FOOD AID DISTRIBUTION DURING DISASTER RESPONSE AND SHORT-TERM RECOVERY: ENHANCING PERFORMANCE OF HETEROGENEOUS HUMANITARIAN LOGISTICS STRUCTURES

by

Juan Camilo Sánchez Gil

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Juan Camilo Sánchez Gil

Approved: _____
Leland Ware, J.D.
Interim Director of the School of Public Policy and Administration

Approved: _____
George H. Watson, Ph.D.
Dean of the College of Arts and Sciences

Approved: _____
Ann L. Ardis, Ph.D.
Senior Vice Provost for Graduate and Professional Education

I certify that I have read this dissertation and that, in my opinion, it meets the academic and professional standards required by the University as a dissertation for the degree of Doctor of Philosophy.

Signed: _____

Sue McNeil, Ph.D.
Professor in charge of dissertation

I certify that I have read this dissertation and that, in my opinion, it meets the academic and professional standards required by the University as a dissertation for the degree of Doctor of Philosophy.

Signed: _____

Tricia Wachtendorf, Ph.D.
Member of dissertation committee

I certify that I have read this dissertation and that, in my opinion, it meets the academic and professional standards required by the University as a dissertation for the degree of Doctor of Philosophy.

Signed: _____

Earl Lee, Ph.D.
Member of dissertation committee

I certify that I have read this dissertation and that, in my opinion, it meets the academic and professional standards required by the University as a dissertation for the degree of Doctor of Philosophy.

Signed: _____

José Holguín-Veras, Ph.D.
Member of dissertation committee

I certify that I have read this dissertation and that, in my opinion, it meets the academic and professional standards required by the University as a dissertation for the degree of Doctor of Philosophy.

Signed: _____

Jeffrey Villaveces, M.Sc.
Member of dissertation committee

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ACRONYMS AND ABBREVIATIONS

ACHD – Armed conflict hypothetical demand

B – Beneficiaries

CAN – Collaborative Aid Network

CERF – Central Emergency Response Fund (UN)

CLOPAD – *Comité Local para la Atención de Desastres* (Spanish acronym)

COP – Colombian Pesos

CRC – Columbian Red Cross

CREPADS – *Comité Regional para la Atención de Desastres* (Spanish acronym)

DC – Distribution Center

DEEP – The Center for Disaster and Extreme Event Preparedness

DS - Downstream

ECHO – European Union Humanitarian Aid and Civil Protection Department

EHP – *Equipo Humanitario Pais (*Spanish acronym*)*

ELN – National Liberation Army

ERF – Emergency Response Fund

FAO – Food and Agriculture Organization (UN)

FARC – Revolutionary Armed Forces of Colombia

FFMM – *Fuerzas Militares de Colombia (*Spanish acronym*)*

FON – Full Outsourcing Network

GHA – Global Humanitarian Assistance

HAN – Hybrid Approach Network

HCT – Humanitarian Country Team

HL – Humanitarian Logistics

ICBF - *Instituto Colombiano de Bienestar Famililar* (Spanish acronym)

ICRC – International Committee of the Red Cross

IDPs – Internally Displaced Persons

INCAS – *Innovacion y gestion de cadenas de Abastecimiento (*Spanish acronym*)*

IOM – International Organization for Migration

MS – Midstream

MSF – Médecins Sans Frontières *(*French acronym)

NDHD – Natural disasters hypothetical demand

NGO – Non-Governmental Organization

OCHA – Office for the Coordination of Humanitarian Affairs

PD-HL – Post-disaster Humanitarian Logistics

POD – Point of Distribution

R-HL – Regular Humanitarian Logistics

RN – Relief networks

SSN – Strong Supportive Networks

UARIV – *Unidad de Atención y Reparación Integral de Víctimas* (Spanish acronym)

UBN – Unsatisfied Basic Needs

UMV - *Unidad Municipal de Víctimas de Medellín* (Spanish acronym)

UNGRD – *Unidad Nacional para la Gestión de Riesgo de Desastres (*Spanish acronym)

UNHCR – United Nations High Commissioner for Refugees

UNJLC – United Nations Joint Logistics Center

US – Upstream

USAID – United States Agency for International Development

VOAD – Volunteer Organizations Active in Disasters

WFP – World Food Program

ABSTRACT

Humanitarian logistics is the lifeline between food and those impacted by armed conflicts and natural hazards in developing countries. Those impacted may also experience "*doble afectación*" as a result of displacement due to armed conflicts and the exposure to one or more disaster events at the same time. Such is the Colombian situation where in 2013 more than 4 million internally displaced persons from the armed conflict, combined with at least 3.5 million impacted by the 2010 and 2011 floods created a population group concurrently impacted by man-made and natural disasters. When self-evaluating the performance of food aid distribution, the humanitarian agencies in Colombia acknowledge dissatisfaction when it comes to assuring minimal food security levels to those impacted by disasters during the response and short–term recovery phases of disaster management. A major challenge is that the humanitarian action that assists each group of impacted people operates separately ignoring opportunities for gaining efficiencies in the food aid distribution process from operating synergistically, either among actors from the same humanitarian agency or combined. This research recognizes the heterogeneity of the humanitarian logistics structures that orchestrate food aid distribution, but hypothesizes that such heterogeneity may be a link to improving the performance of disaster response operations. Based on concepts widely discussed by scholars in humanitarian and commercial logistics, this research identifies typologies of humanitarian logistics structures that contribute to closing a performance gap in the context of orchestrating food aid distribution using the supply chains identified as

well. Following a new approach to humanitarian logistics modeling from the literature, this research assesses the performance of recommended food aid distribution policies, as determined by both operational and social considerations. Using formulations that realistically represent some of the challenges of the humanitarian action and actual data collected though fieldwork, this research focuses on the humanitarian logistics strategies that contribute to minimizing the human suffering of those impacted by the armed conflict and natural disasters in Colombia.

Chapter 1

INTRODUCTION

1.1 The Colombian Situation

The operational challenges of the humanitarian action in Colombia are immense in terms of the area covered, and the diverse locations served when it comes to delivering aid to those impacted. The size of the population impacted and the social, technical and environmental constraints magnify these challenges. After Sudan, Colombia has the second highest number of Internally Displaced Persons (IDPs) in the world as a result of its internal armed conflict. In fact, the number of IDPs in Colombia ranges from 3.5 to 4.9 million people according to different governmental and non-governmental sources. This means that in a total population of 45 million Colombians, approximately 1 in 10 has been internally displaced (International Organizations Position Paper, 2011, p. 2). Emergency assistance to IDPs in Colombia focuses on meeting basic needs relating to food, personal hygiene, cooking utensils, medical and psychological care, emergency transportation and temporary housing. Such needs might be explained by the fact that more than 50% of IDPs have reported physical hunger.

This humanitarian crisis in Colombia is exacerbated when natural hazards, such as floods, landslides, earthquakes and volcanic eruptions, also create pressing needs for disaster operations. More than 10% of Colombian municipalities, distributed throughout more than 68% of Colombian provinces (departments), have had natural disaster-related events in the past 20 years. Specifically, floods and landslides

accounted for 73% of total natural disaster events in Colombia from 1989 to 2009 (Desinventar, 2013). More recently, in 2010 and 2011, “La Niña” caused the worst floods in Colombia’s recent history, affecting 3.1 million people. Given the large number of internally displaced persons, particularly in flood prone areas, as well as 14 million people at permanent risk of flooding, Colombia’s humanitarian crisis of displacement is compounded by natural disaster occurrences (Wong, 2008).

When it comes to government involvement, logistics operations for aid distribution in Colombia are regulated by the legislative framework for humanitarian response, which separates the needs of the IDPs and population impacted by natural hazards. Indeed, the disconnect between the systems that respond to the needs of displaced persons and the needs of those impacted by natural disasters presents problems at both organizational and operational levels.

The origins of the food aid distribution problem in Colombia are primarily explained by the recurrence of disaster events triggered by the most common and pressing hazards, such as the armed conflict and its internally displaced persons, as well as heavy rains. As these hazards turn vulnerable populations into actual populations impacted by disasters, the challenge begins once each humanitarian system separately acknowledges its responsibility in satisfying the food security needs of those impacted, among others duties. Multiple factors challenge the satisfaction of food security needs. Some of them are: the non-collaborative and inconsistent structure of the humanitarian system in Colombia, the weak coordination between the national and local mechanisms and the exogenous variables associated with the location and socioeconomic development of the impacted.

In 2010 and 2011, facing floods triggered by a climate change phenomenon known as La Niña, the national and local governments dedicated efforts to respond to the disaster by creating the *Colombia Humanitaria* Program, whose purpose was to guarantee the life and dignity of the most severely impacted people and communities. In addition to the response of national entities to face this situation, non-governmental actors and the international community were expected to contribute actively to the process as well to enhance the response channels. Evidently, *Colombia Humanitaria* collected financial and goods donations to be used for the response, as well as short-term and long-term recovery phases of disaster management. Nevertheless, *Colombia Humanitaria* left many lessons learned behind in regards to assuring efficiency in the time for responding to the disaster and the deployment of the collected aid during the response phase. The legal framework for Disasters in Colombia issued in 2012 switched the strategic decision-making process to a more presidential level. Still, the operability of the system does not include significant changes aside from the fact that CLOPADS (*Comité Local para la Atención de Desastres*) and CREPADS (*Comité Regional para la Atención de Desastres*), local governmental response entities throughout the country, no longer exist. In linking the current changes of the operational structure with the response capabilities, the humanitarian action system in Colombia struggles in deploying and orchestrating the financial and physical resources once they reach the local governments. For instance, in Chocó, one of the departments (provinces) typically most impacted by the floods, practitioners wonder why problems arise when there is a massive delivery of food aid to those impacted in a semirural area. They are also concerned that the aid is not reaching the population in need (OCHA, 2013).

Additionally, the complexity of the institutional framework that operationalizes the response can potentially magnify the challenges of food aid distribution if the population in need suffers from double vulnerability, i.e. those impacted are IDPs (Internally Displaced Persons) while being hit by any natural hazard such as floods. Both natural and manmade disasters have independent legal frameworks despite the fact that there might be double vulnerability. Indeed, the legal framework totally separates both response systems, which makes one totally disconnected to the other. However, the biggest aid deployment needed has been related to natural disaster response.

