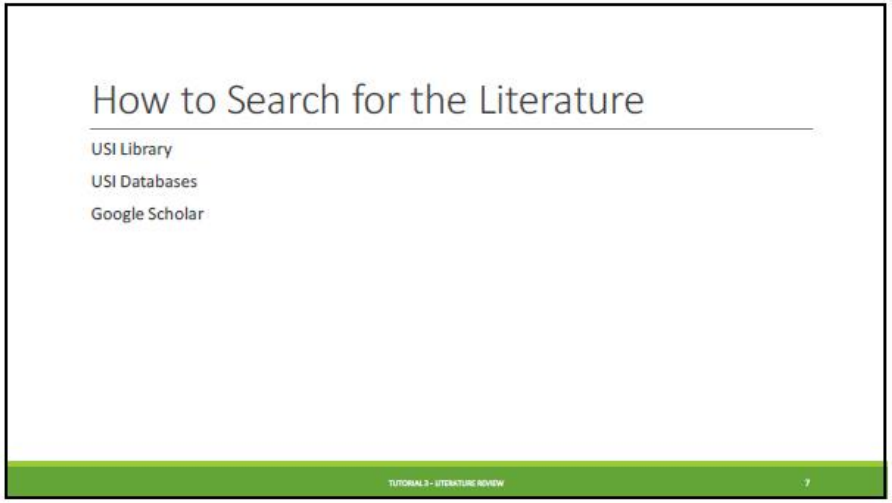

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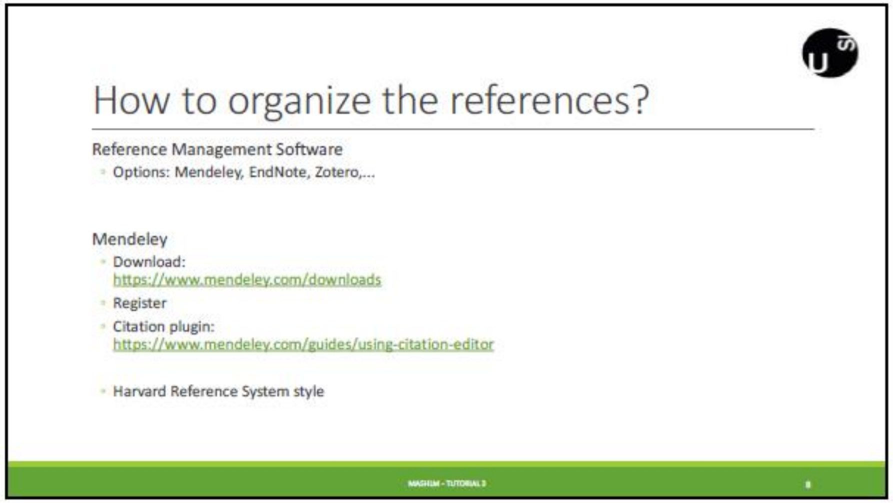

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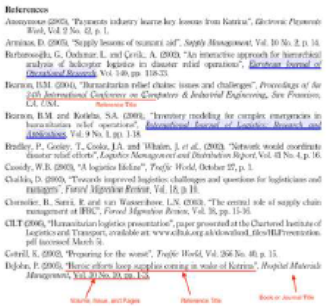
After slide 8: about 20 slides omitted with screenshots of step-by-step process for students to follow along on the mechanics of accessing and using databases and installing and using a reference management software.

How To Cite Articles and Books



TUTORIAL 3 – LITERATURE REVIEW 9

9

How to Cite Websites

A URL is not enough for a reference!

- Start with the name of the author (if one is listed), or the title of the report (if no author is named)
- Include as the date the date of the report or the date the website was last updated
- Also include the date you accessed the website (because web content can change!)
- Example: Economist Intelligence Unit. 2010. Enabling efficient policy implementation: A report from the Economist Intelligence Unit, sponsored by Oracle http://www.oracle.com/us/industries/public-sector/economist-report-193495.pdf. Accessed July 21, 2013.

Originally from Laura J. Black, Ph.D.

10

10

d) Tutorial 4: Article Summary

Tutorial 4: Article Summary

1

Agenda

- Why do you need a summary?
- The ARTICLE SUMMARY structure
- Example 1
- Example 2: Hands-on

2

Why do you need a summary?

You may need go through about 50 articles or reports during doing your thesis

Articles range from 10 to even 50 pages

You do not want to read the whole article every time

Sometimes you need to recall the big picture

3

Components of articles

- Abstract — ✓ A big picture of the article
- Introduction — ✓ The background and research question
- Literature Review — ✓ Reviews the previous works and the gap
- Methodology — ✓ Explain the data and tools used for analysis
- Results — ✓ Results generated from the analyses
- Conclusion — ✓ What the authors infer from the research
- References — ✓ Bibliography; list of cited works

4

Article summary

Title

Problem/Topic

Main Idea

Finding(s)

Data

Method(s)

5

Leiras, A. et al., 2014. Literature review of humanitarian logistics research: trends and challenges. *Journal of Humanitarian Logistics and Supply Chain Management*, 4(1), pp.95–130.

Literature review of humanitarian logistics research: trends and challenges

Adriana Leiras
Department of Industrial Engineering, Pontifical Catholic University of Rio de Janeiro and Graduate Program in Logistics Systems Engineering, University of Sao Paulo, Sao Paulo, Brazil
Irineu de Brito Jr
Department of Production Engineering, University of Sao Paulo and Fatec Jessen Vidal, S J dos Campos, Sao Paulo, Brazil
Eduardo Queiroz Peres and Tábata Rejane Bertazzo
Department of Production Engineering, University of Sao Paulo, Sao Paulo, Brazil, and
Hugo Tsugunobu Yoshida Yoshizaki
Department of Production Engineering and Graduate Program in Logistics Systems Engineering, University of Sao Paulo, Sao Paulo, Brazil

Example 1

6

Example 1: Article summary

Title
- Literature review of humanitarian logistics research: trends and challenges

Problem/Topic
- Increasing number of works published in the humanitarian logistics field
- Increasing relevance of the field

Main Idea
- Need for an updated and detailed review of the current literature
- Need for different criteria for further literature classification

7

Example 1: Article summary

Finding(s)
- Identification of gaps and research opportunities
- Need for more studies into the disaster recovery phase and the need for closer relationships between academia and humanitarian organizations to increase the number of applied research.

Data
- 228 papers
- Source: academic peer-reviewed journals in the humanitarians logistics area
- Time frame: from 1982 to 2012

Method(s)
- Literature review

8

Brito Junior, I. de, Uneddu, S. & Gonçalves, P., 2014. Supply Chain Optimization of the distribution of mosquito nets in Ivory Coast. In *Proceedings of POMS 23rd Annual Conference*. Atlanta: POMS.

Supply Chain Optimization of the distribution of mosquito nets in Ivory Coast

Irineu de Brito Junior
Department of Production Engineering, University of Sao Paulo
Department of Logistics, FATEC Jessen Vidal S J Campos, Brazil

Silvia Uneddu
Emergency & Field Logistics Manager, UNICEF Supply Division, Copenhagen, Denmark

Paulo Gonçalves (paulo.goncalves@usi.ch)
University of Lugano, Switzerland

Example 2

9

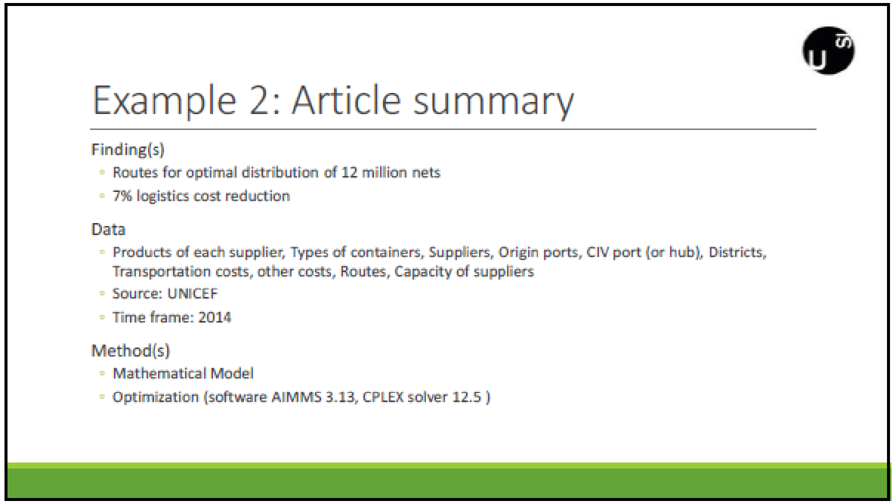
Example 2: Article summary

Title
- Supply Chain Optimization of the distribution of mosquito nets in Ivory Coast

Problem/Topic
- About 1,200 children under the age of 5 die every day of malaria and in Sub-Saharan Africa malaria accounts for 14% of all child related deaths.
- Because of inefficient cost management, many people do not have access to bed nets.

Main Idea
- Death by malaria can be effectively avoided through the use of long lasting insecticidal nets.
- There are not enough nets to supply all Ivory Cost's demand.
- Reducing costs would enable the purchasing of more nets.

10



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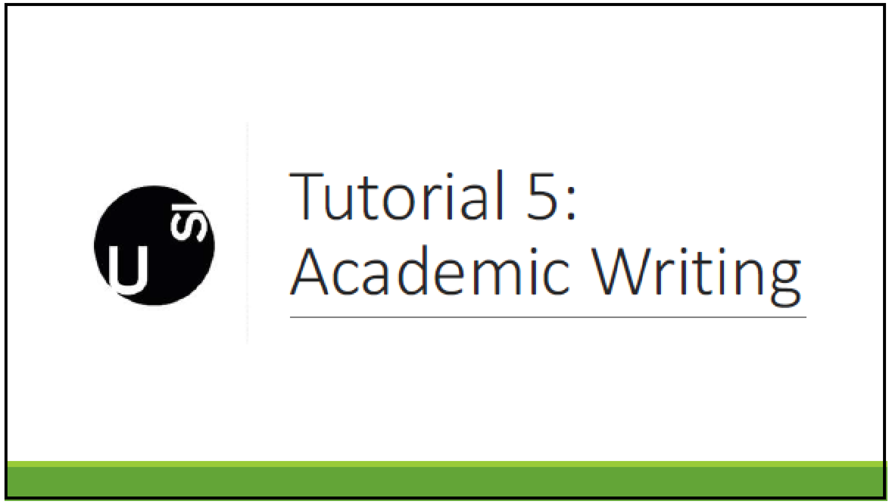
Examples 1 and 2 are accompanied by the original articles for students to analyze.

e) Tutorial 5: Academic Writing



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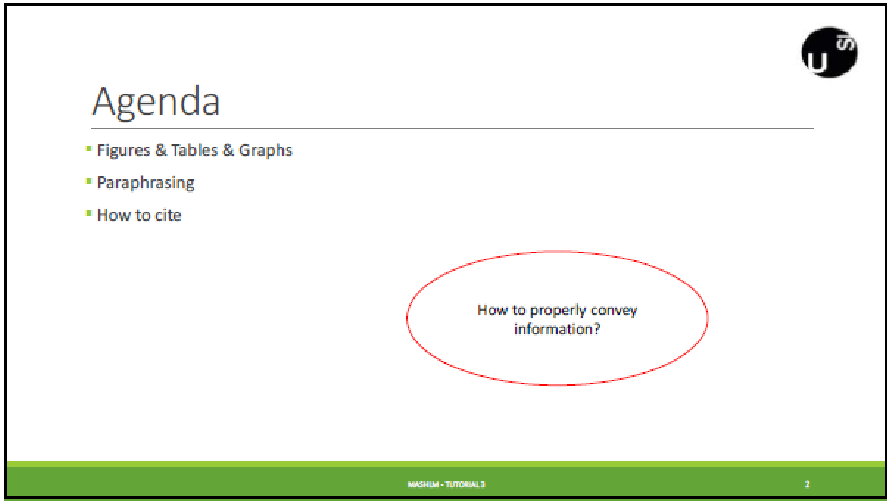

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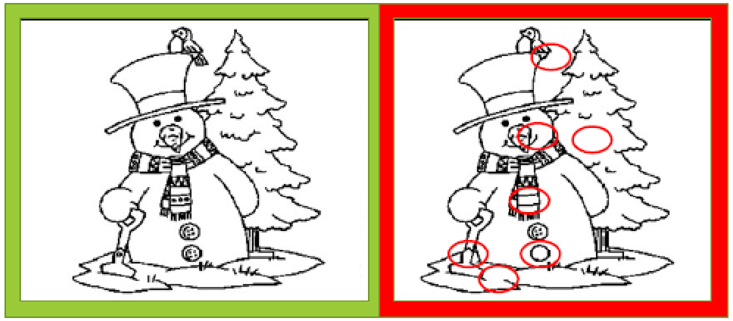
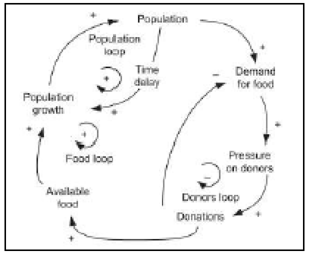


3

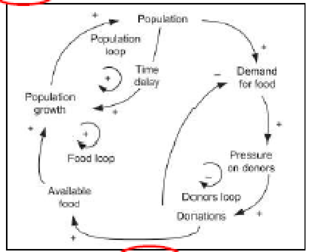
Formatting: figures

Figure 1: Diagram of the simplified population system



Source: Besiou et al. (2011)

Diagram of the simplified population system



Source: Besiou et al.

4

Figures checklist

- Label and sequence
  - Figure 1:....
- Source
  - Authors
  - Year

5

Formatting: tables

Table 10: Application performance

Office	Weight (percentage)	Quantity (tons)	Quantity of responses	Final Score
Burundi	11.5	900	64	1.80
Ethiopia	12.3	798	60	2.05
Kenya	35.6	653	197	1.83
Rwanda	11.2	1010	52	2.15
Somalia	14.1	543	74	1.91
Tanzania	15.3	693	67	2.28
TOTAL	**100.0**	**3697**	**566**	**1.96**

Source: author (2017)

Table 10: Application performance

Office	Weight	Quantity ?	Average Experience for All Surveyed Applications
Burundi	11.5	64	1.80
Ethiopia	12.3	60	2.05
Kenya	35.60	197	1.83
Rwanda	11.2	52	2.15
Somalia	14.1	74	1.91
Tanzania	15.3	67	2.28
TOTAL	**100**	**566**	**1.96**

Source: author (2017)

NO COLOR!!