Eighty-three percent of IDPs live under extreme poverty, which implies the need for a recurrent distribution of food aid to satisfy their food security needs, with the imminent challenge of quantifying the amount of such supplies. Because IDPs mostly head to marginalized areas in big cities, they are also exposed to natural disasters like floods and landslides, which allows for the challenge of concurrently assisting impacted people from both response systems. To recall an example, which is not related to food aid, but does reflect the complexity of the disconnect between the two systems: IDPs who are impacted by natural disasters as well may not be considered as such by the governmental qualifying standards when it comes to assessing how impacted their homes were for recovery purposes. In reality, some of those impacted can actually be seen still in temporary homes not provided by governmental agencies because they did not qualify as “victims”. As a result, the assistance that government may be providing to the impacted people could be somehow discriminatory due to the conflict originated by the disconnection of the two response systems. Those impacted by floods in *Ayapel, Córdoba* for instance, received

$50 a month for supplies over three months, whereas the actual needs far exceeded the aid provided due to supply constraints – among other reasons – in the area. Hence local governmental capabilities really limit the effectiveness of aid distribution despite the supply of certain kits as well as money orders that not necessarily cover the actual needs of the impacted people (OCHA, 2013).

It is true that the more rural the area, the more ineffective the response in Colombia (OCHA, 2013). Some issues are related to the poor economic development of the particular region and the lack of executive skills of local governments in some provinces with such characteristics like *Chocó, Córdoba, Cauca, Nariño, Putumayo* and *Caquetá*. These Departments are impacted by both natural disasters and the armed conflict. The response there is indeed very dependent on the institutions at local levels. For instance, when it comes to *Colombia Humanitaria*, there were indeed sufficient financial resources to be sent to local governments, but because the contractors hired to operationalize the distribution of aid lacked experience in disasters, the response ended up being ineffective (OCHA, 2013). *Colombia Humanitaria* does not have a humanitarian logistics structure to execute the response and recovery at a local level; hence there are plenty of logistics issues to work on in Colombia when it comes to response.

1.2 Background and Motivation

Humanitarian response to and recovery from natural disasters in Colombia requires acknowledgment of the manmade disaster derived from the armed conflict, as well as understanding the impacts of past and potential natural disasters. The armed conflict has created internally displaced persons (IDPs) and natural disasters exacerbate the vulnerability of this population. In attempting to relieve the suffering of

those impacted, “a major dilemma facing Colombia to ensuring that humanitarian assistance, in particular food aid, reaches the most vulnerable IDPs and has the greatest impact, all while adhering to basic principles of neutrality and impartiality” (Hines & Balletto, 2002, p. vii). Indeed, the government has implemented three main food programs for IDPs: food vouchers, dry food rations, and a wet feeding program. However, the impact of these programs has been uneven. For example, it was reported that fewer IDPs benefitted from dry food rations, but more had access to the wet feeding program (Internal displacement monitoring center, 2011, p. 42). Additionally, “while the country has a rather sophisticated legal protection framework and considerable financial resources earmarked for assistance to IDPs, the emergency humanitarian and protection needs of those impacted by the conflict remain uncovered” (ECHO, 2012, p. 6). However, on one hand, the humanitarian organizations have shown concerns about these operational challenges. In fact, fourteen international non-government organizations (NGOs) signed the report “Humanitarian Crisis in Colombia”, stressing the need for the international humanitarian system to fully acknowledge and respond to the humanitarian needs of IDPs in a principled, efficient and coordinated manner (DARA, 2011, p. 254). On the other hand, practitioners and researchers have explicitly acknowledged that humanitarian logistics accounts for 80% of relief operations (Wassenhove, 2006, p. 475).

This research focuses on rethinking the humanitarian logistics activities, through which the delivery of food aid takes place using established structures, to assist either the population impacted by natural disasters or armed conflict in Colombia during the response and short-term recovery phases of disaster management.

This opens the door for suggesting new policies that synergistically operationalize logistics partnerships. The research also aims to propose policies to reduce the gap between the lack of empowerment and execution of available resources and the still existent uncovered food security needs of those impacted by natural disasters and the armed conflict. Ultimately, such policy recommendations target coordination and collaboration approaches between the two humanitarian systems that assist both those impacted by natural disasters and the armed conflict to achieve better performance. A synergistic logistics operational system that still manages to be realistic in spite of the current independent operational frameworks, which disconnects the two humanitarian systems, is pursued as well. In summary, this dissertation:

1) Addresses the issue that logisticians involved in food aid distribution for those impacted by the armed conflict and natural disasters are independent and uncoordinated in spite of the "*doble afectación*" of the population.
2) Characterizes the "last-mile" problem of logistics in the delivery of food aid to better understand strategies and context.
3) Develops needed policies to support a more coordinated, efficient, effective and efficacious logistics system.
4) Estimates measures of improvements in the humanitarian action as it identifies strategies for closing the performance gaps of parties involved in food aid distribution.

1.3 Problem Statement and Research Questions

The coordination capabilities of the various entities that provide humanitarian aid in Colombia are weak, not only because communication ties are unclear, but also because the humanitarian response and coordination strategies might be threatened by dynamic policies to support natural disasters, together with the persistent displacement situation because of the armed conflict. This situation tends to complicate coordination to the extent that the humanitarian action itself has aimed to strengthen the relationship between the persistent food insecurity situation due to the armed conflict and emergency peak periods as a result of natural disasters (Food and Agriculture Organization, 2012, p. 1). The Colombian humanitarian aid system still struggles in meeting the food security needs of those impacted by natural disasters and the armed conflict despite the significant financial resources from the government and NGOs by not delivering food aid in a timely manner that fulfills the amount and quality demanded.

The following research questions are proposed to begin to address the issues related to the two distinct supply chains for humanitarian aid:

a) In practice, how can the established humanitarian logistics structure that orchestrates the “last mile” distribution of food aid to those impacted by natural disasters and the armed conflict, during the response and short-term recovery phases, be characterized in Colombia?
b) How can such humanitarian logistics structures be reconfigured to improve their performance irrespective of the kind of disaster that occurs

and in spite of the operational challenges implied during the response and short-term recovery phases of disaster management?

c) How can performance improvement of the distribution of humanitarian aid be assessed using analytical models of social costs (logistics and deprivation costs) using operations research?

Addressing these research questions draws on: i) “The social science disaster literature, which has examined institutional arrangements and multi-organizational responses to extreme events, but has given little attention to the impact of such arrangements to the process of delivering relief that ensures on-time aid supply and prevent loss of life” Holguín-Veras et al (2007, p. 76). ii) Field work to understand and characterize the operations of the established humanitarian logistics structures that assist a unique set of the population impacted. iii) Models of food aid to be locally distributed that enhance response capabilities and resiliency of the system, recognizing the constraints derived from the armed conflict as well as the social and functional vulnerability of Colombians to natural disasters.

1.4 Objectives

This dissertation pursues a general objective: to design distribution policies and inventory allocation strategies of food aid that recognizes the heterogeneity of the humanitarian action in Colombia, while still achieving a better performance to meet the food security needs of those impacted by natural disasters and the armed conflict.

Three secondary objectives are pursued as well:

i) Characterize the established humanitarian logistics structures that orchestrate the “last mile” delivery of food aid during the response and short-term recovery phases that assist both those impacted by natural disasters and the armed conflict in Colombia.

ii) Identify typologies of humanitarian logistics structures that lead to gaining efficiencies, efficacy, and effectiveness in the distribution of food aid among the distinct supply chains of each humanitarian system separately; and the like by identifying potential logistics operations intersecting among the distinct supply chains irrespective of the humanitarian system to which they belong.

iii) Assess the improvement in the resulting performance if alternative supply structures responded to those impacted by the armed conflict and natural disasters.

1.5 Overview of the Methodology

Figure 1 provides an overview of the methodology used to address the objectives presented in the previous section. The research is structured around four phases for data collection – identification of the actors, identification of the carriers, forwarders and composition of the supply chain, identification of typologies, and definition of alternative policies – that provide the data and structure for assessing the policy implications of alternative policies including alternative structures.

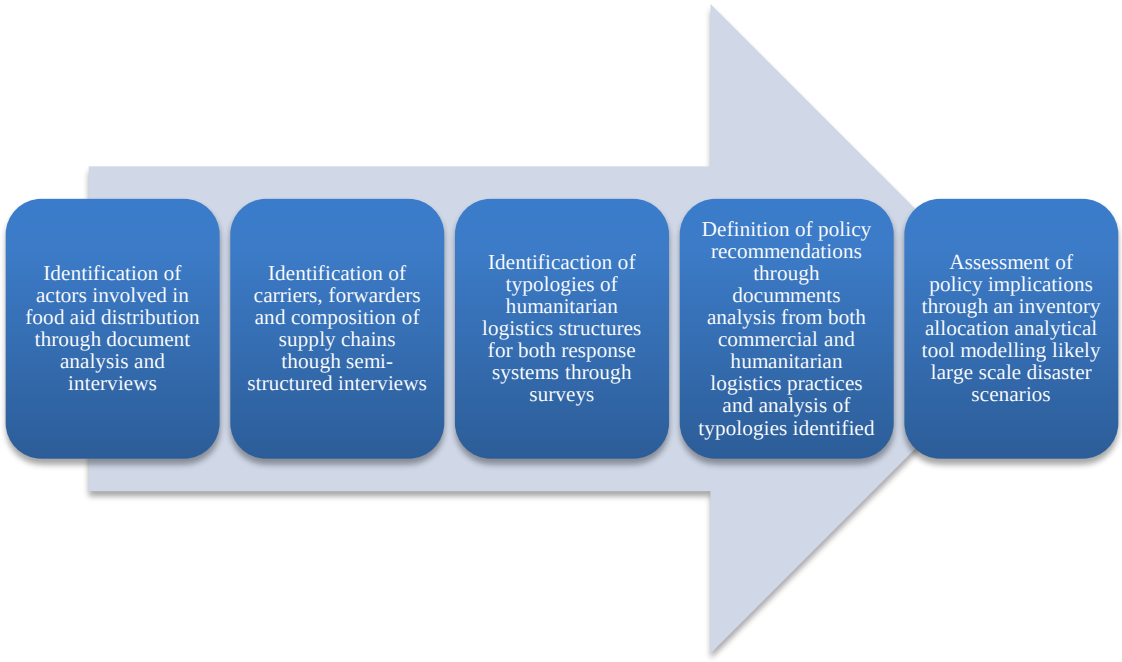


Figure 1. Overview of the methodology

1.6 Outline of the Dissertation

To make navigating the dissertation easier, it is divided into 10 primary chapters:

- Chapter 1: Introduction.
- Chapter 2: Literature review.
- Chapter 3: Research methodology.
- Chapter 4: Phase I results - Identifying the actors.
- Chapter 5: Phase II results - Characterizing the supply chains.
- Chapter 6: Phase III results - Identifying humanitarian logistics structures.
- Chapter 7: Phase IV results - Policy recommendations.
- Chapter 8: Performance assessment methodology.
- Chapter 9: Results of performance assessment and discussion.

- Chapter 10: Final considerations.

Chapter 2 not only reviews literature regarding the width and depth of the main themes attached to this dissertation, such as the Colombian context on disasters, logistics, food security, and organizational aspects, but also reviews the root of the qualitative research strategies, as well as the quantitative methods used.

Chapter 3 introduces the four-phase approach specifying how the qualitative research strategies and quantitative methods were put in context.

Chapter 4 presents the Phase I results. Based on content analysis and surveys, this chapter identifies the actors involved in food aid distribution in Colombia during immediate response and short-term recovery.

Chapter 5 presents the Phase II results: characterizing the supply chains, relief networks (RN) and response systems deploying food aid by the actors identified in Phase I, based on content analysis and surveys, as well geographic information systems.

Chapter 6 identifies the humanitarian logistics (HL) structures (Phase III) by doing content analysis and surveys as well. Ultimately, the HL structures identified in this third phase are comprised of the supply chains identified in Phase II.

Chapter 7 presents Phase IV results, which are divided by policy recommendations drawn on the response systems and HL structures identified on Phases II and III.

Based on analytical model, a performance assessment approach is reached on Chapter 8. Multiple supply and demand scenarios are introduced and assessed to support the decision making process on the policy recommendations reached in Chapter 7.

Chapter 9 opens a discussion on response systems versus HL structures in the Colombian context and infers potential implications of running the analytical model with changes in variables and assumptions.

Chapter 10 concludes the dissertation; highlights contributions and suggests future research in disaster response and HL modeling in countries where natural disasters may hit people impacted by armed conflicts.

Appendices include the Institutional Review Board documents that were used to contact participants and structure the discussions, interviews and surveys, as well as the summary data collected, and detailed analysis results.

Chapter 2

LITERATURE REVIEW

Food aid distribution after a disaster is a recurrent and common goal of the humanitarian action around the world. As this chapter illustrates, a theoretical foundation is presented from a pool of scholars who based their findings on field research experiences regarding scientific contributions to the state of art of disasters and humanitarian logistics. Next, this chapter introduces a discussion of the term "disasters" given the need to understand the theoretical foundations of the IDP crisis and natural disasters in Colombia and the resulting need for humanitarian aid. A review of the disaster literature is also appropriate in order to understand what a disaster is and how the scope of this dissertation is positioned with respect to the specific phases of a particular type of disaster. As the disaster literature is introduced, it is then connected to the term food insecurity. Since this dissertation is particularly concerned with improving the food aid distribution process, understanding the implications of not realizing such distribution becomes essential. Although the term "food insecurity" is broadly discussed by practitioners, the focus here is on scholarly work related to food insecurity during disasters. This then links to the challenges in carrying out humanitarian logistics activities and aims at overcoming such challenges. Thus, understanding the meaning of humanitarian logistics and humanitarian logistics structures is the next step in this literature review. Similarly, given the aim of this dissertation to assess performance regarding food aid inventory allocation strategies, a review of analytical models supporting humanitarian logistics decisions follows. In

summation, Chapter 2 provides the background on which this research aims to be built.

The literature review is presented in seven parts. Section 2.1 reviews the two qualitative research approaches heavily used in this dissertation: surveying and content analysis. Section 2.2 discusses the term “disasters”, the organizational aspects of established parties involved in disaster relief operations, the disaster cycles involving food aid distribution and, finally, a distinction between disasters and catastrophes from a response viewpoint. Section 2.3 highlights the relevance of food insecurity and its implications during post-disaster relief operations. Section 2.4 explores the humanitarian logistics operations in disaster relief, particularly as they differ from commercial logistics in several aspects. Section 2.5 compiles multiple analytical models framing quantitative assessment for humanitarian logistics performance. Finally, sections 2.6 and 2.7 not only summarize the concepts and approaches that directly influenced the development of the subsequent chapters, but also analyze the pertinence of the literature review with the research questions and objectives pursued in this dissertation.

2.1 The Term “Disaster”

Both Perry (2006) and the Federal Emergency Management Agency (2013) agree that there is not a general consensus on the definition of disaster. However, a group of scholars have defined the term around the scope of physical harm and social disruption, which is aligned with the disasters addressed in this dissertation. Thus, the complexity and variety of the events cited here are very representative of both anthropic and natural disasters in Colombia.

Fritz (1961, p. 655) focuses on the physical harm and social impact by defining a disaster as "an event, concentrated in time and space, in which a society, or a relative self-sufficient subdivision of a society, undergoes severe danger and incurs such losses to its members and physical appurtenances that the social structure is disrupted and the fulfillment of all or some of the essential functions of the society is prevented". More specifically, Fritz also highlights that disasters differ in the degree of predictability, probability, and controllability; in the nature of the participating agent (flood, fire, explosion, tornado, hurricane, earthquake, etc.); in their origin (natural, man-made); in their speed of onset (instantaneous, progressive); in their scope (focalized, diffused); and in their destructive effects on people and physical objects. Likewise, Quarantelli (1985) equates the term disaster with physical agents, the physical impact of such physical agents, an assessment of physical impacts, the social disruption resulting from an event with physical impacts, the political definition of certain crisis situations and an imbalance in the demand-capability ration in a crisis situation. Not differing much, Landesman (2004) defines a disaster as any event, typically occurring suddenly, that causes damage, ecological disruption, loss of human life, deterioration of health and health services, and which exceeds the capacity of the impacted community on a scale sufficient to require outside assistance. In line with this definition, Schultz (2006) defines a disaster as an encounter between forces of harm and a human population in harm's way, influenced by the ecological context, in which demands exceed the coping capacity of those in the impacted community, stressing the local capacity for response.

Conversely, Perry (2006) presents a different perspective from several authors who characterize disasters as a social disruption that originates on social structures and

social vulnerability. This perspective also characterizes disaster as the failure of socio-cultural systems, involving cross-national and cross-cultural aspects that are internal to the system itself. This perspective is also strongly linked to the characterization of the disasters addressed in this dissertation, as disasters are a natural outcome of the way Colombian society is structured, particularly regarding the armed conflict and its manipulation of the system. Hence, internal aspects to the system, such as the baseline food insecurity, stratification and inequities, health baseline, cultural plurality, land dispute and land dispossession, fully complement the physical agents that characterize both natural and manmade disasters in Colombia.

2.1.1 Organizational Aspects

As a justification for identifying the type of humanitarian organizations involved in this study, this part of the literature review aims to understand the way practitioners and researches have evidenced the existence of the organizational structures that orchestrate relief aid distribution in post-disasters environments. First, a generic approach is introduced based on the Haitian experience. Next, approaches directly related to the Colombian context regarding natural disasters and manmade disasters are also contextualized.

By classifying organizations as "large and small, international and local, governmental and non-governmental, secular and faith-based, and established and emergent", Holguín-Veras et al (2012a, p. 1625) interviewed representatives from multiple organizations qualifying within any of these types. Specifically, the authors classified not only several UN agencies such as the WFP, but also the Dominican Red Cross and the Dominican Civil Defense as "established" organizations. Conversely, organizations such as *Servicio Social de Iglesias* and *Plataforma de Ayuda a Haití*,

were classified as “emergent” organizations. In another paper, Holguín-Veras et al (2012b) suggest studying the interactions between emergent and established organizations, as well as the coordination mechanisms among them.

Putting the review in a Colombian context, Finger (2011) suggests that established humanitarian actors who assist IDP population can be classified in three groups: “neo-neutral”, “partial-neutral”, and “domestic” entities (both governmental and civil societies). “Neo-neutral” refers to those international organizations that provide assistance strictly based on a specific humanitarian mission and under the principle of neutrality. For instance, while the International Committee of the Red Cross (ICRC) prioritizes humanitarian operations to IDPs based on the “severity of their needs”, the United Nations High Commissioner for Refugees (UNHCR) prioritizes refugees over IDPs. However, other international organizations that may be equally recognized as being as impartial and independent as the ICRC, may not be as neutral. Such is the case of Oxfam, Catholic Relief Services and USAID, for instance, and for which the author classifies as “partial-neutral”. In contrast, governmental agencies, which may represent themselves as an actor of the conflict, are classified as domestic entities.

Continuing the search for secondary information that leads to the right identification of established humanitarian actors in Colombia, the Global Humanitarian Assistance (GHA) program, run by the independent organization Development Initiatives, also suggests a classification of actors assisting IDPs in Colombia (Stirk, 2013). Not differing much from Finger’s approach, the GHA codes actors as those who run domestic (governmental) response, civil society response and international response. In listing specific actors belonging to each classification, the

program stresses the operations of the Department for Social Prosperity, the Victim's unit, and local authorities as the main actors that deploy humanitarian aid from the government. Regarding the civil society response to IDPs, the program highlights the role of national NGOs to improve the situation for the displaced population. Finally, the following organizations represent the international response to IDPs in Colombia: the United Nations agencies system led by the Office for the Coordination of Humanitarian Affairs (OCHA), the World Food Program (WFP) in collaboration with nine UN agencies, seventeen international NGOs, the European Commission's Humanitarian Aid and Civil Protection (ECHO), *Médecins Sans Frontières* (MSF) and the International Committee of the Red Cross (ICRC). In fact, the international response has been upgraded to such a level of collaboration and interaction that they have defined their own organizational structure, called the Humanitarian Country Team (HCT). The HCT operationally segregates into seven response clusters, among which food security and nutrition is led by the Food and Agriculture Organization (FAO) and the WFP. Not sufficiently, the International Organization for Migration (IOM) is funded by USAID to work with the Colombian Government to strengthen the capacity of mayors, governors and other local authorities, as well as the Ministry of Health, the Victims' Unit, the Centre for Historical Memory and the Office of the Ombudsman, to provide assistance to "victims".