NO LINES!!

6

Tables checklist

- Label and sequence
- Source

→ The same as Figures

- Variable names
  - Short and clear name
  - Units
- Numbers
  - Decimal houses
- General formatting
  - Only 3 lines to divide rows
  - Centralized text
  - Variable names in bold

7

Describing Tables

What is the WORST way to describe a table?

Table 10: Application performance

Office	**Weight (percentage)**	**Quantity (tons)**	**Quantity of responses**	**Final Score**
Burundi	11.5	900	64	1.80
Ethiopia	12.3	798	60	2.05
Kenya	35.6	653	197	1.83
Rwanda	11.2	1010	52	2.15
Somalia	14.1	543	74	1.91
Tanzania	15.3	693	67	2.28
TOTAL	**100.0**	**3697**	**566**	**1.96**

Source: author (2017)

8

Describing Tables

As we can see in table below, the Burundi office had an accumulated weight of 11.5%, handling 900 tons of food through the application and 64 people answered the question. Ethiopia office, on the other hand, had an weight of 12.3%, handled 798 tons of food and 60 sent their responses. ....

Table 10: Application performance

Office	**Weight (percentage)**	**Quantity (tons)**	**Quantity of responses**
Burundi	11.5	900	64
Ethiopia	12.3	798	60
Kenya	35.6	653	197
Rwanda	11.2	1010	52
Somalia	14.1	543	74
Tanzania	15.3	693	67
TOTAL	**100.0**	**3697**	**566**

Source: author (2017)

9

Describing Tables

Table 10 shows that Kenya office accounts for an exceptionally high value of importance (35.6%) according to managers, even though the quantity of food handled through its application (653 tons) is less then 70% of that one of Rwanda (1010 tons). One hypothesis for this is that in Kenya the engagement of locals in developing the application is encouraged; the quantity of responses (197) is a clear indicator of this culture at the office.

Table 10: Application performance

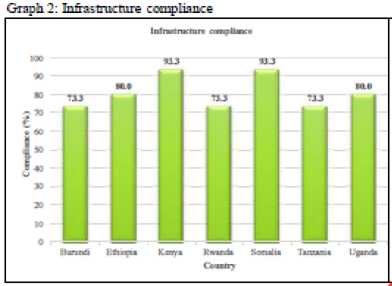
Office	**Weight (percentage)**	**Quantity (tons)**	**Quantity of responses**
Burundi	11.5	900	64
Ethiopia	12.3	798	60
Kenya	35.6	653	197
Rwanda	11.2	1010	52
Somalia	14.1	543	74
Tanzania	15.3	693	67
TOTAL	**100.0**	**3697**	**566**

Source: author (2017)

10

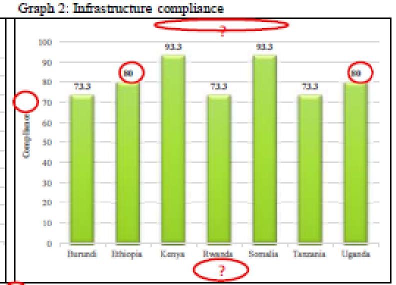
Formatting: graphs

Graph 2: Infrastructure compliance



Source: author (2017)

Graph 2: Infrastructure compliance



Author (2017)

11

Graphs checklist

- Label and sequence
- Source
- Variable names
- Numbers

The same as Tables

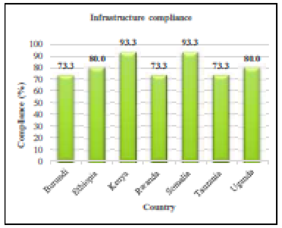
- Title
- Axes
- Legend
  - In cases of more than 1 information

12

Which one should I use?

Infrastructure compliance is also relevant. Burundi, Rwanda and Tanzania have a compliance of 73.3%; Ethiopia and Uganda show small improvements and comply with 80% of the standards, and Kenya and Somalia achieve 90% of compliance.

Country	Compliance (%)
Burundi	73.3
Ethiopia	80.0
Kenya	93.3
Rwanda	73.3
Somalia	93.3
Tanzania	73.3
Uganda	80.0



13

Which one should I use?

- Can I use more than 1 format to show the same information? NO
- Use the format that better convenes the information YOU want to share.
- A format that is CLEAR.
- The format that better SUMMARIZES the data.
  - 1 Table is better than 10 graphs (or 1 graph with 10 different types of information)

14

Agenda

- Figures & Tables & Graphs
- Paraphrasing
- How to cite

15

Paraphrasing

- Much needed for the Introduction and the Literature Review
- Using a synonyms dictionary? You are doing this wrong.
- "Use your own words" -> What does that mean?

16

Paraphrasing

- Turnitin document
- Acceptable: less than 10% similarity

17

Paraphrasing – how to do it

- Suggestions when collecting references
  - Copy everything in one document (with references!), but do not use it directly when writing the text
  - Copy it in the document (with references!) and color it, but do not use it directly when writing the text
- Suggestions when writing the text
  - What is the main point of the sentence/paragraph/article?
  - What do I want to convey?
  - Read a few references/paragraphs and only then write it down

18

Paraphrasing

- Many organizations provide humanitarian aid, whether in immediate response to a disaster or in the months that follow. United Nations bodies, local and international non-governmental organizations (NGOs) and host governments, as well as donors, military and commercial service providers, are all involved in one form or another (Jahre and Hansen, 2010).

↓

- During the response and reconstruction phases many organizations mobilize to relief victims suffering. Examples of organizations are: United Nations bodies, local and international non-governmental organizations (NGOs), host governments, donors, military and commercial service providers.

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19

Paraphrasing

- Vertical coordination is a common topic in the literature and has been defined as "when two or more organizations, such as the manufacturer, the distributor, the carrier and the retailer, share their responsibilities, resources and performance information to serve relatively similar end customers" (Simatupang and Sridharan, 2002).

↓

- Vertical coordination has been approached by many studies. It occurs when two or more organizations of different tiers in the supply chain align their goals and share information about their organizations to achieve it.

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20

How to Cite Others' Works

Financial flows play an important role in humanitarian operations and impact their scope, effectiveness and efficiency. While the total amount of donations received can impact the efficacy of such operations, the timing, predictability, and flexibility of usage around those funds also have a strong influence (Wakolbinger and Toyasaki 2011). In a global health context, unpredictability and delays in donor funding are often cited as the reasons behind impaired supply chain management and reduced coverage (Fininnov 2011). A recent study by the Brookings Institution (Lane and Glassman 2008) estimates that for every dollar received in funding, 7 to 28 cents is lost due to funding delays.

21

21

How to Cite Others' Works

The Interface between Operations and Finance: In this stream of literature, a firm's available capital at the start of any given period is endogenously dependent on the revenues generated in the previous period. Papers that study the interaction between operational and financial decisions include Archibald et al. (2002), Babich and Sobel (2004), Xu and Birge (2004), Gaur and Seshadri (2005) and Chao et al. (2008). Our work is more closely related to Chao et al. (2008). They study a periodic–review inventory replenishment problem faced by a self–financing retailer whose objective is to maximize the terminal wealth at the end of the planning horizon. For their model, they show that a capital–dependent base stock policy is optimal. One aspect that distinguishes our work from the existing literature is the presence of a donor funding stream that is exogenous to realized demand. In our work, demand fulfilled in the previous periods does not generate any revenue due to the non–profit nature of the business.

22

22

f) Tutorial 6: Method Alignment

Tutorial 6: Method Alignment

1

Expectations about the class and its content...

2

Agenda

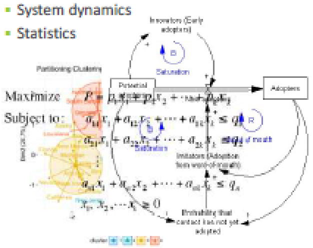
- Overview of Methods
- What goes into Methods chapter?
- What does NOT go into Methods chapter?
- Exercise

- Comparing Methods & Data
- Failure modes of Methods/Thesis

3

Overview of Methods

- Quantitative Methods
  - Optimization
  - System dynamics
  - Statistics
- Qualitative Methods



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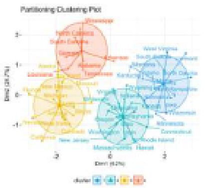
Overview of Methods

- Quantitative Methods
  - Optimization
  - System dynamics
  - Statistics
- Qualitative Methods
  - Questionnaires
  - Focus group discussion
  - Case based research



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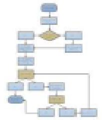
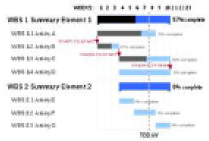
Overview of Methods

- Quantitative Methods
  - Optimization
  - System dynamics
  - Statistics
- Qualitative Methods
  - Questionnaires
  - Focus group discussion
  - Case based research





- Project management
- Scenario planning
- Strategic planning
- Risk analysis
- CPR/PERT
- Lean six sigma

6

What goes into Methods chapter?

What do I need the methods CHAPTER for?

- It is all about HOW you will do the study
- What is the method?
- What data will you need?
- Data from which years will be analyzed?
- What/who is your source?
- Interviews and questionnaires:
  - who collected the data?
  - who were the interviewees?
  - give an overview of the questions
  - add complete I/Q formular as an Appendix

Qualitative/Quantitative is TOO BROAD. **Be specific!**

Interviews and questionnaires **MUST** be aproved by the supervisor **PRIOR** to using them!

7

What does NOT go into Methods chapter?

- Results
- Implementation

8

Exercise – what goes into Methods chapter?

- ✗ 1 - Review of Ministry of Health literature and policy documents in immunization.
- ✓ 2 - Data types and sources; use of Immunization budgets from WHO, UNICEF, GAVI, and other players to evaluate budget lines for planning meetings, training sessions per administrative level, number of individuals trained, evaluation and supervision of activities in regards to designation of the supervisor and level of administration supervised.
- ✗ 3 - Description of immunization strategies employed for the various diseases and coverage measures.
- ✓ 4 - Description of questionnaires and interviews that assess staffing needs and gaps.
- ✓ 5 - System Dynamics to analyze the holistic coordination system and draw cross-cutting conclusions and recommendations.
- ✗ 6 - Suggest recommendations to the existing challenges of coordination.

9

Agenda

- Overview of Methods
- What goes into Methods chapter?
- What does NOT go into Methods chapter?
- Exercise

- Comparing Methods & Data
- Failure modes of Methods/Thesis

10

Comparing Methods & Data

- Context
  - HAYAT in Azerbaijan
  - What it does: develops projects for IDPs as a way of creating opportunities for their economic and psychological rehabilitation.
  - Where: 5 regions in the country

Table 1 - Portfolio of training conducted by HAYAT.

Public Awareness Training	Vocational Training
- Water Supply and Sanitation - Maternal Health - Mine Risk Education - Education on HIV/Aids - Reproductive Health Education - Education on Gender-Based Violence	- Rural Development Techniques and IT - Small Business Entrepreneurship - Administrative Techniques - Development Entrepreneurship for Milk and Dairy Products - Handicraft Techniques - Carpet Weaving - Irrigation Techniques

  - Choice of courses influenced by: donors, budget, and internal competition.

11

Comparing Methods & Data

- Context
  - HAYAT in Azerbaijan

Table 2 – HAYAT Data for vocational training courses.

Training course	Cost/hour of Training/ Participant	Impact on beneficiaries	Number of beneficiaries/session	Minimum number of sessions	Beneficiary level of satisfaction	Duration of training
Rural Development Techniques	15	1	10	20	4	220
Small Business Entrepreneurship	14	3	15	12	3	620
IT	38	9	10	4	9	880
Administrative Techniques	30	8	15	4	6	540
Development Entrep. for Dairy Products	16	3	15	4	2	220
Handicraft Techniques	16	3	5	10	4	320
Carpet Weaving	12	2	5	16	6	220
Irrigation Techniques	8	4	10	20	6	240

12

Comparing Methods & Data

- Context
  - HAYAT in Azerbaijan

What **method** would you use?
What **data** do you need for that?
What is your expected **result**?

13

Comparing Methods & Data

Method	Data	Expected Results
Optimization model – Resource Allocation	Types of courses, characteristics of courses (cost, impact, time...), budget, demand	What courses and how many times they shall be presented. Total impact and total time investment. Optimal cost/benefit.
Project management – Flowchart, Design Structure Matrix (DSM)	Processes, sequence, information feedback, responsibilities, time	New process design. Less rework. Smaller lead time. Better work division.
Risk Analysis	List of risks and its characteristics (probability, impact, relevance) for each region	Region ranking. Measure of risks. Recommendation of mitigation measures.
System Dynamics	Variables influencing the system, behavior modes	Understand the behavior of the system, feedback loops, and critical variables. Suggest policies to change the system.

14

Comparing Methods & Data

Method	Data	Expected Results
Strategic Planning	Mission, vision, goals, stakeholders, capacity environment...	Structured strategy plan.
Scenario Planning	Description of possible futures, capacity,...	Structured scenario plan.
Case Study	Compare training courses and its outcomes.	Identify similarities and relevant diferences. Suggest a framework.
Statistics – descriptive statistics, cluster analysis	Detailed data from many years.	Find patterns. Explain situations and suggest recommendations.

15

Failure modes of Methods

- Avoid the multi-method temptation

> The following methods (qualitative and quantitative) will be used to analyze the problem at hand:
>
> 1. Forecasting, Economic Order Quantity and ABC Paretto analysis for inventory / warehouse management.
> 2. Lean Six Sigma, Process Management, cause and effect analysis for transport and procurement.
> 3. Capacity management on staff skills.
> 4. Vensim, SPSS and Microsoft Excel will be used to assist in data analysis.

16

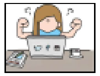
Failure modes of Methods

- Lack of data for a chosen method

17

Failure modes of Methods

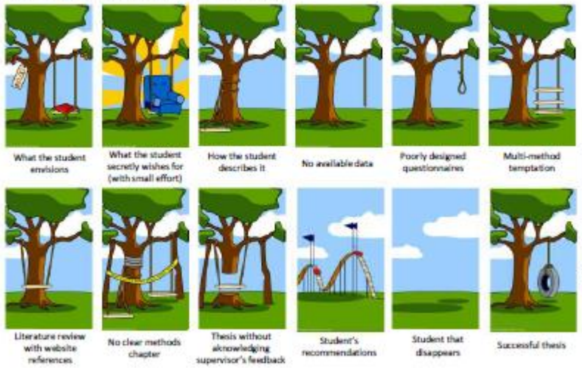
- When gathering data with questionnaires or interviews:
- Who is answering your questions?



- What questions are you asking?
  - "Is the coordination good?" vs "Is everybody involved?"
  - "Is the user satisfied?" vs "How many complaints do you receive per month?"

18

Adapted from "The Project Construction Cycle – The Tree Swing"



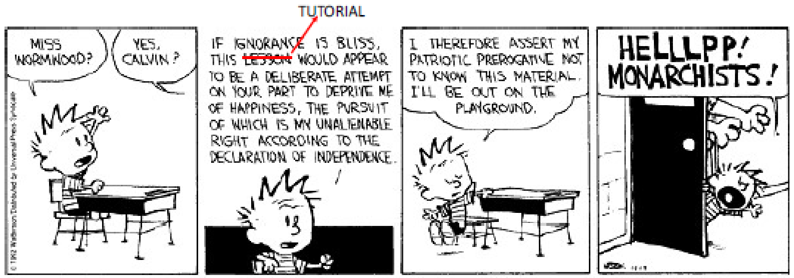
Failure modes of Thesis

19

g) Tutorial 7: Quantitative Methods and Thesis Scope Sheet Workshop

Tutorial 7: Methods & Thesis Scope Sheet

1



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2

Agenda

- Quantitative Methods
  - Optimization
  - System Dynamics
  - Descrete Event Simulation
  - Process Management
  - Lean Six Sigma
  - Statistical Analysis
  - Econometrics
  - Cost/Benefit Analysis
- Thesis Scope Sheet

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3

QM – Optimization (1/8)

- Static problem: analysis at a defined point in time
- Parts of an optimization:

Objective: $Min \sum_i \sum_j C_{ij} X_{ij}$ ← Decision variables

Constraints: $\sum X_{ij} \leq S_i$ for each i

$\sum X_{ij} \geq D_j$ for each j

$X_{ij} \geq 0$ for each i and j

Heuristics

Data: costs, distances, time, budget, locations, routes, impact…

- Types: linear program (LP) or nonlinear program (NLP)
- Continuous or discrete variables
- Budget allocation, Facility Location, Scheduling, Transportation, Maximum Flow, Shortest Path, …
- Examples: Sílvia Uneddu, Bervery Chawaguta, George Nohra

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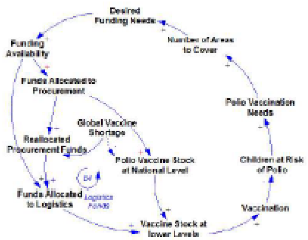
4

QM – System Dynamics (2/8)

- Dynamic problem: analysis over several points in time
- Focused on behavior; strategical approach
- Continuous variables; delays in the system

- Causal Loop Diagram: Anne Ukwuagu
- Model implementation: Simplice Kamdem, Rebecca Turner

Data: variables, relationships, past behavior, policies



5

QM – Descrete Event Simulation (3/8)

- Dynamic problem: sequence of events that changes the system
- Tactical approach
- Modeling procedures and processes, queues
- Testing scenarios

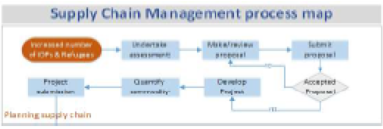
Data: characteristics of the system, event list, influence of event on the system

- Example: Martin Hiltbrünner

6

QM – Process Management (4/8)

- Static Problem: process analysis
- Theory of contraints; identifying bottlenecks
- BPMN, DSM



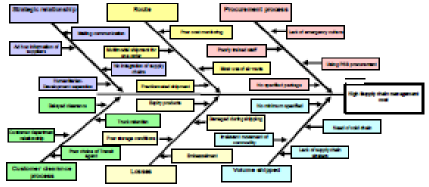
Data: processes list, sequence and relationships, capacity

- Example: Bwato Nsindi

7

QM – Lean Six Sigma (5/8)

- Static problem: analysis of a process at a defined point in time
- Operational approach; reducing waste
- Phases: Define – Measure – Analyze – Improve – Control (DMAIC)



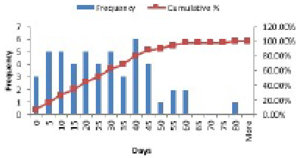
Data: processes list, sequence and relationships, outcome variability

- Example: Bwato Nsindi

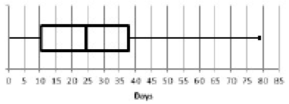
8

QM – Statistical Analysis (6/8)

- "Descriptive statistics"
- Used when there is data about the **whole** population
- Tools: mean/median/STD, graphs
- Example: Messay Gebre



Data: characteristics of the population



9

QM – Econometrics (7/8)

- Used when there is data about **part** of the population and *inferences* are made about the whole population
- Most common tools: linear regression, cluster analysis

$Y=\beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \varepsilon$

- *Take Care!* Spurious relationship: variables are correlated but causually unrelated

Data: characteristics of the sample

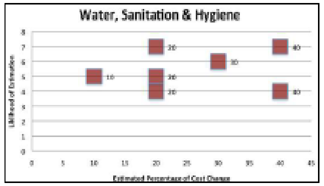
- Example: Tonny Odong

10

QM – Cost/Benefit Analysis (8/8)

- Used to compare alternatives
- Translates costs and benefits into monetary value
- Calculates the net present value
- Example: Bernhard Zlanabitnig

Data: costs and benefits of each alternative



11

Agenda

- Quantitative Methods
  - Optimization
  - System Dynamics
  - Descrete Event Simulation
  - Process Management
  - Lean Six Sigma
  - Econometrics
  - Statistical Analysis
  - Cost/Benefit Analysis
- Thesis Scope Sheet

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Thesis Scope Sheet

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Thesis Scope Sheet

Let's work in pairs! (no, 3 is not a pair)

Exchange your Thesis Scope Sheets

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Thesis Scope Sheet

- TITLE
  - Max of 15 words
- RESEARCH QUESTION
  - If there are 2, are they related or completely different?
- THESIS OBJECTIVE
  - Is it clear?
- **PROBLEM** DESCRIPTION

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Thesis Scope Sheet

- DATA SOURCES/TYPES
  - Details of data
  - Check for access of ALL data (do you need questionnaires or interviews? Add them to methods)
- METHODOLOGY
  - Is there reference to data? (Take it out, move it back to data)
  - "Analyze" is not a methodology
- EXPECTED RESULTS
  - Are all results listed?
  - Try to identify results of intermediate phases of your work

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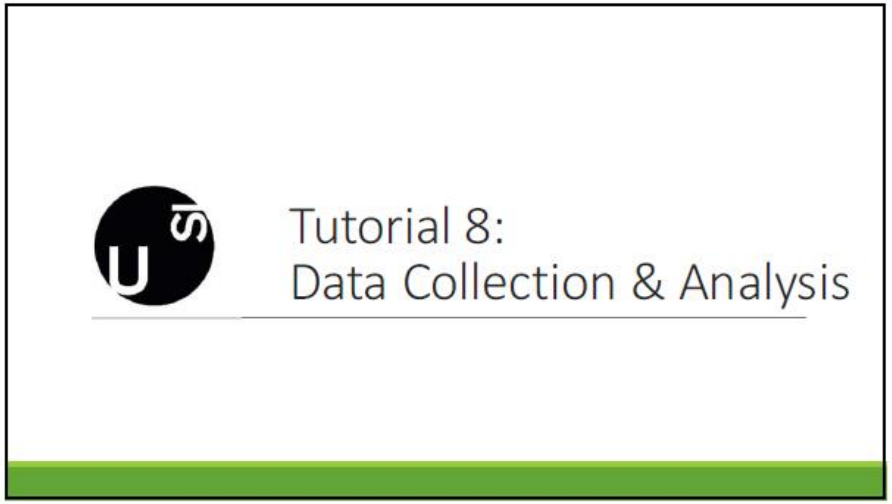
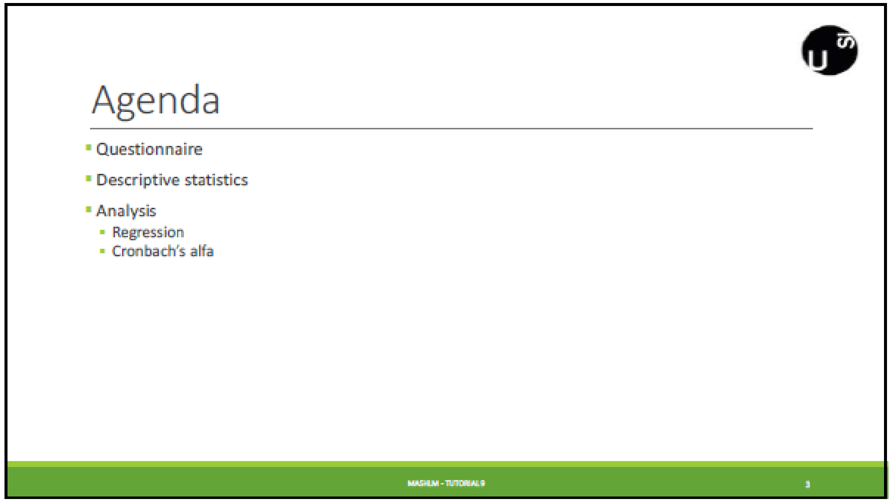
h) Tutorial 8: Data Collection & Analysis



1

2



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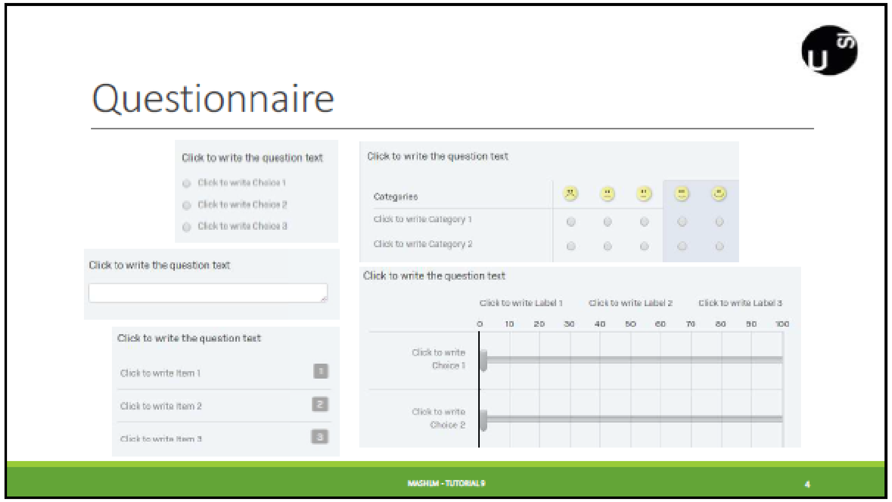
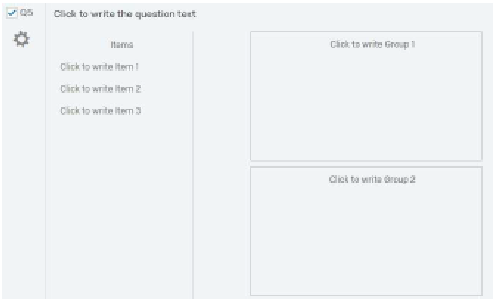


4

Questionnaire



5

Questionnaire

Steps:

1. Plan blocks of questions (broad content and order)
2. Design the questions (relation to objectives, vocabulary, type(s) of question, total time to complete)
3. Ask for feedback and approval of your supervisor
4. Pilot the questionnaire
   - Carry out the questionnaire with a few individuals of your sample
   - Ask them to answer a few questions about the questionnaire itself; they can be general (e.g.: Was any question ambiguous? Did you understand all questions?) or specific
   - If needed, make adjustments to the questionnaire
5. Carry out the final questionnaire

6

Agenda

- Questionnaire
- Descriptive statistics
- Analysis
  - Regression
  - Cronbach's alfa

7

Descriptive Statistics

- 1st quartile, 3rd quartile, mean, media, mode
- Graphs
- code: **summarize**

Variable	Obs	Mean	Std. Dev.	Min	Max
make	0				
price	74	6165.257	2949.496	3291	15906
mpg	74	21.2973	5.785503	12	41
rep78	69	3.405797	.9899323	1	5
headroom	74	2.993243	.8459948	1.5	5

Any doubt of how a specific command works in stata? Type:
help name_of_command

8

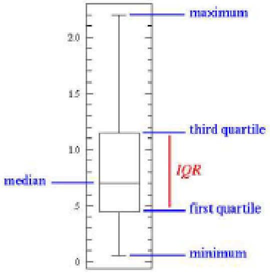
Descriptive Statistics

- code: **summarize name_of_variable, detail**

```
                        writing score
-------------------------------------------------------------
      Percentiles      Smallest
 1%        31             31
 5%      35.5             31
10%        39             31
25%      45.5             31          1st quartile

50%        54
                        Largest
75%        60             67          3rd quartile
90%        65             67
95%        65             67
99%        67             67
```

- code: **graph box name_of_variable**



9

Agenda

- Questionnaire
- Descriptive statistics
- Analysis
  - Regression
  - Cronbach's alfa

10

Analysis - Regression

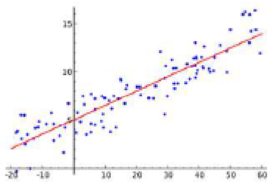
```
regress science math female socst read

      Source |       SS       df       MS              Number of obs =     200
-------------+------------------------------           F(  4,   195) =   46.69
       Model |  9543.72074     4  2385.93019           Prob > F      =  0.0000
    Residual |  9963.77926   195  51.0963039           R-squared     =  0.4892
-------------+------------------------------           Adj R-squared =  0.4788
       Total |     19507.5   199  98.0276382           Root MSE      =  7.1482

------------------------------------------------------------------------------
     science |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        math |   .3893102   .0741243     5.25   0.000      .243122    .5354983
      female |  -2.009765   1.022717    -1.97   0.051    -4.026772    .0072428
       socst |   .0498443    .062232     0.80   0.424    -.0728899    .1725784
        read |   .3352998   .0727788     4.61   0.000     .1917651    .4788345
       _cons |   12.32529   3.193557     3.86   0.000     6.020943    18.62364
------------------------------------------------------------------------------
```

https://stats.idre.ucla.edu/stata/output/regression-analysis-2/

- regress y x
- regress y x a b c, r
  - r = robust



11

Analysis – Cronbach's alfa

- Internal consistency reliability
- Based on the covariance and variance of the sample
- Range: 0 to 1 (should be at least 0.70)
  - Alpha nearer to 1 : more probably the items measure the same underlying concept
  - Example: 0.70 = 70% of the variance in the scores is reliable variance; 30% is error variance

Sample	Question 1	Question 2	Question 3	Question 4
Individual 1	3	4	4	5
Individual 2	1	3	3	2
Individual 3	5	5	4	4
Individual 4	2	2	1	2

- code: **alpha question1 question2 question3 question4**
- Excel: https://www.youtube.com/watch?v=uXKnn0T6Cyw&t=162s

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i) Tutorial 9: Presentation

Tutorial 9: Presentation

1

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Agenda

- How to begin your presentation
  - Introducing yourself and your Thesis
  - Capturing your listener's attention
- Organizing your presentation
  - Agenda / Keeping track of the presentation
  - Presentation time / Number of slides
- Thesis Chapters
  - Introduction
  - Literature Review
  - Methodology
  - Results
- How to end your presentation
  - Conclusion
  - Final information
- Final tips
  - Presentation
  - Body language

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3

HOW TO BEGIN YOUR PRESENTATION

Introducing yourself and Your Thesis

- On the FIRST SLIDE:
  - Your Full name
  - MASHLM Cohort
  - Current Year

  - Thesis title
  - University name
  - Supervisor

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4

HOW TO BEGIN YOUR PRESENTATION

Capturing your listener's attention

- A joke? A cartoon? **An image?**

Source: globo.com

REMEMBER:
Your thesis presentation is a formal event!