On the other hand, upon reviewing organizational aspects associated to natural disaster response in Colombia, three authors suggest a classification of actors keeping within sight the Colombian context. First, Vitoriano et al (2013) states that the agents involved in disaster response can be classified into three levels, according to the involvement in the operations depending on the consequences. These are listed below:

- Local level: the first response level, usually addressed by local agencies, civil society organizations and civil protection. Typically, this level of emergency is not declared as a disaster.
- National level: the army and national civil protection, governmental organizations and NGOs, usually involved when an emergency is defined as a disaster. Also, sometimes, international organizations with local offices participate at this level.
- International level: foreign governments and inter-governmental organizations, international NGOs for disaster response, and the United Nations Agencies. This level is reached when national capacity of response is not enough (due to the scale of the disaster and/or the vulnerability of the country) and the national government authorizes an international humanitarian operation.

Second, complementary to this academic approach, the International Federation of the Red Cross (2014) introduces two reports related to the identification and classification of actors in disaster response. A first approach focuses on bridging national and international support, while the second one specifically focuses on the Colombian context. Drawing on the international dialogue to straightening partnership in disaster response, the former highlights the role of international actors when coordinating with local authorities and international mechanisms, being the immediate disaster response one of the scope of the analysis.

Lastly, Harvey & Harmer (2011) suggest another multi-organizational approach for classifying the humanitarian actors worldwide: International organizations and donor governments, governmental officials, private sector and media, community-based organizations and national civil societies, NGOs and national Red Cross societies.

All of these approaches will be addressed further in this dissertation, as they were crucial for identifying the actors directly involved in food aid distribution in Colombia.

2.1.2 Disasters and Catastrophes

Catastrophes can be defined as high-consequence events that generate widespread and crippling impacts, where the ability of the impacted society to respond is severely compromised. They range in scale from cases where the impacted country can cope, to those where the country has to invite outside assistance, either regional or global. How the country copes will very much depend on the strength of the government and society, and the vulnerability of the population. In Haiti and Somalia, "even a relatively minor disaster can have huge consequences, whereas Japan has well-developed disaster-response mechanism", as reported by Holguín-Veras et al (2012b, p.495).

Technically, a catastrophic event is one in which "most or all of the community-built structure is heavily impacted. . . [and] facilities and operational bases of most emergency organizations are themselves usually hit"; "local officials are unable to undertake their usual work role"; "help from nearby communities cannot be provided"; "most, if not all, of the everyday community functions are sharply and concurrently interrupted"; "the mass media system, especially in recent times, socially constructs catastrophes even more than they do disasters"; there are "mass out-migrations for protracted periods of time"; and, "because of the previous six impacts, the political arena becomes even more important" (Quarantelli E. , 2006). However, Holguín-Veras et al (2012b) state that a catastrophe does not have to exhibit all seven characteristics, but the prevalence of multiple characteristics is an indication of how

catastrophic an event can be. Thus, the authors exemplify catastrophic events using the Tohoku (Japan) tsunami's impact on the town of Minani Sanriku, and the Port-au-Prince earthquake (Haiti).

A non-catastrophic disaster is one in which the local population, authorities and humanitarian organizations can cope with the consequences, despite significant casualties and destruction of infrastructure. The response involves fewer converging entities, less of an interface between the public and private sectors, and allows more autonomy and freedom of action (Quarantelli E. , 2006). In terms of the humanitarian logistics effort, Wachtendorf et al. (2013) point that "in the event of a catastrophe the majority of supplies have to be brought from (well) outside the impacted area, while in a non-catastrophic scenario some resources remain (e.g., trucks, leadership structures, inventory stocks at households and businesses) that could become the first wave of aid to the needy" (Holguín-Veras et al, 2012b, p. 495).

Although scholars clearly distinguish between disasters and catastrophes from the logistics operations involved in distributing supplies during response and recovery, determining whether the scenarios that typically occur in Colombia match the technical aspects of a disaster or a catastrophe is critical to justifying the approach used in this research. For instance, although the food aid distribution to those impacted by the armed conflict takes place mainly from national parties, a significant proportion of the aid deployed is performed by the World Food Program in collaboration with NGOs, given the lack of effective response capabilities from local governments. Clearly, Colombia hasn't been impacted by a catastrophe so far, however, the complexity from being a country prone to natural disasters in areas under the influence of an armed conflict, as well as the existence of isolated areas governed by local

autonomous indigenous communities, demands a unique configuration of response efforts that do not necessarily stick to a unique set of technical features of disasters and catastrophes.

2.2 Food Insecurity during Disasters

OXFAM (2001) defines food security as when everyone has at all times access to and control over sufficient quantities of quality food for an active healthy life. Within this definition, two elements of food security are presented: availability understood as the quality and quantity of the food supply; and access understood as the entitlement to food through purchases, exchange and claims.

Understanding the severity of food insecurity is essential for determining the best type of response. In a livelihoods approach, Young et al (2001) argue that the severity of food insecurity is gauged by its impact on people's ability to feed themselves in the short term (risk to lives), and its impact on livelihoods and self-sufficiency in the longer term (risks to livelihoods). Specifically, a population or livelihood group is considered acutely food insecure if:

- People experience a large reduction in their major source of food and are unable to make up the difference through new strategies;
- The prevalence of malnutrition is abnormally high for the time of year, and this cannot be accounted for by either health or care factors;
- Large proportion of the population or group is using marginal or unsustainable coping strategies;
- People are using 'coping' strategies that are damaging their livelihoods in the

longer term, or incur some other unacceptable cost, such as acting illegally or immorally.

In this respect, OXFAM's definition of food insecurity gets represented by the consequences of disasters, as disasters do manage to disrupt both the availability of and access to food. The following paragraphs elaborate on the connection between food insecurity and disasters.

The World Health Organization (WHO) (2013) discusses how disasters affect the status of food and nutrition, arguing that not all disasters produce food shortages that are so severe as to have a critical impact on the nutritional status of the impacted population. However, they do point out that the nature of food and nutrition problems depends on the type of disaster, its duration and the size of the area impacted, and the nutritional status of the population prior to the disaster. For instance, agents such as hurricanes, floods, and tsunamis directly affect the availability of food, by ravaging crops, killing livestock and domestic animals, and destroying stored food.

Food aid aims to prevent malnutrition in the population impacted by the disaster. WHO (2013) exposes the challenges of distributing food aid during disasters as disasters disrupt transportation systems, communications, and social and economic structures. Thus, even though food stores may exist, the population may not have access to them. The goal of the humanitarian actions then is to overcome these challenges and ensure food security to those impacted by disasters through Humanitarian Logistics activities.

In particular, both researchers and practitioners have expressed concern about the combination of armed conflicts and natural disasters. For example, supported by

the German government, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) offers the following insight (GIZ, 2013):

"Armed conflicts and natural disasters are threatening the livelihood of many millions of people. Poverty, food insecurity and rising food prices trigger new conflicts, especially with regards to access to natural resources such as water and land. In many countries, this situation is further aggravated by a high level of vulnerability to natural disasters, such as flooding, hurricanes or cyclones, and persistent drought. The vicious circle of hunger, conflict, natural disasters and the often-unsustainable survival strategies, adopted by the population impacted, is a permanent source of food crises. The challenge for food security in the context of conflicts and natural disasters is to break this vicious circle and restore the foundations, which ensure survival of the local population."

In agreeing with what practitioners have stated, Haen (2007) addresses the fact that a large and growing share of the world's poor lives under a double risk. They are food insecure and live in conditions where the high risk of natural hazards coincide with high social vulnerability. As a result, natural disasters hit the poor disproportionately. The scholar argues that in order to mitigate disaster impacts on poor population groups, both development policy and disaster management need to become more mutually supportive. Focusing on food security, the researcher suggests that in disaster-prone locations, measures to improve disaster resilience should be an integral part of food security policies and strategies.

2.3 Humanitarian Logistics

Scholars typically draw on concepts and models used in commercial logistics when explaining the origins of humanitarian logistics. Holguín-Veras et al (2012b)

stress that the recent focus that sociologists and engineers have given to humanitarian logistics has been based on a comparison with commercial logistics, hence determining the most salient differences and commonalities between the two approaches. In doing so, authors point out that the field of humanitarian logistics is too broad to be neatly characterized by a single definition of operational conditions. In this sense, Holguín-Veras et al (2012b) break down humanitarian logistics in two groups of operations. The first, regular humanitarian logistics (R-HL), refers to operations conducted in long-term disaster recovery and humanitarian assistance where operational efficiency, similar to the commercial logistics setting, is a primary consideration. At the other end is post-disaster humanitarian logistics (PD-HL) operations, which covers part of disaster response and short-term recovery activities taking place in chaotic situations where urgent needs, life-or-death decisions, and scarce resources are the norm. The authors argue then that the vast differences in these operational environments require that the R-HL and PD-HL be treated separately. Nevertheless, the research questions that this literature review addresses may challenge such an argument since assisting the Internal Displaced Persons crisis in Colombia involves humanitarian operations with specific food aid distribution in both R-HL and PD-HL. In addition, although natural disasters most likely involve merely PD-HL operations when it comes to food aid distribution in Colombia, this dissertation hypothesizes that treating specific activities from either response system together as opposed to separately, leads to synergies and additional benefits to both groups of impacted people.

As a result of the recent research regarding logistics and humanitarian operations, a new logistics concept has emerged, which is developed by Holguín-

Veras et al (2012b, p. 504): "a socio-technical process that uses a number of supporting systems: a social network of individuals involved in the effort manages, orchestrates, and conducts technical activities, relying on supporting systems". As explained by the authors of this novel concept, the social network of individuals (e.g., carriers, drivers, receivers, warehouse operators) arranges a series of technical tasks (e.g., inventory management, routing, pricing) that depend on the supporting systems available at that particular location (e.g., transportation systems, communication technologies). Logistic activity thus involves three complementary components: a social network, the technical activities it performs, and the underlying support systems on which they depend. As a result of the inter-linkages between these components, malfunction in any of them could bring the entire process to a halt, as argued by Holguín-Veras et al (2012b).