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Agenda

- How to begin your presentation
- Organizing your presentation
  - Agenda / Keeping track of the presentation
  - Presentation time / Number of slides
- Thesis Chapters
- How to end your presentation
- Final tips

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ORGANIZING YOUR PRESENTATION

Agenda / Keeping track of the presentation

- Introduce your **agenda (outline, overview)**
- Add **slide numbers** on your presentation
- Add a **tracking mechanism**

Agenda

- How to begin your presentation
  - Introducing yourself and the Thesis
  - Capturing your listener's attention
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- Thesis Chapters
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  - Methodology
  - Results
- How to end your presentation
  - Conclusion
  - Final information
- Final tips

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ORGANIZING YOUR PRESENTATION

Presentation time / Number of slides

- Time for…
  - … presentation: 20 minutes
  - … questions and answers: 15 - 20 minutes
- How many slides?
  - 2 minutes per slide: 10 slides
  - 1 minute per slide: 20 slides
  - 30 seconds per slide: 40 slides

Spend more time on RESULTS than on literature review!

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8

Agenda

- How to begin your presentation
- Organizing your presentation
- Thesis Chapters
  - Introduction
  - Literature Review
  - Methodology
  - Results
- How to end your presentation
- Final tips

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9

THESIS CHAPTERS

Introduction

- What is the problem?
  - Background
  - Impact (money lost, people not assisted…)
- Research question(s)
- Objective
  - Sub-objectives
- Contribution
  - Practical contribution
  - Academic contribution

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10

THESIS CHAPTERS

Literature Review

- Main definitions
- Main themes (headings)

KEEP IT SHORT!

- Add the shortened reference (Author, Year)

Material Convergence

Occurs when supplies, general donations, and equipment from governments, humanitarian agencies, groups or individuals **arrive** to a disaster affected area, in a **short time frame**

(Fritz and Mathewson, 1957; Holguin-Veras et al., 2012)

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THESIS CHAPTERS

Methodology

- Diagrams are excellent here!
- Justify the use of methodology
- Show the step-by-step

  Professors are familiar with the methodologies, don't spend too much time on details!
- Be specific about what source of data you used for each step of the process
- Address limitations of your approach and how you handled them

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THESIS CHAPTERS

Results

- Take your time! This is the MOST IMPORTANT part of your presentation
- Show the outcome of the steps of the process
- Use graphs and summarizing tables (do not repeat information!)
- Recommendations based on the results of the thesis

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Agenda

- How to begin your presentation
- Organizing your presentation
- Thesis Chapters
- How to end your presentation
  - Conclusion
  - Final information
- Final tips

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HOW TO END YOUR PRESENTATION

Conclusion

- Present the research questions and the answers to each one of them separately
- Limitations
- Restate your contributions
  - Practical contributions
  - Academic contributions
- Future research

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HOW TO END YOUR PRESENTATION

Final Information

- On the LAST slide:

Thank you.

Raquel Froese Buzogany

froesr@usi.ch

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Agenda

- How to begin your presentation
- Organizing your presentation
- Thesis Chapters
- How to end your presentation
- Final tips
  - General
  - Presentation
  - Body language

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FINAL TIPS

General – Tell your story

- How did you decide on your topic?
- Why did you choose the methodology you used?
- How did you collect data? Did you have to overcome a problem – share the experience!
- Results: was there anything that surprised you? What and why?
- Implications: how can an individual or organization benefit from your findings?
- Epilogue:
  - Will you able to implement any of your findings now or in the future?
  - How have you contributed to the knowledge about your topic?

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FINAL TIPS

Presentation

- Font size: at least 20
- Use diagrams / graphs / images "whenever" possible (all readable!!)
- Do not overcrowd your slides with details: one image, you can explain in words
- Test your (entire!) presentation on the computer
- Practice your presentation with colleagues

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FINAL TIPS

Body language

- ENGAGE:
  - Start strong – show your passions for the subject
  - Always keep your feet pointed towards your audience
  - Come closer to the person asking a question
- WATCH: Keep eye contact
- CHECK AND ADJUST: Notice how the audience responds, move on if they lose interest!
- PROJECT: Use your voice as an instrument
  - Vary your speed; vary your pace; use short sentences for emphasis; keep your language simple
- RELAX:
  - ENJOY yourself... and your audience will enjoy your presentation
  - BREATHE. Pause. Make sure your audience is with you

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Chapter 4 - Online Multiplayer Experiments

(with Alireza Akhavan)

Abstract

Online multiplayer experiments are challenging to conduct, particularly impacting the study of fields that depend on an interaction between subjects. This is the case for common-pool resource (CPR) settings, where resource scarcity arises as a number of actors compete for resources. While the extant literature either simplified the CPR setting for one subject or developed in-presence experiments, we detail how to make use of online platforms and crowdsourcing for advancing research. In this study, we show the step-by-step process to manage different tools and software packages to develop and integrate the qualification test, multiplayer game, and data processing steps. We also shed light on several player behavior challenges, including handling several players simultaneously, keeping them engaged, and avoiding player mischievousness. This allows us to carefully document all the necessary parts to carry out online multiplayer experiments and to lead the way for future research to explore this type of experiment design overcoming critical research barriers.

Keywords: multiplayer experiment, online game, system dynamics, common-pool resources

4.1 Introduction

Research questions and the technology to answer them walk hand in hand to advance science. Newer and more powerful computers help answer more complex questions, and the ensuing answers beg for new questions that need even more processing power or another new technology (Brooks, 1995). Online multiplayer experiments are such a technology that can help answer many questions - as well as create new ones - and help overcome several hurdles of in-person multiplayer experiments. First, researchers can now reach out simultaneously to multiple experimental subjects from around the world, which would usually be difficult and expensive, especially for small labs (Hawkins, 2015). Second, it provides researchers with a larger subject pool, thus allowing for more data collection (Rezlescu et al., 2020). This allows researchers to test more factors instead of focusing only on those believed to be the more important ones (Almaatouq et al., 2021b). Finally, it also reduces the time invested in fieldwork (Poteete et al., 2010).

This development is especially promising for fields where the interaction among actors is critical, such as in common-pool resources (Ostrom, 1990, Ostrom 2000). Studying common-pool resources can be challenging, and a multitude of methods has been employed (Poteete et al., 2010). Some studies have singled out different factors, including how single players react to feedback and the environment (Moxnes, 2009) but aspects that have repeatedly been proven positive such as communication (Ostrom et al., 1992; Lindahl et al., 2015; Osborne et al., 2019; Tisdell et al., 2004), are inherently based on the interaction of actors. Other research fields suffer from the same issues and have used similar strategies, including behavioral economics and cognitive psychology (Almaatouq et al., 2021b).

According to Hawkins (2015), technical difficulties are the main reason why the advantages of online multiplayer experiments are out of reach for many research groups. Existing work does not shed light on all the necessary steps to implement online multiplayer experiments connected with software that can handle the multiplayer experience (Mason and Suri, 2012). Also, if programming is involved, it can become an insurmountable obstacle (Almaatouq et al., 2021c; Rezlescu et al., 2020).

Additionally, numerous player behavior challenges need to be addressed in online multiplayer experiments. Although some challenges are identified in the literature (Cheung et al., 2016; Hawkins, 2015), solutions are not detailed and do not specifically address the issues encountered when using system dynamics software for the design and implementation of experiments.

Further, multiplayer settings are usually complex, involving not only many actors but also many potential leverage points and influencing factors (Almaatouq et al., 2021b). System dynamics offers the tools to handle complex problems that include feedback processes and non-linear behavior (Sterman, 2000; Größler et al., 2008), thus perfectly aligned with the needs of these specific multiplayer experiments.

This paper expands the literature by presenting step-by-step instructions on connecting system dynamics tools with a crowdsourcing platform to create online multiplayer experiments and process collected data. It also covers using system dynamics models for interface development and experiment design. Further, the paper addresses challenges related to player behavior and steps to overcome them. Finally, it adds to the common-pool resource literature by showing how to conduct an online crowdsourcing multiplayer experiment for common-pool resource problems.

The authors chose Amazon Mechanical Turk (MTurk) to source participants. This is a common platform among researchers to source participants for experiments. It allows for reaching out to a large number of experiment subjects while accounting for unique participants and anonymity. While criticism has emerged regarding the average profile of participants, studies have shown that the subject pool is much more diverse than typical lab samples at universities (Hawkins, 2015; Mason and Suri, 2012). As in other experimental studies, methodological concerns and validity threats have to be addressed properly. We discuss some of these mostly related to multiplayer experiments in this paper, other concerns related to single-player experiments can be found elsewhere (Cheung et al., 2016). Other studies using system dynamics have used MTurk to crowdsource participants. The authors identified one multiplayer experiment (Rahmandad and Gary, 2020) and several single-player experiments (Qi and Gonzalez, 2019; Keith et al., 2017; Sewell et al., 2017; Lakeh and Ghaffarzadegan, 2015).

Stella Architect is used to create the survey, the system dynamics model, and design the user interfaces. It provides support for multiplayer experiments, the user interfaces allow subjects to have a better feel of the experiment dynamics enhancing their understanding and are easily created using the interface features, and the software is continuously updated.

This article continues as follows. The subsequent section introduces the experiment structure, including the detailed setup and data processing steps. This is followed by a section discussing worker behavior challenges, accompanied by proposed solutions. The lessons learned and future developments section underscores further considerations in online multiplayer experiments. Finally, the conclusion offers closing remarks. Appendix 4.1 introduces the common-pool resources context for the experiment, highlights model features, and presents pilot data collected and processed according to the steps outlined in the article.

4.2 Experiment Structure

The experiment development and implementation include several steps depicted in Figure 4.1 and detailed in the next sections. The software and platforms employed in these steps are Stella Architect v3.0 to design simulation models and user interfaces, Amazon Mechanical Turk (MTurk) to crowdsource participants (workers), and Stata v16.1 to process data.

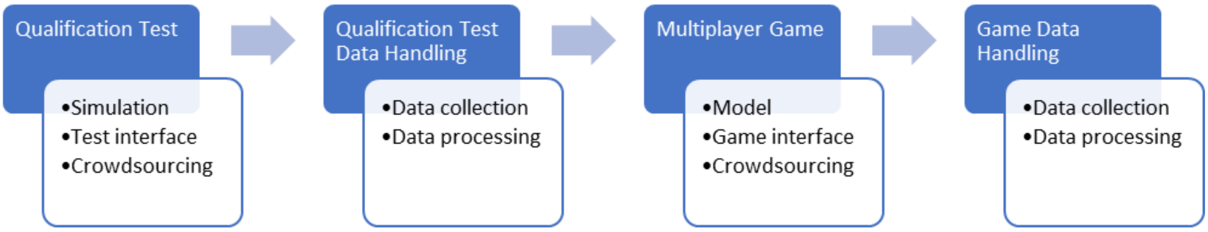


Figure 4.1: Experiment Steps

4.2.1 Qualification Test

The qualification test is needed to screen workers and select those qualified to join the game. As pointed out by Rahmandad and Gary (2020), some workers might not be interested in carefully reading the instructions and playing the game according to the rules, thus a selection process is needed.

The slide deck consists of five slides with instructions and one slide with six qualification questions. The qualification questions touch upon the objectives of the game, the decisions workers must make, the components of the game (time and number of players), and graph interpretation. Workers who correctly answer half or more of these questions are invited to participate in the game.

The qualification also includes a welcoming slide with general instructions about the Human Intelligence Tasks (HITs) and one slide to collect demographics about workers. The general instructions point out that the qualification test is one HIT and that the game is a subsequent HIT, remind workers of the payment, and mention how much time the HITs will approximately take to complete.

Appendix 4.2 presents the simulation model in Stella for the qualification test questions. Variable names do not contain spaces (“ “) since this would later preclude processing data in bulk on Stata. Each question has the same weight toward the final score. Questions are structured with multiple choice options as Stella only accepts numeric answers, i.e., alpha-numeric answers cannot be entered. Once workers submit the qualification test, a unique code is generated and workers enter the code in MTurk to match their work on Stella with their personal ID on MTurk. This is needed to issue the correct payment for each worker. In this experiment, the code is a random number between 6000 and 10000 for qualified workers and between 1000 and 5999 for not-qualified workers. Workers are not aware of this distinction but it helps to issue the correct payment on MTurk without having to check each worker’s number of correct answers as there are only two options: a high payment for qualified workers and a small payment for not qualified ones.

The simulation model in Stella for the demographics survey is available in Appendix 4.3. An equation check verifies that all mandatory demographic questions have been answered. If the worker hits the submit button on the demographics survey slide without having answered all of the questions, they are sent to a page that highlights that they need to complete it and then redirected to the demographics survey.

Amazon Mechanical Turk (MTurk) is used to crowdsource workers for the qualification test. The MTurk qualification test setup includes several aspects:

- Filling out identifying information such as the experiment title and adding a link to the experiment if not performed on the platform itself.