Researchers have tended to discuss humanitarian logistics operations by highlighting not only the applications that have been taken from commercial logistics, but also the commonalities and, more importantly, the disparity between one and the other. As stated, and originally addressed by Holguín-Veras et al (2012b, p. 500), successful commercial logistics practices are applicable to PD-HL activities where the uncertainty and the level of urgency reach extreme low levels. The authors also define seven aspects along which to describe and compare logistical operations between the commercial and the humanitarian: the objectives pursued, origin of the commodity flows, knowledge of demand, decision making structure, periodicity and volume of logistic activities, state of the social networks, and state of supporting systems. The authors argue that there is a need for significant advances in humanitarian logistics modeling to ensure that analytical formulations adequately take into account the full

complexity of the humanitarian logistics operations that the humanitarian action face. However, they highlight that such need is most acute in PD-HL (response and short-term recovery activities, such as the resettlement period of internally displaced persons for instance) despite the fact that R-HL also have presence in long term-recovery activities. The authors also state that when it comes to PD-HL, "relief organizations are challenged by striving to alleviate human suffering at the impacted site, operating in an environment characterized by an impacted social system and networks; a massive influx of goods due to material convergence; dynamic, fragmented and, at times, competing supply chains; severe damage to the physical and virtual infrastructure; and short timeframes to respond and prevent loss of lives and property" (Holguín-Veras et al., 2012b, p. 504). They also argue that the situation is aggravated by uncertainty about demand and supply.

From a practitioner's viewpoint, and without explicitly citing humanitarian logistics activities or strictly defining the term, WHO (2013) describes the steps to follow in order to ensure an effective food aid distribution program during disasters: i) Estimate the quantity of food available, ii) Calculate the dietary needs of the impacted population and determine the food rations in accordance with the characteristics of the population and estimated duration of the effects of the disaster, iii) Determine the priorities of a food aid program during disasters, provide food where need is urgent, or appears to be, as in isolated populations, institutions, hospitals, refugee camps, and among rescue teams and aid personnel, iv) Make an initial estimate of the food needs of the impacted population, taking into account its demographic characteristic and vulnerable groups (children under 5, pregnant and breast-feeding women, and malnourished persons need to receive a supplements), and v) Identify food stocks,

(food stockpiles elsewhere in the country, food assistance organizations, etc.), transportation, storage, and distribution.

Indeed, WHO addresses humanitarian logistics activities that link to the process of food aid distribution through the following steps: i) Ensure the safety and suitability of locally available food and supplies received. ii) Monitor the food and nutrition situation closely, so that the supply and rationing of food can be modified in keeping with changing conditions. iii) Ensure safety and prevent the transmission of disease through food. iv) Guarantee to any population group that is or appears to be at high nutritional risk with 3 or 4 kg of food per person per week as long as the food provided is part of the food pattern of the population. The quantity of food in a ration should depend on the stage of the crisis and available resources. WHO (2013) recommends that for a period of weeks or even months, and while the impacted people depend exclusively or almost exclusively on food aid, rations should aim to provide 1700 to 2000 Kcal per person/day.

The WHO also suggests considering certain factors when preparing rations, which afterward are humanitarian logistics concerns as well: i) Make decisions on whether to distribute dry or wet rations; ii) Estimate the short-term and medium-term needs for food based on food rations; iii) Take into account the effect of the disaster on harvests, livestock, and environmental factors (extensive damming, mudslides, avalanches, volcanic ash falls, etc.); iv) Approximate number and composition of the impacted population; v) If the impacted people are in shelters, without the ability to cook their own meals, food distributed must already be cooked; vi) Raw rations ("dry") are to be given, preferably by family, over a certain period of time (e.g. for a

week). Guarantee composition of a food ration that provides approximately 1700 Kcal.

The Sphere guidelines make a distinction between wet and dry rations. Wet rations refer to the daily distribution of a cooked meal. These may be provided during the initial days after an emergency or in cases where beneficiaries carrying supplies back to their homes increases their security risks, the displaced population has lost their cooking utensils or when they are in no condition to cook, among others (The Sphere Project, 2013). On the other hand, dry rations are the supplies distributed to be cooked by the beneficiaries at their homes and last for several days (The Sphere Project, 2013). Obviously, the distribution of dry rations requires that beneficiaries have the minimum conditions (e.g., cooking utensils, energy) to use them. "The food distribution strategy selected will then depend on the post-disaster conditions of the impacted population" (Jaller, 2011, p. 79).

Other kinds of strategic challenges for food aid distribution during disasters are related to humanitarian logistics activities according to the WHO: i) Reaching collaboration with national and local authorities in priority activities; ii) Reaching collaboration with relevant agencies and organizations, and organize a coordinating group if there is none; iii) Identifying supply sources; iv) Assuring provision of experienced personnel.

Another issue is the magnitude of the logistical challenge in terms of the volume of cargo to be transported after a disaster. The needs are different in a post-disaster context because many existing activities that consume freight disappear, while others that generate freight demand are created. Holguín-Veras et al (2012b) suggest that the volume of cargo per capita depends on the needs to be satisfied, ranging from

a bare minimum (subsistence level) to a standard that enables survivors to satisfy other needs. The U.S. Army Corps of Engineers (2010) specifies a minimum per person of a bag of ice (5 kg), a gallon of water (4 kg) and 2 meals-ready-to-eat (MREs) (1 kg) per day, which translates into 5 kg of supplies per day (10 kg if ice is provided). The minimum standard set by the Sphere Project is 7.5–15 kg of water per day (without water for sanitation), and an energy intake of about 2000 Kcal, obtained from half a kilogram of food (e.g., maize, rice, beans) (The Sphere Project, 2013). However, these estimates do not take into account that individuals who have lost their possessions have other basic needs, such as shelter, clothing, kitchen and cleaning utensils, and medicine. This implies that in the days after a major disaster, between 15 kg and 80 kg per person/day will be needed to satisfy the needs of both constituencies, as reported by Holguín-Veras et al (2012b, p. 498).

2.3.1 Humanitarian Logistics Structures

Based on the experience from the Haiti earthquake, Holguín-Veras et al (2012b, p. 503) state that "the behavior that arises after disasters translates into decision-making structures that are profoundly different from commercial logistics". Particularly, researchers in Haiti witnessed the emergence of humanitarian logistics structures to implement extremely efficient operations that out-performed more established organizations. Given the lack of accounting in the humanitarian logistics modeling, there is an evident need to conduct research involving the characterization of humanitarian logistics structures that arise after major disasters, their role and their inherent characteristics, especially the role of public-private sector partnerships, as well as the interaction and coordination between emergent and established humanitarian logistics structures, as stated by the authors.

As an example of identification of humanitarian logistics (HL) structures, Holguín-Veras et al (2012a), suggest a typology of HL structures responding to catastrophic scenarios. These structures can be classified on the basis of their level of integration with the social fabric of the impacted area. Thus, the relevant operations are exemplified with three types of HL structures. At one end of the spectrum, authors introduce operations performed by a group that is foreign (outsider) to the area, with little or no integration with the locals. This case is labeled “Agency Centric Effort” (ACE), as the operation is based on the internal capacities of the group. At the other end of the spectrum, networks of individuals/groups that are part of both the community impacted by the disaster, and part of a larger network that extends to other communities, such as a religious group, are referred to as a “Collaborative Aid Network” (CAN). In between these, the authors introduce endless possibilities depending on to what extent, and in what way(s), they integrate with the locals. To refer to these cases, authors use the term ‘Partially Integrated Effort” (PIE). The authors also highlight the importance of reiterating that these classifications apply not to the groups themselves, but rather to the relief operations performed.

2.3.2 Supply Chain Segments

In order to understand the architecture and characterization drawn on the results obtained within each response system in this dissertation, networks are introduced being broken down into supply chain segments or positions: upstream, midstream and downstream. Hence, Christopher’s concept of supply chain (Christopher, 2010, p. 10) is adopted in this dissertation as a “network of organizations that are involved, through upstream and downstream linkage, in the different processes

and activities that produce value in the form of products and services in the hand of the ultimate customer".

Upon expanding Christopher's definition, the term "supply chain" draws on how the involved organizations in a specific supply chain are linked together. This is, a typical commercial supply chain that links a company with its suppliers, its distributors, and its customers frequently involving three segments: upstream, where sourcing, procurement or input supply from external parties occurs; midstream, where manufacturing, assembly, packaging and handling take place; and downstream, where distribution to customers takes place, frequently by external distributors. Under the assumption that the supply chain segment approach, frequently addressed in commercial logistics, is also applicable to understand the architecture of the networks through which food aid is distributed in Colombia, this and subsequent phases are strongly based on these foundations to elaborate novel results. However, this dissertation not only acknowledges that this terminology (upstream, midstream and downstream) is typically used to characterize commercial supply chains, but also that other conventional terms could have been used instead, such as "inbound" and "outbound" logistics when describing the architecture of the supply chains under study. Still, this dissertation seeks to adopt a terminology that not only describes the direction of flows, but also the stages of humanitarian supply chains as a system that comprises of multiple bounds

2.3.3 Outsourcing

In commercial supply chains, outsourcing is defined as purchasing services, semi-finished products and components from outside companies (referred to as "vendors") as opposed to providing these elements in-house. A company that

outsources is referred to as a “buyer”. Furthermore, care should be taken when comparing outsourcing with subcontracting. Subcontracting refers to “tasks or services that are simply handed over to a company that has the required specific skill and/or resources to be efficient”. A subcontractor works “for” a buyer, while a “vendor” works “with” a buyer, as Folgui & Proth (2010) clarify. Nevertheless, because the outsourcing as a logistics strategy in private supply chains far surpasses its implementation in the humanitarian sector, Hajdarovic & Jensen (2013) argue that little can be addressed when it comes to defining the meaning of outsourcing in a humanitarian supply chain context or when combining outsourcing and road transportation with humanitarian science.

Cottam et al (2004) provided evidence that when deploying food aid in the Ethiopian famine in 2000, relief organizations outsourced their road transportation activities not only to international companies that only serve relief organizations, but also to local companies and freight forwarders. Indeed, the authors affirm that relief organizations mainly used commercial companies, which in some cases turned out to be a negative experience due to lack of the maintenance of the fleet and other technical issues, such as the lack of spare parts. By outsourcing 89% of their road transportation operations, relief organizations in Ethiopia were responsible for the transportation of aid to the points of distributions, where their partners would take over and distribute the aid to the final beneficiaries, locally or from NGOs. As a primary conclusion, the authors state “relief organizations suggested the central benefits for outsourcing were the reduction in costs and the increase of flexibility which corresponds with the main reason commercial companies outsource”.

In separate research, Hajdarovic & Jensen (2013, p.ii) found several challenges involved in running road transportation in humanitarian operations, making the overall management complex. They also found that “there are good opportunities to outsource some of the fleet activities”. As a primary finding the authors conclude: “there is not necessarily an outsourcing rationale lying behind current decisions to source these from external providers” and “outsourcing is a strategy that has the potential of improving fleet management in the humanitarian sector, thus improving humanitarian logistics”.