- Defining the base payment paid to all workers that complete the qualification test (a bonus payment only to those that qualify can be defined outside the setup). After some trial and error, the authors found that a higher number of workers qualified when the bonus payment was significantly higher than the base payment (8:1). The base payment considered the recommended minimum hourly payment and the amount of time spent on the activity. In a common sorting procedure by workers, higher base payments appear first on workers' lists of available HITs, so it is recommended to increase the payment within reason to get workers.
- Designating the time allowed per worker to complete the HIT. This should be approximately three times the expected time to complete the HIT to preclude rushing workers and receiving complaints regarding insufficient time.
- Identifying how much time the HIT will be available on the crowdsourcing platform. While it would be great to ask for the total number of workers needed and accordingly set up a long time for the survey to be available on MTurk, experience shows that after 24 hours, few workers access the HIT. Thus, the recommended approach is to republish the HIT after 24 hours if additional workers are needed so that the HIT shows again on the top of the workers' HIT list - the default sorting procedure of HITs displayed to workers on MTurk.
- Specifying worker requirements. In this experiment, only free requirements have been chosen. To source from the better-qualified workers on MTurk, a "HIT approval Rate (%) for all Requester's HITs" greater than 95 and the "Number of HITs Approved" greater than 500 are selected (Litman, 2017). Further, we limit worker location to English-speaking or developed countries in the Americas and Europe because, first, the user interface is displayed in English only and, second,

the multiplayer game requires workers to join at times that are not reasonable for the attendance of workers in the Australasian time zones. The last requirement is that "Survey Completed" has not been granted. While MTurk only allows a worker to complete a specific HIT once, this check does not automatically occur for republished HITs. The new requirement is 1 for each worker that completes the qualification test.

4.2.2 Qualification Test Data Handling

The data is collected on the isee exchange platform (https://exchange.iseesystems.com/) according to the simulation run (Table 4.1).

Table 4.1: Qualification data as on the isee exchange

☐	Run Name	Created By	Created	Last Updated	Full Model?	Finished?	
☐	Run 1	Anonymous User	03/24/2022, 13:19:46	03/24/2022, 13:21:53	Full Model	In progress	Delete
☐	Run 1	Anonymous User	03/24/2022, 13:13:43	03/24/2022, 13:16:24	Full Model	In progress	Delete
☐	Run 1	Anonymous User	03/24/2022, 11:54:03	03/24/2022, 12:02:16	Full Model	In progress	Delete
☐	Run 1	Anonymous User	03/24/2022, 11:45:25	03/24/2022, 11:48:19	Full Model	In progress	Delete
☐	Run 1	Anonymous User	03/24/2022, 11:43:53	03/24/2022, 11:45:59	Full Model	In progress	Delete
☐	Run 51	Anonymous User	03/17/2022, 12:15:55	03/17/2022, 12:19:47	Full Model	Finished	Delete
☐	Run 51	Anonymous User	03/17/2022, 12:12:31	03/17/2022, 12:18:53	Full Model	Finished	Delete

Workers may try the qualification test more than once (although this is not mentioned or encouraged in the instructions), therefore creating multiple runs under the same Stella identifier. The duplicates must be removed before proceeding to the next step by verifying the run details and removing the run with the lowest number of correct answers from the isee exchange platform; checking the created epoch time allows identifying the correct run. There is no penalty for people trying the qualification test a second time since this covers only the game instructions.

Runs are then downloaded in bulk by selecting all comparable runs. The downloaded data now has a different structure: each variable is presented in a single CSV file and contains all information for each run and time (Table 4.2).

Table 4.2: Survey data structure extract from Stella downloads

Run Name	Run 1	Run 1	Run 1
Created By	Anonymous User	Anonymous User	Anonymous User
User/Team Identifier	68c09a08-7f2e-4319-8ae4-968750238c19	c4710ec1-6cf0-4ea3-9094-c502efc53b5d	91ddbf4b-b69b-483b-825b-38d0e3e9f062
User IP Address	104.57.184.84	24.129.220.240	63.75.245.67
Created (Epoch)	1643154896.516	1643155418.639	1643156085.065
Last Modified (Epoch)	1643155109.165	1643155793.836	1643156305.951
Full Model	Full	Full	Full
Time	Value	Value	Value
1	1	1	1

If the CSV file name contains characters (“ “, [,]) that cannot be processed by Stata, the file must be renamed at this stage. File names must also be shorter than 32 characters. A practical tool to make these file name changes is PowerRename from Microsoft PowerToys v0.48.1, used by the authors.

Stata is used to process data so that the higher aggregating factor is the run and not the variable (Table 4.3). The code used to do so is found in Appendix 4.4.

Table 4.3: Survey data structure extract after Stata processing, additional variables are found to the right of the table.

UserStellaID	UserID	FinalScore	notqualified
009a4c72-5fab-45f1-87f6-b52252691b3a	9213	6	0
016c1539-d8d4-4fce-9f15-f523e1d0d802	5343	2	1
039d6d9e-9adc-4017-9f47-8e2c7a370d39	1433	2	1
091e5df5-0716-4489-af52-3f9665a459d7	4839	2	1

4.2.3 Multiplayer Game

The game model is developed in Stella with specific features to accommodate the multiplayer experience. Instructions on how to adapt the model for game advancing and ending can be found in Stella's tutorials, as well as tips on how to build and enhance the user interface (https://www.iseesystems.com/resources/tutorials/).

The user interface on Stella consists of five instruction slides - three already presented during the qualification test and two with new information - one instruction slide, and one dashboard slide for decision input and graph visualization (Figure 4.2).

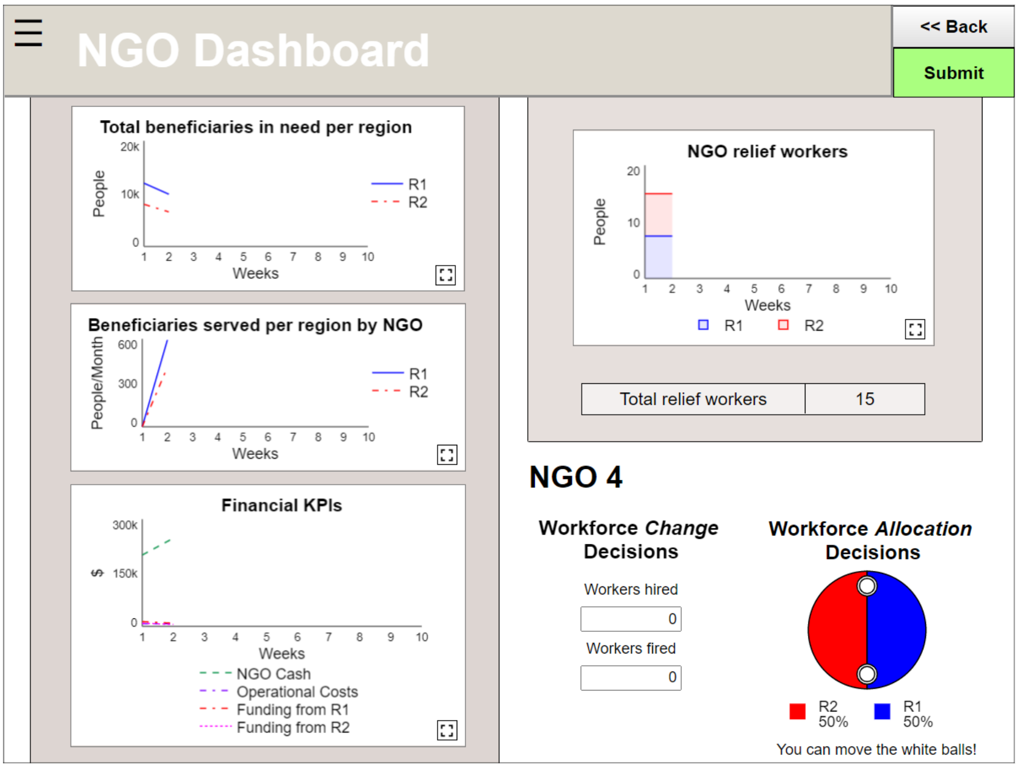


Figure 4.2: Game dashboard

The publishing options on Stella include several features. First, a maximum time of 180 seconds is specified before the game automatically advances, which ensures workers will not be held up by distracted or missing workers. Second, the simulation does not require authentication, therefore enabling anonymized participation. Finally, "collect page tracking data generated by users" is enabled, which allows the requestor access to additional data enabling further worker behavior analysis.

The MTurk setup for the multiplayer game is similar to the qualification test. The only difference regards the requirements: the minimum HIT approval numbers and rates are no longer needed, and neither is location. Instead, the Survey Qualification must be equal to 1, and the Game Completed must not have been granted.

4.2.4 Game Data Handling

The game data is also collected on the isee exchange platform by simulation run (Table 4.4). Runs for which the current time is smaller than the simulation time are runs that have not been completed by workers and can be dismissed.

Table 4.4: Game data as on the isee exchange

Run Name	Created By	Created	Last Updated	Full Model?	Finished?	
Run 5	Team: Zephir	01/17/2022, 18:43:52	01/17/2022, 19:04:26	Full Model	In progress	Delete
Run 5	Team: Umber	01/17/2022, 17:55:11	01/17/2022, 18:40:35	Full Model	Finished	Delete
Run 5	Team: haven	01/17/2022, 17:37:01	01/17/2022, 17:59:52	Full Model	In progress	Delete
Run 5	Team: Indigo	01/17/2022, 17:18:40	01/17/2022, 17:41:35	Full Model	Finished	Delete

Game runs are also downloaded in bulk selecting all comparable runs. Each variable in a different CSV file contains all information for each run, worker, and time (Table 4.5).

Table 4.5: Game data structure in Stella downloads

Run Name	Run 3
Created By	Team: Delta
User/Team Identifier	###
User IP Address	
Created (Epoch)	1643044951.928
Last Modified (Epoch)	1643045113.639
Full Model	Full
Time	Value
1	546
2	842
3	648
4	180
5	228
6	114
7	73
8	28

Stata is also used to process the game data so that the run is the higher aggregating factor (Table 4.6). The code is available in Appendix 4.5. Once processed, the full game data is ready for statistical or other types of analysis.

Table 4.6: Game data structure after Stata processing

Time	actualbnserve dperngon1r1	actualbnserve dperngon1r2	actualbnserve dperngon2r1	actualbnserve dperngon2r2
1	546	448	598	412
2	842	234	592	406
3	648	283	876	615
4	180	283	650	486
5	228	53	461	306
6	114	56	353	250
7	73	51	267	188
8	28	65	205	142

4.3 Insights into Worker Behavior Challenges

To ensure the collected data is adequate, the authors had to solve a series of worker behavior challenges. While some challenges were clear from the outset, others emerged from clues in the collected data and the communication of issues between workers and the requestors. Solving the challenges was a demanding process that included trial and error as well as exchanges with the software developers.

Challenges included bringing workers simultaneously together in an online setting, avoiding worker mischievousness, and keeping them engaged for the duration of the qualification test and the game. These challenges and our solutions are described next in detail. Research elsewhere (Hawkins, 2015) has identified some of these challenges but did not attempt to stir worker behavior in the right direction, rather giving advice on how to separate good from bad data.

Further challenges have also been listed by Cheung et al. (2016), such as selection bias, repeated participation, criteria restriction, and extraneous factors.

4.3.1 How to Bring Workers Together Online

Bringing four workers together online at the same time to start the game was expected to be a challenging situation. Once the game HIT was published, usually not more than one group of four workers would form in the next minutes. Others would try to start the game during the next hours but would wait in vain for enough people to join or would already be distracted once this occurred. This resulted in less than desirable data - both regarding quantity and quality. Thus, two strategies were developed to overcome this challenge.

The first strategy to bring workers together online was to ask workers to identify the best day and time for the game. In this strategy, the qualification test included an additional slide, for qualified workers only, on which they could identify the most suitable times and weekdays to take part in the game. This procedure was useful to identify the beginning of the week (Monday and Tuesday) as more suitable days (even when the qualification test was posted at the end of the week). Yet, not many workers joined the game when made available during the specified times, and the ones that joined usually had to wait a large amount of time until others joined. As in the original challenge, this led to complaints about waiting time, lost run data as workers tried to trick the system to advance more rapidly, and overall low attendance of qualified workers.

The second strategy used the knowledge acquired previously that Mondays and Tuesdays were the best days and expanded on this strategy. Workers would be crowdsourced for two weeks and, on Sunday, the qualified workers would receive their bonus. Issuing a bonus on MTurk allows the requester to send a message which was used to communicate the game schedule details for the following two days - Monday and Tuesday - at three different times - 8 am, 12 pm, and 5 pm ET. This strategy enabled players to join at the same time while still allowing for flexibility and greatly improved attendance. Complaints dropped drastically and a higher percentage of collected data could be used.

4.3.2 How to Avoid Worker Mischievousness

Worker mischievousness challenges comprised two types of behaviors: first, joining the game in multiple roles to make the game start faster, and second, skipping instruction pages to make the game advance faster.

Regarding the first challenge, workers would open additional anonymous browser pages or join the game from other devices pretending to be another worker. This would make the game start faster as all four mandatory roles would have been filled. The Stella ID for these workers would though be the same and these double entries are easily recognized. Yet, it invalidates the collected data. A mix of strategies was needed to keep workers in place: 1) adding a warning on the HIT description on MTurk to let workers know they would be blocked on MTurk and would not receive any payment, 2) asking them to insert their MTurk worker ID into the role name when starting the Stella game, and 3) asking workers to join only games where all other role names (which they can see before joining a game) are worker IDs.

Regarding the second challenge, workers cheated the experiment by manually increasing the page count on the URL to skip instruction pages and get the unique code needed for MTurk to issue the payment. This could be observed by downloading the "Page Tracking Data" and checking how much time workers spent on the slides - sometimes equal to 0. Sorting out these records consumed some processing time and led to unnecessary expenditures. A partial solution was implemented with a warning on the welcoming slide: "workers that use the address bar to advance to the code page thereby not answering the survey and qualification test will be BLOCKED and won't receive any compensation." Later on, a better solution was proposed by the Stella team as they implemented a new feature on the publishing options: choosing to "hide page numbers in URL and ignore browser base navigation" solves the problem as workers cannot skip any more pages.

4.3.3 How to Keep Workers Engaged

Another challenge was to keep workers engaged in the online multiplayer game. If a player felt disengaged, they could invalidate the data collected for that particular run and nullify the effort to qualify all four workers. The engaged workers would still have to be paid, which increased the cost of the experiment.

The Stella page tracking data was the first dataset to help gauge worker engagement as this dataset shows how much time individual workers spend on each slide. The number of instructions could impact how long workers would keep engaged. Thus, instructions were reduced to the minimum that felt reasonable. The number of decisions was also reduced: instead of three allocation decisions, only two were kept in the final version and their sum amounted to 100%, thus enabling workers to only make one allocation decision and automatically calculate the complementary percentage.

While minimizing instructions and decisions was helpful, some workers would start the game and leave it after a couple of rounds. Analyzing the values for the decision-making variables was invaluable for this verification. E.g., we found out that when decision-making variables would remain the same during the game (or would change only in the first couple of timesteps), workers had left the game and further values would only be recorded because the game would advance automatically. A minimum threshold of changes had to be adopted and runs that did not fulfill the requirement had to be dismissed.

Finally, enabling communication among workers had an unintended positive effect on worker engagement. Communication among workers was allowed in this experiment and even encouraged. The communication feature was available to workers from the first game slide, thus workers would help each other navigate the instruction pages. They would also cheer each other on if one of the workers was not responsive. Additionally, they conferred among themselves and would send the requestor an email if they encountered an issue during the game - usually regarding a fellow worker - and would pass the response on to the other workers.

While the game consisted of only one task, extant literature has described the presentation of tasks with different complexity and their sequence to keep participants engaged (Almaatouq et al., 2021a).

4.4 Lessons Learned and Future Developments

Besides the many lessons learned from worker behavior, a few more aspects are highlighted regarding facilitator mediation, time management, and gender bias in communication. This section closes with suggestions for future development.

Facilitator mediation. The challenges in worker behavior hint at the differences between traditional in loco experiments and online experiments. Some issues may have been prompted by the lack of direct contact between researchers and workers that would allow for some trust to emerge. No direct contact means that workers are not being observed by the researchers and only loosely by peers (through communication), maybe feeling less pressured to conform to social rules (Sproull et al., 1996).

Time management. Data collection in any research project can be very time-consuming, and crowdsourcing from MTurk is no exception - quite the contrary. There is additional time spent processing each new batch of data every 24 hours and each batch must be checked for data validity. Further, data must be processed promptly to issue the correct payment and, in this experiment, issue the bonus payment for qualified workers just before the game becomes available. Research projects that envision online multiplayer experiments must account for these procedures and plan accordingly.

Gender bias in communication. The mix of strategies to avoid worker mischievousness joining the game in multiple roles took care of another concern. The authors anticipated the possibility of gender bias in communication among workers as the role assignment on Stella requires a name entry. To avoid gender bias, the authors first asked workers to choose from a gender-neutral list of names during the role assignment. Asking for the worker ID is though more efficient as it is an alpha-numeric code that does not hint at gender and solves the worker mischievousness issue. Workers would address each other according to their roles, in this case, NGO1, NGO2, NGO3, and NGO4, and not introduce themselves by their names.

Future developments. While this paper aims to present and provide possible solutions to what are perceived as common challenges in online multiplayer experiments, it is nonetheless based on the experiences of two authors. Different experiment rules, e.g., not allowing workers to take the qualification test twice, would require modifications or additions to the challenges and solutions presented here. Experiments with other software combinations are another possibility. If keeping Stella, it would be great if there was an option to automatically present the collected data to researchers as currently is done after processing on Stata; this would also make the step on Stata not necessary anymore. Finally, games that traditionally have needed a facilitator, e.g., beer game, could be adjusted to not need facilitators and be conducted on crowdsourcing platforms, enabling more data collection, analysis, and further insights.

4.5 Conclusion

We hope this paper is useful for other researchers considering conducting online multiplayer experiments. Receiving feedback about player behavior is more challenging for researchers in online experiments and it becomes increasingly hard when the multiplayer factor adds complexity. Many steps are necessary to implement the full crowdsourcing and data processing phases, and enough time should be allowed for multiple iterations to address all challenges.

While each experiment may present its own challenges, online multiplayer experiments are subject to greater challenges in bringing workers together simultaneously, avoiding worker mischievousness, and keeping workers engaged. This paper presents how design and software features can prevent some of these issues, and provides a guide for the common-pool resource field to benefit from system dynamics software and crowdsourcing platforms to advance research.

Acknowledgements

The authors would like to thank the Stella team for their kind willingness and excellent assistance to further update Stella Architect and the isee exchange platform.

Appendix 4.1: CPR Context for the Experiment

During the early phases of an emergency response to a rapid-onset disaster, when media attention is abundant and financial resources are readily available (Eisensee and Strömberg, 2007), HOs typically compete for resources (Stephenson Jr. et al. 2006; Lindenberg, 2001). Beyond media attention and donor funding, HOs also compete for transport (e.g., helicopters, trucks), qualified human resources (e.g., local translators), local infrastructure (e.g., accommodation, communication materials), data (e.g., information on affected population), and even beneficiaries (Oloruntoba and Gray, 2006).

While competition for such resources is common among HOs, it leads to negative and undesirable effects during humanitarian operations. For instance, HO competition duplicates efforts and increases overall costs (e.g., conducting parallel needs assessments, collecting and not sharing impact data), creates inefficiencies and lowers overall performance (e.g., inadequately allocating resources and response efforts), and hampers coordination (e.g., acting individually and myopically) in humanitarian response (Kent, 1987; Stephenson, 2005). All of which translates into more suffering and even unnecessarily lost lives.

Enhanced coordination among the numerous actors could potentially yield improved outcomes for both HOs and beneficiaries. This challenge is not exclusive to this context; the common-pool resource (CPR) literature also examines the difficulties in coordinating and surmounting social dilemmas, in which individuals must choose between their optimal decisions as individuals and those as community members. According to Ostrom (2000), common-pool resources are "natural or humanly created systems that generate a finite flow of benefits where it is costly to exclude beneficiaries and one person's consumption subtracts from the amount of benefits available to others."

Humanitarian operations, too, are constrained by finite resources, whether it be funding or the number of beneficiaries they can assist. HOs try to be first on the ground and secure service to beneficiaries, to convey their operational capability and impact in hopes of gaining broader access to donor funding (WFP, 2019; UNICEF, 2021; Nafi, 2018; Stairs, 2010).

Aiming to enhance the collective performance of HOs, we develop several hypotheses (with a comprehensive theoretical framework to be presented in detail elsewhere):

H1: a group allowed to communicate discusses elements that coordinate its effort and has, therefore, a higher probability of maximizing the collective performance.

H2: providing a group with an explicit explanation of stock-and-flow dynamics supplies the group with relevant and necessary information therefore increasing collective performance.

H3: providing a group with contrasting information unveils the logical dissonance of correlational thinking, therefore increasing the probability that the group accurately forecasts the system's dynamics and increases the collective performance.

H4: an explanation of the dominant reinforcing feedback loop provides the group with behavioral information on the most impactful variables which increases the collective performance.

H5: H3 + H4

The dependent variable, collective performance, is captured in the form of an adapted gini coefficient which measures the inequality in beneficiaries served between both regions. The original gini coefficient measures the inequality arising from parts of the population receiving different levels of income. In the adapted gini coefficient we measure the inequality arising from two populations (those in regions 1 and 2) being subject to different waiting times to be served (Figure 4.3). The average waiting time is given by the division of the beneficiaries in need divided by the outflow rate for each region. As the value of the adapted gini coefficient gets closer to 1, there is higher inequality between the time to serve the beneficiaries in both regions. The closer to 0, smaller is the inequality.

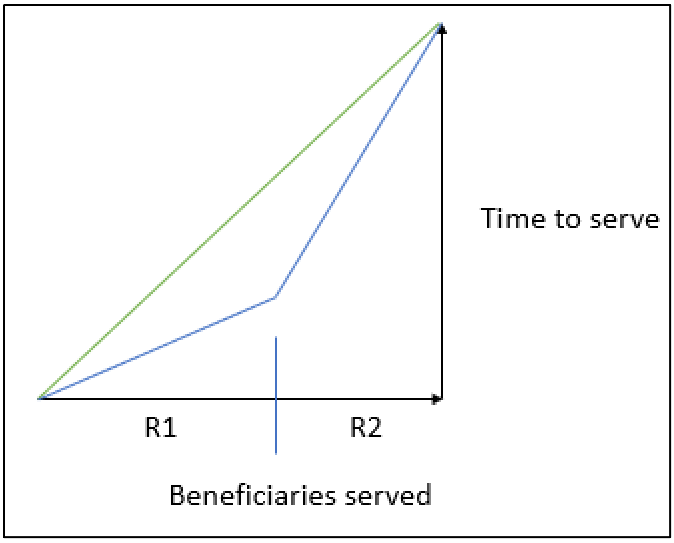


Figure 4.3: Adapted gini coefficient for game

In order to test the hypotheses, we developed a system dynamics model that includes a beneficiary (Bn) component, a relief worker (RW) component, and a cost component. Beneficiaries are assigned to two regions, while relief workers are affiliated with four organizations.

The beneficiary component simulates how beneficiaries are served according to relief worker effectiveness and calculates the remaining beneficiaries in the two regions (**Figure 4.4**).

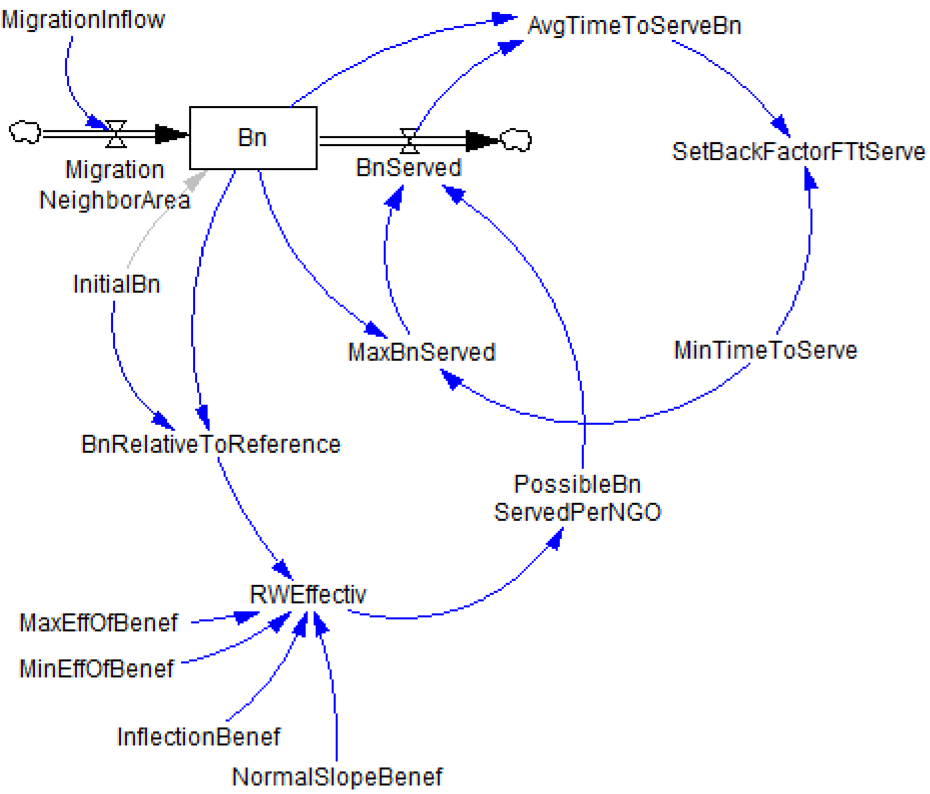


Figure 4.4: Beneficiary component

The relief worker component enables players to make decisions in three areas: the number of relief workers to fire, the number to hire, and the allocation of relief workers to each of the two regions (ensuring that the combined percentages allocate 100% of the relief workers) - Figure 4.5.

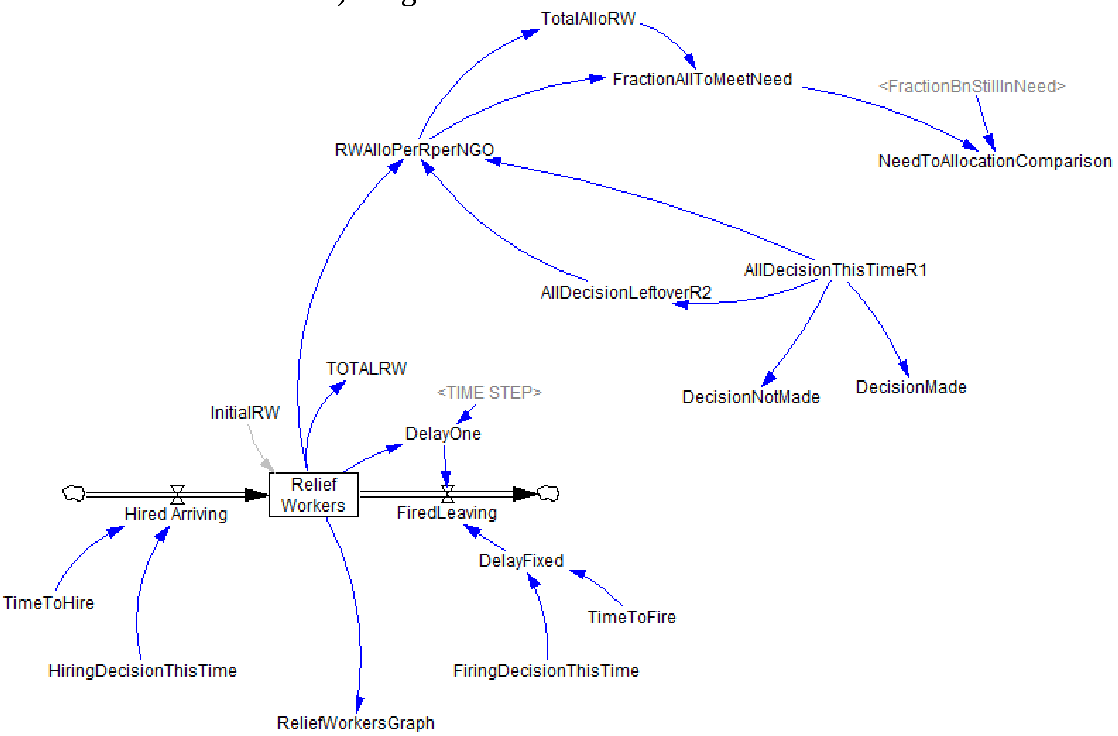


Figure 4.5: Relief worker component

Lastly, the cost component takes into account relief worker-related expenses and the amount of funding received per assisted beneficiary (Figure 4.6). These factors jointly influence the organization's cash position.