2.4 Modeling Humanitarian Logistics Operations

Analytical models that represent humanitarian logistics activities have been studied by researchers from various disciplines. The operations research community has pioneered the development of quantitative approaches that, despite the limitations – such as the lack of both data and the challenges representing uncertainty as exposed by the research community itself – encourages research in areas that have been highlighted. Four groups of scholars have successfully studied such analytical models by classifying several approaches found in the literature: De la Torre et al (2012), Caunhye et al (2012), Galindo & Batta (2013) and Holguín-Veras et al (2012b). Because the research conducted by these scholars is documented in dozens of papers concurrently, this section focuses on their findings, conclusions and future research suggestions.

First, De la Torre et al (2012) classify several papers based on multiple criteria describing analytical models in humanitarian logistics. One commonality among the papers reviewed is that the objective function of the model is one such criteria; minimizing costs, minimizing unsatisfied demand, minimizing latest arrival,

minimizing total response time and maximizing travel reliability. Other criteria were analyzed to put the reviewed papers in context: test data (from real disasters or hypothetical scenarios), single or multi-modal transportation systems involved, single or multi-commodities to be transported, and perishable or non-perishable items. Likewise, the routing problems involved either multiple, single or no depots at all, with either homogeneous or heterogeneous fleets of vehicles. Several conclusions can be drawn from the papers reviewed by De la Torre et al (2012): i) Models require inputs from relief organizations; ii) Multi-period routing has not been modeled in the relief routing literature; iii) Risk-averse behavior in routing has not been studied in depth; iv) Any modeling approaches imply advances in the ability to model chaotic and unpredictable distribution systems regardless of the modeling context; v) Models are to be flexible enough to address the high uncertainty of disasters. Finally, the authors present suggestions for future research based on the papers reviewed. For example, developing multi-period models with multi-stage characteristics can lend insight into simple rules of thumb and be useful for practitioners, while helping advance research in solving large multistage deterministic and stochastic models.

Second, Caunhye et al (2012) also reviewed papers that incorporate optimization models for pre-disaster and post-disaster operations. This review considers mostly published literature that includes book sections, conference proceedings, and journal papers. The models involved in the analysis consisted of humanitarian logistics activities regarding relief distribution and stock prepositioning, resource allocation, casualty transportation, commodity flow and the combinations of all of the above. Most objective functions pursued the minimization of cost as a function of distance, equipment operations, response time, maximizing efficiency,

minimizing set up costs, transportation operations costs, travel time, maximizing demand fill rate, amount of food delivered and demand satisfaction as well as the minimization of transportation costs, total unsatisfied demand and sum of unsatisfied demand. The domains of the variables (integer, mixed, binary), number of periods, number of levels and number of objectives are also included when categorizing the models. Concurrently, deterministic and stochastic treatments are also evaluated. The authors conclude that: i) Stock pre-positioning models are fairly popular; ii) Casualty transportation models are associated with relief distribution in most instances; iii) Cross-operation models (models that combine different operations) are limited; iv) Emergency logistics researchers seem reluctant to apply multi-objective models with the view that they are difficult to solve; v) Most of the literature surveyed aims for better responsiveness by minimizing response times, distance costs, and unmet demand over time. However, by considering responsiveness only, one can encounter problems, such as oversupply of resources (leading to difficulty with coordination), greater traffic, and complex scheduling. According to the authors, suggestions for future research are oriented towards specific features: i) Facility location modeling in post-disaster situations under dynamic and uncertain disaster environments; ii) Stock transfer from one facility to another in a post-disaster scenario. Likewise, the authors suggest the need to address some general features: i) Optimization models that can also be used for dynamic post-disaster inventory modeling, arguing that such models would introduce a new generation of inventory planning models; ii) Delving into the effects and requirements of all the various tasks involved in emergency logistics can help to better understand the process and, hence, build more realistic models; iii) Models whose objectives are other than responsiveness and cost-efficiency and that

involve coordination effectiveness and proper organizational structure; iv) Models that tackle the fact that distribution can be uneven, resulting in oversupply to some impacted families and undersupply to others; v) The use of robust optimization arguing that robustness of relief planning can be a new objective aside from responsiveness and cost-efficiency.

Third, in directly linking the term “disasters” with operations research methods, Galindo & Batta (2013) eschew the term “humanitarian logistics” in the scope of their paper. However, the authors define six attributes to classify the papers surveyed: author’s affiliation, disaster type, solution methodology, operational stage, research contribution and final dimension. In addition, the most common assumptions used in the surveyed papers are also classified as limited, reasonable and unrealistic. The authors highlight specific analytical tools found among the papers reviewed: statistical approaches to estimate risk, Monte Carlo simulation for verification purposes, math programming for optimization models, system dynamics, and soft operations research. Regarding the disaster type found in the papers reviewed, a commonality is an all-hazard approach. When it comes to research contributions made by the approaches reviewed, the following are the classification attributes used: theory (reflections about a particular area, test hypothesis, describe the behavior of a system, provide a framework, or define principles and taxonomies), models (analysis) and applications (products such as computer software or devices or Decision Support Systems).

In addition the authors also classify such contributions by field: i) Management Science-MS, which is research whose objective is to contribute to the knowledge of a given research area by using real, hypothetical, random or no data; ii)

Management Consulting-MC, which is research where a practical problem is solved by standard methods either through novel or widely used situation and approaches in OR, and, iii) Management Engineering-ME, which refers to research that uses existing methods in a novel way to solve practical problems by focusing on the type of results (specific or general) and the further research implications (existing and nonexistent) that explain the applicability and usefulness of the research contributions. The authors conclude that the inclusion of sociological perspectives in operations research models provides an opportunity to better capture the complexity of disaster response and enrich post disaster operations management.

The authors also argue that "delivering humanitarian supplies without incorporating humanistic knowledge into the methods, models and approaches that disciplines like supply chain management and operations research contribute to humanitarian relief supply chains, translates into low efficiency and delays because of the inherent complexities of any social disruption labeled a Disaster".

When it comes to future research suggestions, the authors highly recommended incorporating ethical factors in modeling service allocation to those impacted by disasters, as well as conducting research that focuses on minimizing the socioeconomic disruption of displaced families while minimizing the associated cost for temporary post-disaster housing. Similarly, the authors stress the lack of papers that focus on specific conditions in developing countries. Regarding methodologies, the need for interdisciplinary methodologies and new methods is highlighted, as is developing rules of thumb for deciding what methods to use in specific situations. Last but not least, the authors remark on the lack of research in efficiency indicators in disaster operations and management.

Fourth, building on the argument that Post-Disaster Humanitarian Logistics (PD-HL) models should explicitly consider the opportunity costs of delivery actions, and lead to models that are structurally different from those inspired by the commercial logistic paradigm, Holguín-Veras et al (2012b, p. 498) go beyond this, and in addition to simply compiling some analytical models for PD-HL, contrast these models to the deprivation cost approach. The justification for this approach from the authors lies in the their argument that, while in the commercial case, minimization of logistic costs is the primary motivation, in the humanitarian case other factors come into play, such as the impacts on human suffering. Besides, "while commercial logistics emphasize ways to efficiently satisfy demand in conditions where supply equals or exceeds demands, humanitarian logistics emphasize how to distribute a shortage of food aid in a manner that leads to the greatest social good". As the authors address specifics of the alternative analytical models contrasted to the deprivation cost approach such as the inventory allocation model developed by Pérez (2011), they come to the statement that although such analytical models aim to minimize logistic costs, the impacts on the population that could negatively affect their welfare is lacking. That is, they strongly recommend incorporating a measure in the objective function that captures the suffering experienced by the beneficiaries, from their lack of access to a good or service. Such a combination is expected to achieve the best compromise between logistic effort and level of service so that the objective function properly measures both aspects, and hence a balance can be accomplished. This external effect, neither incurred by the organizations conducting PD-HL activities nor by the scholars who have attempted to model PD-HL operations, is what the authors call a “deprivation cost.”

Aside from giving representation to the human suffering in the objective function, the authors also recommend two additional components of economic welfare (both positive and negative external effects) that must be computed at a given delivery time period. The first is the economic impacts on the relief agency that incurs the logistic costs associated with the delivery of relief aid. The second consideration is the opportunity cost of the delivery strategy, or the increase in deprivation costs for the population that does not receive supplies, and has to wait for future deliveries.

Likewise, the authors affirm that identifying the optimal delivery strategy requires consideration of the inter-temporal externalities (both positive and negative) involved; arguing that this is the only way to assess the strategy's full impacts and that single period models are therefore not appropriate for PD-HL modeling. Additionally, they argue the formulation with deprivation costs does not require the specification of equity constraints, as the level of service that the PD-HL system could deliver is endogenously determined.

As the prime future research recommendation, the authors encourage empirically developing formal estimations of a deprivation cost function that represents the economic cost of human suffering as a function of deprivation time, or, the amount of time that an individual is without a given good or service. However, the authors clarify that, although such estimation is based on economic valuation techniques, it is still superior and preferable to using some of the proxy measures found in the literature. Finally, the authors highlight that estimating deprivation cost functions is an objective way to the modeling community to assess the impacts of delivery strategies for key supplies after disasters.

Because it is a fact that food aid supplies may not be distributed in a timely manner to those impacted by natural disasters and the armed conflict (OCHA, 2013) in Colombia, Pérez model (2011) is used in this dissertation as an analytical tool to measure multiple supply structures when it comes to capturing the suffering experienced by the beneficiaries, from their lack of access to a food aid during immediate response and short term recovery. Again, when making a decision on what analytical model to use, Pérez model prevails over other conventional analytical models as they focus on minimizing logistics costs only.

2.5 Literature Summary

Based on a review of the state of the art, section 2.2 presents evidence that the IDP crisis and natural disasters in Colombia do qualify as disasters. Disasters develop along phases or stages (preparedness, response, recovery and mitigation) where humanitarian logistics operations have a presence throughout. Food aid distribution takes place during post-disaster phases (response and short-term recovery). One of the principles to ensure food security in post-disaster environments is to guarantee food aid distribution. Particularly in the Colombian context, food aid has to be deployed during both the immediate response period and the short term recovery period, and not only to those impacted by the armed conflict, but also to those impacted by natural disasters as well. Scholars argue that by executing humanitarian logistics operations, the challenges of food aid distribution during disasters are more likely to be overcome.