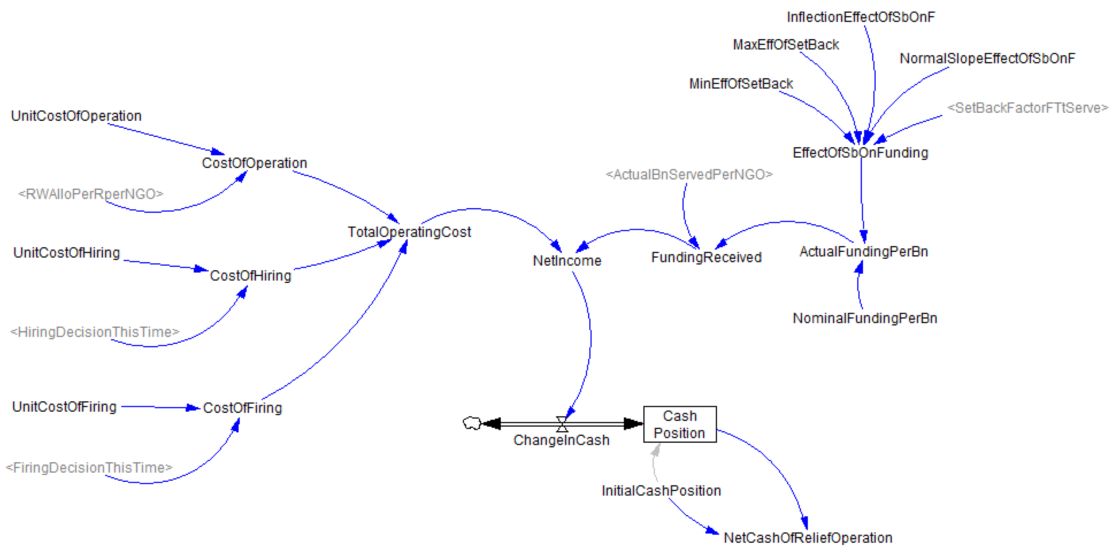


Figure 4.6: Cost component

Integrating these components reveals the underlying feedback dynamics. The stock of beneficiaries increases with migration from neighboring areas and decreases as beneficiaries receive assistance. The assistance rate provided by relief workers is influenced by the number of beneficiaries, as larger numbers are more easily accessible than smaller ones. The number of relief workers is affected by the organization's hiring and firing decisions, and more specifically, their allocation to a particular region. As more relief workers are assigned to a region, their effectiveness diminishes due to the decreasing number of beneficiaries. As more beneficiaries are served, HOs receive increased funding from donors, which in turn enables them to hire more relief workers. This reinforcing feedback loop can, however, operate viciously, with reduced relief worker effectiveness leading to fewer beneficiaries being served, decreased funding, and ultimately, further firing of relief workers.

Utilizing the outlined procedure for data collection and processing, we gathered the following pilot data:

- Base case (BC): 1 game
- Communication (CO): 8 games
- Bathtub(BT): 5 games
- Bathtub + contradictory info (BT+): 3 games
- R Loop (RL): 2 games
- All together (AT): 5 games

Figure 4.7 shows the Gini Index over time (8 periods) for the communication games.

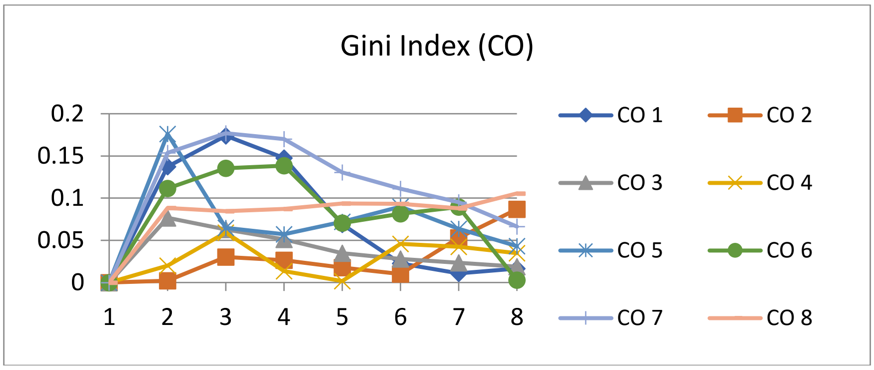


Figure 4.7: Gini index for communication games

Figure 4.8 displays the average net cash operation and total relief workers for the various pilots, which evidently lack statistical significance due to the limited amount of data collected for each scenario.

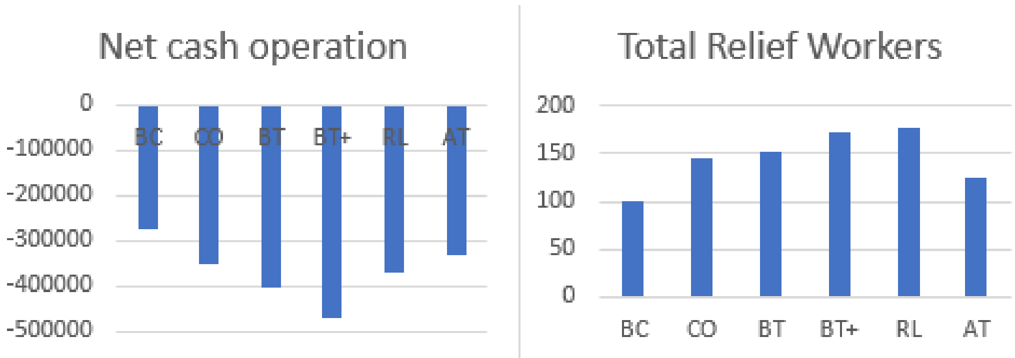
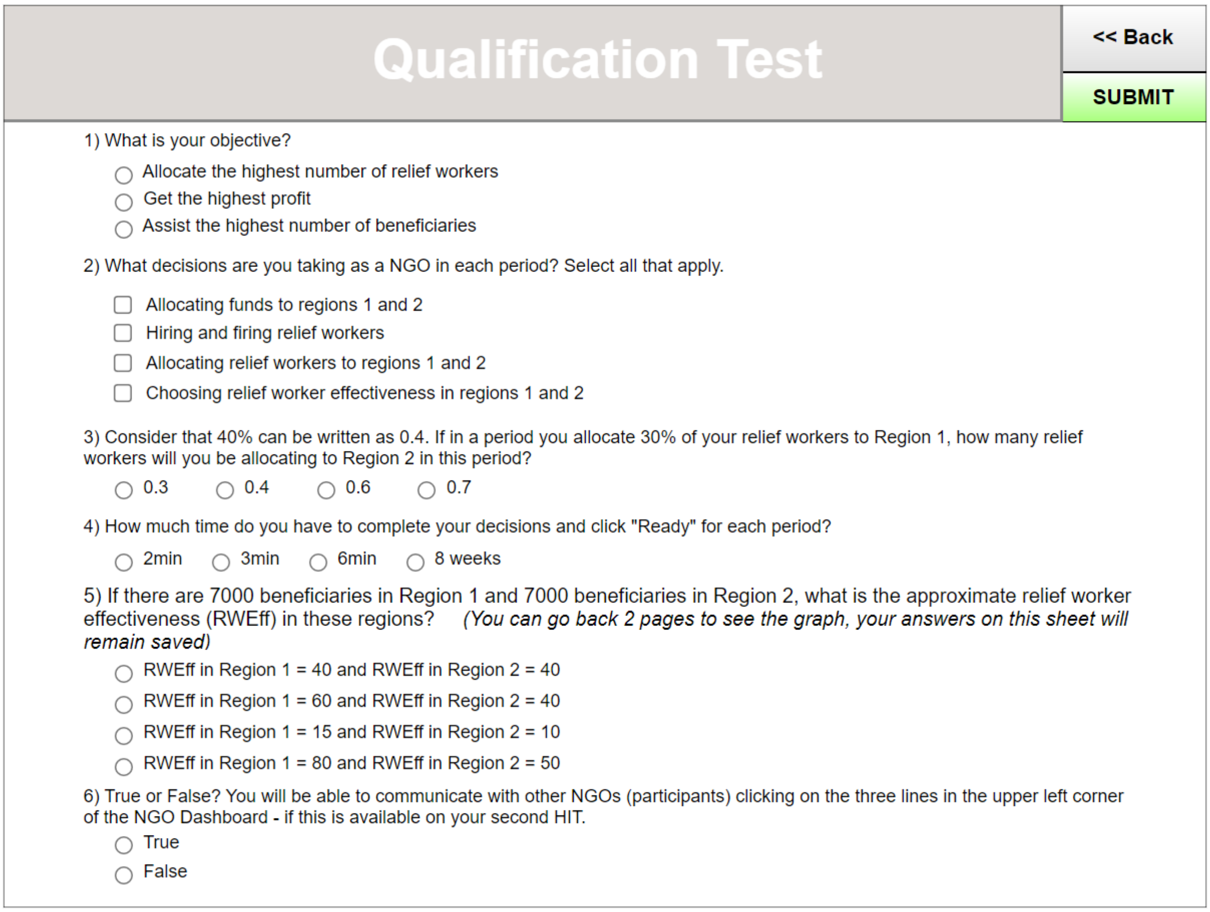


Figure 4.8: Average net cash operation and total relief workers for the different scenarios

Appendix 4.2: Qualification Test Stella Structure

This appendix presents the qualification test components. Figure 4.9 presents the model interface design and Figure 4.10 presents the relationships between variables. The code as implemented in Stella is shown next.



Qualification Test

<< Back

SUBMIT

1) What is your objective?

- Allocate the highest number of relief workers
- Get the highest profit
- Assist the highest number of beneficiaries

2) What decisions are you taking as a NGO in each period? Select all that apply.

- Allocating funds to regions 1 and 2
- Hiring and firing relief workers
- Allocating relief workers to regions 1 and 2
- Choosing relief worker effectiveness in regions 1 and 2

3) Consider that 40% can be written as 0.4. If in a period you allocate 30% of your relief workers to Region 1, how many relief workers will you be allocating to Region 2 in this period?

0.3   0.4   0.6   0.7

4) How much time do you have to complete your decisions and click "Ready" for each period?

2min   3min   6min   8 weeks

5) If there are 7000 beneficiaries in Region 1 and 7000 beneficiaries in Region 2, what is the approximate relief worker effectiveness (RWEff) in these regions? *(You can go back 2 pages to see the graph, your answers on this sheet will remain saved)*

- RWEff in Region 1 = 40 and RWEff in Region 2 = 40
- RWEff in Region 1 = 60 and RWEff in Region 2 = 40
- RWEff in Region 1 = 15 and RWEff in Region 2 = 10
- RWEff in Region 1 = 80 and RWEff in Region 2 = 50

6) True or False? You will be able to communicate with other NGOs (participants) clicking on the three lines in the upper left corner of the NGO Dashboard - if this is available on your second HIT.

- True
- False

Figure 4.9: Interface Design

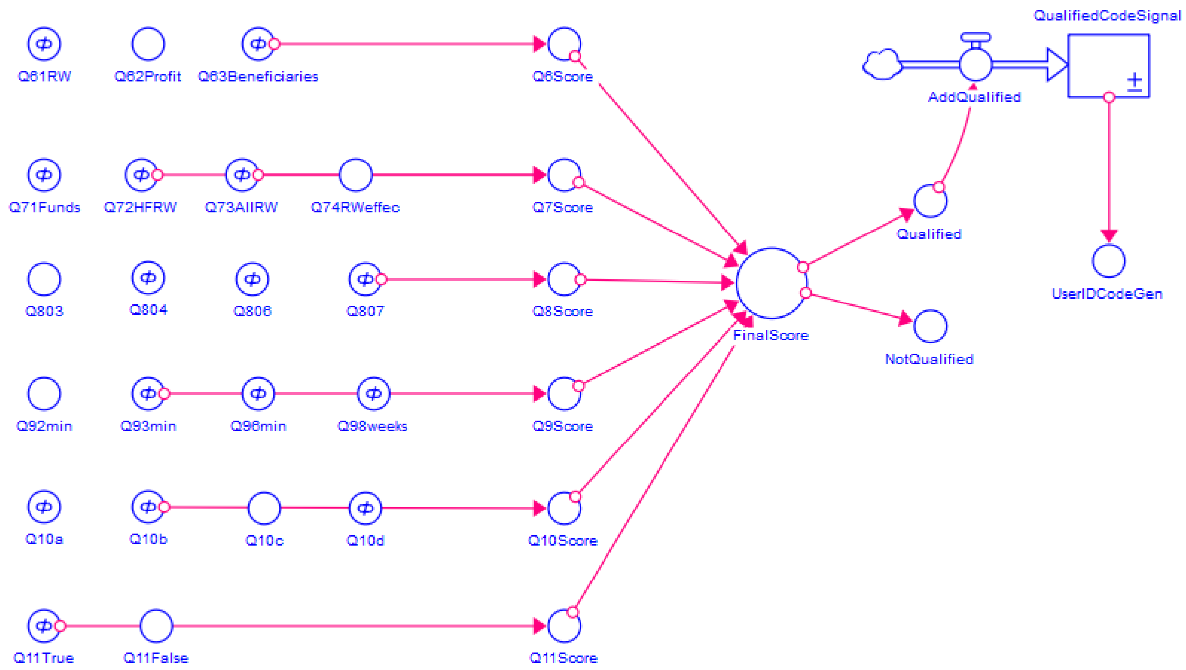


Figure 4.10: Relationships between variables

Code:

```
FinalScore = Q6Score+Q7Score+Q8Score+Q9Score+Q10Score+Q11Score
    UNITS: dmnl
Qualified = IF FinalScore>3 THEN 1 ELSE 0
    UNITS: dmnl
NotQualified = IF FinalScore<4 THEN 1 ELSE 0
    UNITS: dmnl
QualifiedCodeSignal(t) = QualifiedCodeSignal(t - dt) + (AddQualified) * dt
INIT QualifiedCodeSignal = 0
AddQualified = Qualified {UNIFLOW}
UserIDCodeGen = IF QualifiedCodeSignal>0 THEN INT(RANDOM(6000,
10000)) ELSE INT(RANDOM(1000, 5999))
    UNITS: dmnl
Q61RW = Q62Profit = Q63Beneficiaries = 0
    UNITS: dmnl
Q6Score = IF Q63Beneficiaries=1 THEN 1 ELSE 0
    UNITS: dmnl
Q71Funds = Q72HFRW = Q73AllRW = Q74RWeffec = 0
    UNITS: dmnl
Q7Score = IF Q72HFRW=1 AND Q73AllRW=1 THEN 1 ELSE 0
    UNITS: dmnl
Q803 = Q804 = Q806 = Q807 = 0
    UNITS: dmnl
Q8Score = IF Q807=1 THEN 1 ELSE 0
    UNITS: dmnl
```

Q92min = Q93min = Q96min = Q98weeks = 0
UNITS: dmnl
Q9Score = IF Q93min=1 THEN 1 ELSE 0
UNITS: dmnl
Q10a = Q10b = Q10c = Q10d = 0
UNITS: dmnl
Q10Score = IF Q10b=1 THEN 1 ELSE 0
UNITS: dmnl
Q11False = Q11True = 0
UNITS: dmnl
Q11Score = IF Q11True=1 THEN 1 ELSE 0
UNITS: dmnl

Appendix 4.3: Survey

This appendix presents the survey components. Figure 4.11 presents the relationship between variables for the survey check mechanism. The code as implemented in Stella is shown next.