Literature regarding humanitarian logistics encourages the identification of both emerging and established humanitarian logistics structures, as well as the interactions between them, as they are pillars for effectively deploying the aid needed for the population impacted by different magnitudes and types of disasters.

Section 2.5 reviews calls from scholars for improved analytical models to support humanitarian logistics that: i) Incorporate multi-period and with multi-stage characteristics; ii) Are built and validated based on more realistic environments; iii) Involve coordination effectiveness and proper organizational structure as objectives, in addition to responsiveness and cost-efficiency; iv) Tackle the fact that distribution can be uneven, resulting in oversupply to some impacted families and undersupply to others; v) Use robust optimization methods, arguing that robustness of relief planning can be a new objective aside from responsiveness and cost-efficiency; vi) Incorporate ethical factors in service allocation to those impacted by disasters, as well as minimize the socioeconomic disruption of displaced families, while minimizing the associated cost for temporary post-disaster housing; vii) Focus on specific conditions in developing countries; viii) Deal with interdisciplinary methodologies and new methods so that rules of thumb for deciding what methods to use in specific situations are achieved; ix) Develop formal estimations of a deprivation cost function based on empirical evidence that represents the economic cost of human suffering as a function of deprivation time, or, the amount of time that an individual is without a given good or service. Estimating deprivation cost functions is an objective way to the modeling community to assess the impacts of delivery strategies for key supplies after disasters.

2.6 Analysis

This literature review presents evidence of the need for incorporating interdisciplinary approaches, built from analytical methods and an understanding of the challenges that humanitarian logistics activities face when aiming to alleviate the suffering and minimizing the loss of life of those impacted by the armed conflict and natural disasters. Operations research and humanitarian logistics can support

objectivity in the delivery of humanitarian aid by formulating and solving models that translate into new policies and strategies. According to De la Torre et al (2012), these two fields contribute to minimizing the loss of life and improving the conditions for the population impacted by disasters. Connecting disaster science, operations research and humanitarian logistics in responding to disasters addresses five areas of concern:

i) Strategies for delivering humanitarian aid and satisfying the actual demands are developed recognizing actual conditions.

ii) Coordination of and improved efficiency in relief supply chains evolves from a research question to a practical solution by drawing from the benefits that partnerships among actors can bring to the system (Coles et al, 2011).

iii) The challenging environment inherent in responding to a disaster in conditions of urgency and uncertainty is recognized and is a key issue in making more applicable and realistic contributions to relief supply chains from operations research (Guojun & Caihong, 2012).

iv) Introducing the needs of the impacted population from a sociological perspective, as well as from a political and organizational framework of responders, may contribute to developing food aid distribution practices that better understand the necessities of individuals, families and communities despite the complexity derived from the multi-sectorial component of the involved actors.

v) Researchers in the third world call for a rethinking of disasters from a political-economic perspective, leading to the conclusion that the root causes of disasters lay more in society than in nature (Oliver-Smith, 2009).

This research is aligned with the findings of the limited number of research studies that combine sociological and engineering perspectives. These studies recognize the need to develop and implement analytical models that capture the complexity of humanitarian logistics operations and fill an evident gap, as current models simply do not take into account the key aspects of PD-HL, thus risking the production of sub-optimal results. Consequently, the summary statements that lead to the research questions of this dissertation are:

- Additional research regarding involvement of public policy and social aspects should be conducted to improve both basic knowledge of the underpinnings of post-disaster humanitarian logistics, the level of realism of the analytical models and decision support tools, the overall efficiency of the humanitarian logistics response, and, last but not least, measures to assess the impact in terms of minimization of human suffering.
- The various stakeholders in the disaster response community should proactively support such research as they have complementary views of this complex subject.
- The research community calls for a concerted effort to develop a new paradigm of PD-HL models since the underlying dynamics of PD-HL are still poorly

understood and more field and case research is necessary, as claimed by Holguín-Veras et al (2013).

- The social science disaster literature has examined institutional arrangements and multi- organizational responses to extreme events, but has given little attention to the impact of such arrangements to the process of delivering relief that ensures on-time aid supply and prevent loss of life, as stated by Holguín-Veras et al (2007).
- Fieldwork is needed to understand and characterize the food aid distribution of the two response systems in Colombia, including a precise characterization and identification of the established humanitarian logistics structures that compose such systems, which in multiple instances share the same actors, such as UN agencies and the Red Cross, in order to assist a unique population with *"doble afectación,"* but responding to disasters of different onsets features.
- Humanitarian logistics models whose response capabilities and resiliency recognize the constraints derived from the armed conflict as well as the social and functional vulnerability of Colombians to natural disasters should be pursued.

This research recognizes the involvement of humanitarian aid actors and the assimilation of social perspectives when attempting to model the humanitarian logistics performance that support the needs of those impacted. By introducing synergies into the relief supply chains that support internal displacement and natural disasters in Colombia, a novel approach emerges to answer the call. This call comes

not only from current researchers, such as Holguín-Veras & Jaller (2011), who highlight the importance of incorporating collaborative approaches in relief supply chains, but also from practitioners whose political and organizational frameworks impede collaborative performance (ECHO, 2012). Furthermore, sociological and behavioral perspectives of the population impacted are not yet fully understood when aiming to satisfy their needs as a suffering population under the extremely complex situation encompassed in a disaster.

Despite the fact that scholars argue that R-HL and PD-HL must be treated separately, the research questions presented here may challenge such argument, since assisting the IDP crisis in Colombia involves food aid distribution in both R-HL and PD-HL according to the phase of the crisis. In addition, although natural disasters most likely involve merely PD-HL operations when it comes to food aid distribution in Colombia, this dissertation hypothesizes that treating specific activities from either response system together as opposed to separately, leads to gains through logistics synergies and hence providing additional benefits to either types of impacted people.

This literature review supports three research fronts:

i) The impacts of institutional arrangements for socially constructed disasters on relief supply chains.
ii) The incorporation of operations research methods (analytical models) into humanitarian logistics. These methods model variables that speak for the complexity of supporting the impacted population and with aid distribution under emergency situations, such as proxy measures for measuring the human

suffering in the distribution of aid when supporting different social vulnerability levels.

iii) The compilation of best applicable practices in supply chain management that both practitioners and researches have adopted from commercial supply chains, in order to improve the resiliency of relief supply chains aiming to minimize the loss of life and suffering of the population impacted.

Logistics has emerged and refined over recent decades, thanks to its applicability in the private sector (commercial logistics). In contrast, humanitarian logistics has just started to question how to best cope with the particular features that involve responding to a disaster in the short-term recovery and response phases. However, the few or many self-developed practices in the field, in addition to the applicable best practices from commercial supply chains, have brought up important theoretical foundations to the field of humanitarian logistics. Consequently, such theoretical foundations conceptually support this research, which indeed is present at most of the methodological phases of this dissertation (as next chapter elaborates), making the philosophical approach of this research both descriptive and directive driven.

Chapter 3

RESEARCH METHODOLOGY

3.1 Outline of Methodology

A qualitative approach based on mixed methods is used to assemble data in four phases, as shown in Figure 2. In addition, an analytical model is taken from the literature and then adjusted according to the findings of the multi-method approach. This analytical model facilitates the exploration of alternative decision-making processes, including resource allocation strategies and food aid inventory levels. Drawing on data collected in the field, a quantitative analysis assesses the performance improvement associated with the implementation of alternative distribution policies derived from the information assembled in the four phases using the mixed methods.

Phase I identifies the actors involved in the distribution of food aid. The identification of carriers and forwarders for each actor found in Phase I lead to identifying the composition of supply chains in Phase II. This way, Phase I and II together depict and characterize the delivery practices of food aid in Colombia. Phase III identifies both a typology of humanitarian logistics (HL) structures for each of the two response systems, and a typology of "intersectional" HL structures that are composed by supply chains from either response system. Finally, Phase IV provides policy recommendations from both humanitarian and commercial logistics, which are the best practices not only for both response systems' typologies but also for the intersectional typology. The recommendations are tailored to the typologies of the HL

structures identified in Phase III. These expected products are developed through the methods summarized in Figure 2 and Figure 3.

To explore the impacts of alternative policies and strategies, this dissertation defines potential large-scale disasters that could occur in Colombia as scenarios. These scenarios draw on historic records found in open source disaster databases to define potential large populations demanding food aid. The performance of the HL system resulting from simulating the change in different inventory allocations strategies is then assessed through the analytical model coded to represent the response to these scenarios with different supply structures, resulting from the policy recommendations of Phase IV and to the demands defined in the potential scenarios.

Institutional Review Board (IRB) approval was obtained for this work. Appendix A includes the approval letter, Appendix B documents the protocols, Appendix C is the recruitment letter, and Appendix D is the informed consent form. This remainder of this chapter elaborates on each of the elements of this research methodology. The following sections take each of the phases, as outlined in Figure 2 and Figure 3, and details the process used. Specific protocols and survey documents are referenced in each of the sections.