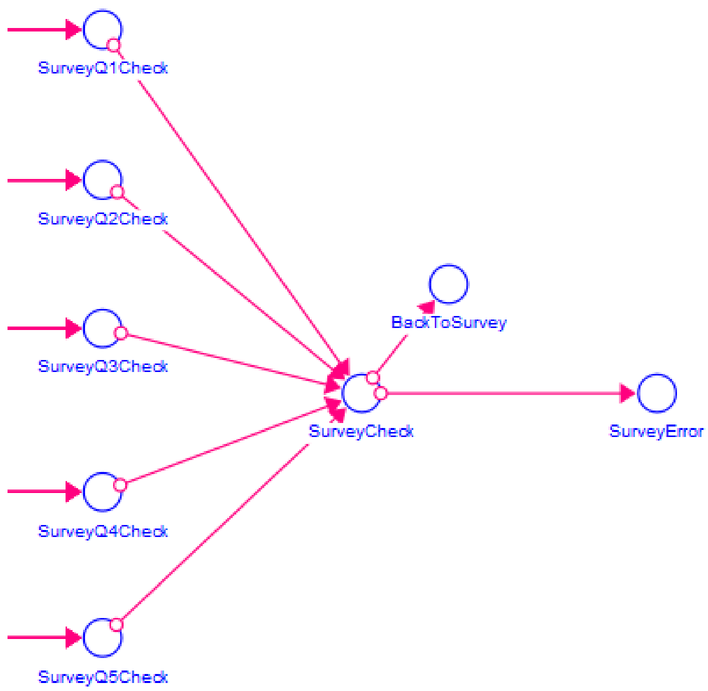


Figure 4.11: Variable relationships for survey check mechanism

Code:

SurveyCheck = IF SurveyQ1Check=0 OR SurveyQ2Check=0 OR SurveyQ3Check=0 OR SurveyError = IF SurveyCheck=0 THEN 1 ELSE 0

```
        UNITS: dmnl
BackToSurvey = 1-SurveyCheck
        UNITS: dmnl
SurveyQ1Check = IF Q1Male=0 AND Q1Female=0 AND Q1Nonbinary=0
AND Q1PNtS=0 THEN 0 ELSE 1
        UNITS: dmnl
SurveyQ2Check = IF Q21Under18=0 AND Q2218to24=0 AND Q2325to34=0
AND Q2435to44=0 AND Q2545to54=0 AND Q2655to64=0 AND
Q2765to74=0 AND Q2875orolder=0 THEN 0 ELSE 1
        UNITS: dmnl
SurveyQ3Check = IF Q31PrimaryEducation=0 AND
Q32SecondaryEducation=0 AND Q33Bachelors=0 AND Q34Masters=0 AND
Q35Doctorate=0 THEN 0 ELSE 1
        UNITS: dmnl
SurveyQ4Check = IF Q41None=0 AND Q42LessThan1year=0 AND
Q431to3Years=0 AND Q444to6Years=0 AND Q457orMoreYears=0 THEN 0
ELSE 1
        UNITS: dmnl
SurveyQ5Check = IF Q51Student=0 AND Q52Homemaker=0 AND
Q53Retired=0 AND Q54Unemployed=0 AND Q55PartTimeWorker=0 AND
Q56FullTimeWorker=0 THEN 0 ELSE 1
        UNITS: dmnl
```

Appendix 4.4: Stata Code for Handling Qualification Test Data

This appendix presents the code for handling qualification test data as implemented in Stata.

Code:

```
// set the path for the data folder

cd "/Users/froesr/Stata/20220820/data-download"

local files : dir . files "*.csv"

foreach file in `files' {
        clear
        import delimited `"`file'"'
        local outfile = subinstr("`file'",".csv","",.)
        drop v1
        drop if _n!=3 & _n!=11
        sxpose, clear
        rename _var1 UserStellaID
        rename _var2 `outfile'
        save "`outfile'", replace

}
```

```
save master, replace empty

tempfile master
save `master', replace empty

local files : dir . files "*.dta"
foreach file in `files' {
	merge 1:1 UserStellaID using `file'
	drop _merge
}

save master, replace

// gender and age variables handling are shown as examples below

gen str Gender="0"
replace Gender="Female" if q1female=="1"
replace Gender="Male" if q1male=="1"
replace Gender="Non binary" if q1nonbinary=="1"
replace Gender="Prefer Not to Say" if q1pnts=="1"

gen str Age="0"
replace Age="Under 18" if q21under18=="1"
replace Age="18 to 24" if q2218to24=="1"
replace Age="25 to 34" if q2325to34=="1"
replace Age="35 to 44" if q2435to44=="1"
replace Age="45 to 54" if q2545to54=="1"
replace Age="55 to 64" if q2655to64=="1"
replace Age="65 to 74" if q2765to74=="1"
replace Age="75 or Older" if q2875orolder=="1"

//code for calculations

gen AgeN=0
replace AgeN=18 if Age=="Under 18"
replace AgeN=21 if Age=="18 to 24"
replace AgeN=29.5 if Age=="25 to 34"
replace AgeN=39.5 if Age=="35 to 44"
replace AgeN=49.5 if Age=="45 to 54"
replace AgeN=59.5 if Age=="55 to 64"
replace AgeN=69.5 if Age=="65 to 74"
replace AgeN=75 if Age=="75 or Older"

gen GenderN=0
replace GenderN=1 if Gender=="Female"
replace GenderN=2 if Gender=="Male"
replace GenderN=2 if Gender=="Non binary"
replace GenderN=3 if Gender=="Prefer Not to Say"

//removing all Stella generated codes
```

```
drop q1female q1male q1nonbinary q1pnts
drop q21under18 q2218to24 q2325to34 q2435to44 q2545to54 q2655to64
q2765to74 q2875orolder

//cleaning the data

destring useridcodegen, replace
destring finalscore, replace
destring qualified, replace

rename useridcodegen UserID
rename finalscore FinalScore
rename qualified Qualified

tab Gender
tab Age

save master, replace
```

Appendix 4.5: Stata Code for Handling Game Data

This appendix presents the code for handling game data as implemented in Stata.

Code:

```
// set the path for the data folder

cd "/Users/froesr/Stata/20220924_Communication/data-download_20220124"

local files : dir . files "*.csv"

//Reading the data in the CSV files

foreach file in `files' {
        clear
        import delimited `"`file'"'
        local outfile = subinstr("`file'",".csv","",.)
        local name1 = subinstr("`outfile'","]","",.)
        local name2 = subinstr("`name1'","[","",.)
        drop if _n!=3 & _n<9
        drop in 1
//insert time periods
        drop in 9
        rename v1 Time

/*

        local i 2
```

```
		foreach var of varlist _all {
			local try = strtoname(v`i'[1])
			local try2 = subinstr("`try'","_","",.)
			local try3 = subinstr("`try2'",".","",.)
			rename `var' `name2'ID`try3'
			local ++i
		}

*/

	local i 1
			foreach var of varlist _all {
			destring `var', replace
			local ++i
		}

	egen avg = rowmean (v*)

	rename avg `name2'

	drop v*

	save "`name2'", replace

}

save master, replace empty

tempfile master
save `master', replace empty

// merging the datasets

local files : dir . files "*.dta"
foreach file in `files' {
	merge 1:1 _n using `file'
	drop _merge
}

tsset Time
```

Chapter 5 - Conclusions

5.1 Findings

This dissertation proposes capacity management improvements in the humanitarian setting.

Chapter 2 focuses on material convergence in a complex environment aiming to identify the policies that successfully address non-priority materials, therefore leading to an effective humanitarian response. Based on a system dynamics model that quantitatively represents causal relationships, this chapter finds eight feedback loops that affect the flow of high-priority materials. It shows that policies that directly or indirectly reallocate resources from handling non-priority to high-priority materials lead to a more effective response and that, overall, the policies of admission control, donor education, quantity of human resource, and pre-positioning policies perform better than the others. In an effort to place the case study of São Luiz do Paraitinga and draw more general conclusions that affect the parameters of the model although not the relationships, additional aspects are considered: forecastable and concentrated disasters increase the effectiveness of almost all policies, and decentralized decision-making is overwhelmingly negative for processing NP and HP materials efficiently. An estimate of the implementation difficulty of policies provides further insights into the various aspects to be considered. Finally, this chapter also presents the result of combining policies and concludes that blending policies that intervene on different feedback loops can result in more efficient humanitarian operations.

Chapter 3 refers to the need of supporting humanitarian professionals in achieving a master’s degree as a capacity-building initiative. The chapter presents the full development of instructional materials to support students in their thesis development. The materials include assignments, rubrics, and tutorials that guide students step-by-step and allow supervisors to spend time counseling students on content rather than on form. The materials were successful in building capacity in humanitarian professionals contributing, as shown by comparing cohorts before and after the thesis process implementation, MASHLM09 and MASHLM10 students achieved a higher graduation rate and presented more outstanding theses in comparison to earlier cohorts; MASHLM10 also achieved the highest average grade for all cohorts.

Chapter 4 considers the development needed to study humanitarian operations from a common-pool resource perspective, i.e., how to develop online multiplayer experiments to empower researchers in understanding capacity allocation problems among several actors that source from one specific finite resource. The chapter presents detailed setup and data processing steps for integrating system dynamics tools, a crowdsourcing platform, and statistics software. Further, this work renders insights into how worker behavior affects online multiplayer experiments and offers solutions to bringing workers together simultaneously, avoiding worker mischievousness, and keeping workers engaged.

5.2 Contributions

In its entirety, this dissertation contributes to the capacity management literature with individual contributions from each chapter.

Chapter 2 contributes to the material convergence literature (Fritz and Mathewson, 1957; Holguín-Veras, 2012b; Wachtendorf et al., 2013; Holguín-Veras et al., 2014) by presenting a system dynamics model that differentiates material flows and explicitly quantifies causal relationships. The model captures both feedback loops that help unveil the negative effect of in-kind donations and human resources allocation rules related to ten different policies. The model allows testing the policies and three different metrics help rank their effectiveness, which extends previous literature that focused on a comparison of up to two policies on limited metrics (Organización Panamericana de la Salud, 2008; Besiou et al., 2011; Jaller, 2011; Holguín-Veras et al., 2012b; Cuervo et al., 2010; Kunz et al., 2013; Costa, 2015). The holistic view adds to the literature on aggregate disaster response analysis and allows a better comprehension of how specific policies impact aid distribution. This chapter also extends the literature by including aspects of different kinds of disasters and decision-making processes, thus increasing the robustness of the findings and addressing generalization concerns.

Chapter 3 contributes to the capacity-building literature in humanitarian operations by presenting instructional materials that build the capacity of humanitarian professionals, specifically focusing on the MASHLM program (MASHLM, 2021). This chapter also contributes to the education literature by providing materials that offer methodological support and knowledge of research sub-processes for students and supervisors in guiding positions to use during thesis development activities (Van der Marel et al., 2022; Filippou et al., 2021; Ibragimova et al., 2020). This chapter also illustrates the process of deconstructing and structuring complex issues for effective problem-solving, an essential skill for humanitarian organizations. Additionally, the chapter employs the deliberate practice approach, which provenly has a significant impact in the humanitarian context.

Chapter 4 contributes to several research areas. First, it adds to the system dynamics literature by integrating system dynamics tools with other software for data collection. It also adds to the experiment literature by providing step-by-step instructions on how to set up and collect data using crowdsourcing tools. It further highlights the player challenge behaviors and how these can be addressed (Hawkins, 2015; Cheung et al., 2016). Finally, the chapter expands the common-pool resource literature by showing how to conduct an online crowdsourcing multiplayer experiment for common-pool resource problems (Ostrom, 1990; Lindahl et al., 2015; Osborne et al., 2019; Tisdell et al., 2004), which can also be transferred to other literature that focuses on experiments involving multiple actors synchronously. Chapter 4 opens the avenue for researchers using system dynamics models and interfaces to explore online multiplayer experiments and their benefits such as diverse subject pools, reduced costs compared to field experiments, and scalability (Rezlescu et al., 2020; Hawkins, 2015; Almaatouq et al., 2021b; Poteete et al., 2010).

5.3 Future Research

Starting from this dissertation, several next steps for future research can be envisioned.

Chapter 2 can be expanded by introducing further human resource allocation policies and fine-tuning the proportion of resources allocated to the high-priority processing steps. The system dynamics model helps highlight avenues for further data collection, which in turn can lead to a fully calibrated model. Further, the admission control policy could be explored and implemented. Finally, the model could be expanded to include factors such as transportation capacity and jams, customs procedures, closing the feedback loop between donations and an organization's acquisitions through monetary donations, donor and media agendas, cultural aspects and legislation, further discrimination of material flows with the addition of low priority flows, and reprioritization of materials during the disaster response cycle.

Chapter 3 can serve as the foundation for other undergrad and master programs to adapt the materials and provide support to their students. Adapting the materials can be done in mainly two ways. First, master programs with a less managerial focus will focus on different methods, which can be presented instead of the methods highlighted in this version. Second, it can be difficult for students to transfer knowledge from the given examples in the humanitarian field to their area of interest – adapting the examples not only reduces the barriers to knowledge transferability as well as can keep students more motivated on the topic.

Chapter 4 opens research avenues for the humanitarian, common-pool resource, and other fields that study decision-making involving several actors to collect data using online multiplayer experiments. Based on the presented setup, experiments can be modified to not allow workers to take the qualification test twice or encompass other experiment rules. Further, tools can be exchanged according to the needs, e.g., other system dynamics platforms can be used, thus increasing the flexibility and availability of experiment design and setup. Finally, system dynamics games that have traditionally needed facilitators (e.g., beer game) could be modified so as to not need facilitators and take full advantage of empowered data collection through crowdsourcing platforms.

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