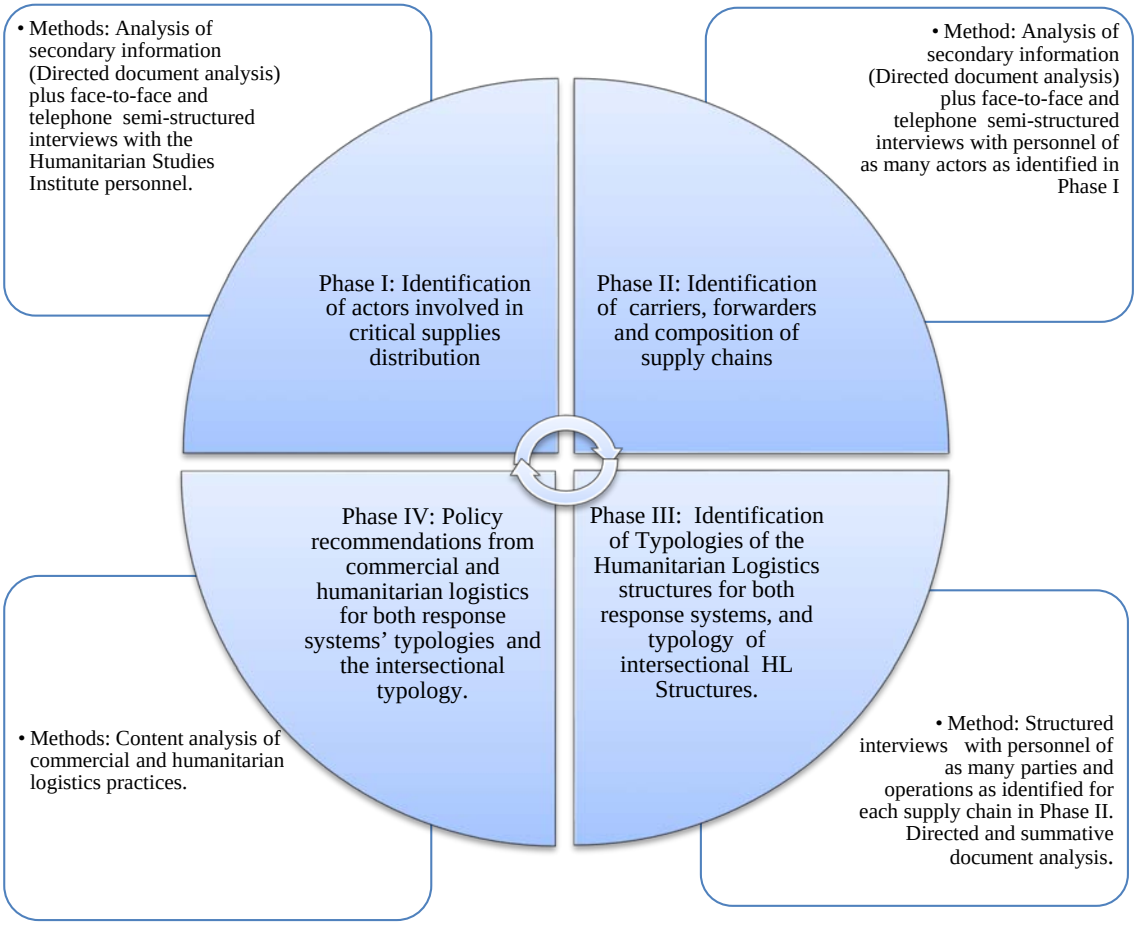


Figure 2. Four phase qualitative research methodology (data collection)

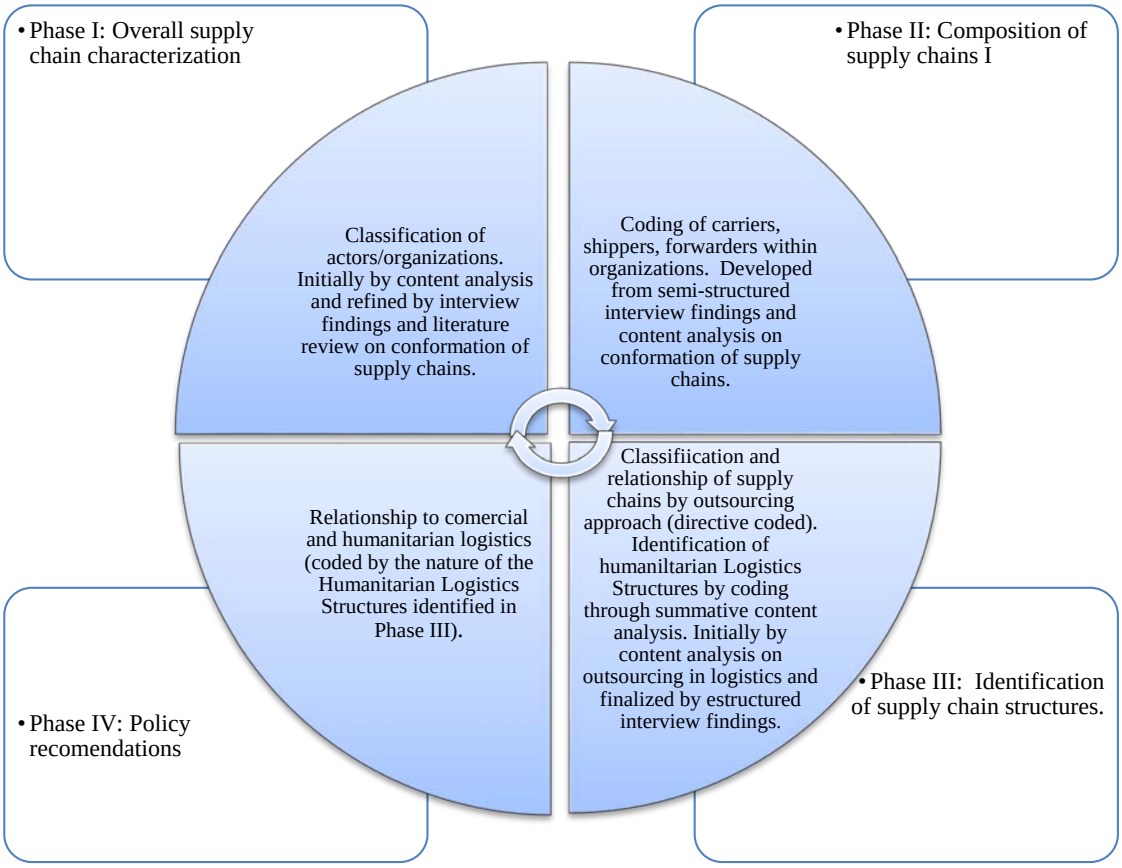


Figure 3. Four phase methodology (data analysis)

3.2 Research Strategies

Qualitative methods and qualitative research are useful in constructing or developing theories or conceptual frameworks for generating hypotheses. These methods can also be used in refining theories and hypotheses through preliminary testing (Sofaer, 1999). An important insight from Patton (2002) is that when

qualitative researchers begin to see a pattern that might be articulated as a hypothesis, they should then search systematically for evidence that will lead to the rejection of the hypothesis. Creswell (2009) groups multiple characteristics of qualitative research from three different authors, concluding that qualitative research:

i) Is conducted in a natural setting (the field), which provides a source of data for close interaction.

ii) Relies on the researcher as the key instrument in data collection.

iii) Involves using multiple methods.

iv) Involves complex reasoning going between inductive and deductive.

v) Focuses on participants' perspectives, their meanings, and their multiple subjective views.

vi) Is situated within the context or setting of participants/sites (social/ political/historical).

vii) Involves an emergent and evolving design rather than tightly prefigured design.

viii) Is reflective and interpretive (i.e., sensitive to the researcher's biographies/social identities).

ix) Presents a holistic, complex picture.

The following subsections elaborate on the qualitative research methods used in this descriptive research.

3.2.1 The Survey Approach

The term “survey” is used in a variety of ways, but generally refers to the selection of a relatively large sample of people from a pre-determined population (the “population of interest”; this is the wider group of people in whom the researcher is interested in a particular study), followed by the collection of a relative small amount of data from those individuals. The researcher therefore uses information from a sample of individuals to make some inference about the wider population. In the words of Denscombe (2010) “The survey approach is a research strategy, not a research method. As with any research approach, a choice of methods is available and the one most appropriate to the individual project should be used” (Denscombe, 2010, p. 261).

Kelley et al (2003) developed a practical way to implement the survey approach. The following are some considerations from these authors, which support the research methodology described in chapter III.

i) Using questionnaires and interviews may be an effective strategy when aiming to collect data in a standardized form. Surveys are well situated to descriptive studies, but can also be used to explore aspects of a situation, or to seek explanation and provide data for tasting hypothesis.

ii) Data collected through surveys methods used in this dissertation aim to make it descriptive, analytical and evaluative. Descriptive research is understood here as “a most basic type of enquiry that aims to

observe (gather information on) certain phenomena". The aim is to examine a situation by describing important factors associated with that situation, such as demographic, socio-economic, event, behaviors, attitudes, and knowledge. Descriptive studies are also used to estimate specific parameters in a population and describe associations.

iii) Analytical studies, however, go further than mere description; their goal is to highlight a specific problem through focused data analysis, usually by looking at the effect of one set of variables upon another set. Evaluation research is a form of research that collects data to ascertain the effects of a planned change, which takes place in Chapter 7 in this dissertation.

iv) The survey approach can employ a range of methods to answer the research question. Common survey methods include face-to-face interviews and telephone interviews. Face-to-face interviews involve the research approaching respondents personally. The researcher then asks the respondent a series of questions and notes their responses. Like face-to face interviews, telephone surveys allow a two-way interaction between researchers and respondent. Whether using face-to-face interviews or telephone interviews, the questions asked have to be carefully planned and piloted.

v) When designing a questionnaire or question route for interviewing or

interview guide, the following issues should be considered: planning the content, questionnaire layout, interview questions, piloting, and covering letter or invitation letter. Open questions are used more frequently in unstructured interviews, whereas closed questions typically appear in structured interview.

A structured interview is like a questionnaire that is administrated face-to-face or by telephone with the respondent. When designing the questions for a structured interview, the researcher should consider some particular points regarding questionnaires, such as guaranteeing its reliability and validity. Also, the interviewer should have a standardized list of questions. If closed questions are used, the interviewer should also have a range of pre-coded responses available. If carrying out a semi-structured interview, the researcher should have a clear, well-thought-out set of questions; however the questions may take an open form and the researcher may vary the order in which topics are considered.

vi) The method by which the sample is selected from a sampling frame is integral to the external validity of the survey: the sample has to be representative of the larger population to obtain a composite profile of that population. The survey methods influence how a sample is selected and the size of the sample.

vii) There are two categories of sampling: random and not-random

sampling. Not-random sampling is commonly applied when qualitative methods (e.g. interviews) are used to collect data, and is typically used for exploratory work. Non-random sampling deliberately targets individuals within a population. There are three main techniques: purposive sampling, wherein a specific population is identified and only its members are included in the survey; convenience sampling, wherein the sample is made up of the individuals who are the easiest to recruit; and finally, snowballing, wherein the sample is identified as the survey progresses; as one individual is surveyed he or she is invited to recommend others to be surveyed.

Kelley et al (2003) also highlight researchers that data collection should be approached in a rigorous and ethical manner suggesting that the following information must be clearly recorded:

- How, where, how many times, and by whom were potential respondents contacted?
- How many times were respondents approached, and how many of those agreed to participate?
- How did those who agreed to participate differ from those refused with regard to characteristics of interest in the study?
- How was the survey administered (e.g. telephone interview)?

- What was the response rate (i.e. the number of usable data sets as a proportion of the number of people approached)?

3.2.2 Content Analysis

Hsieh & Shannon (2005) identified three distinct approaches to content analysis: conventional, directed, and summative. All three approaches are used to interpret text data and are actually implemented in this dissertation. Just like in this dissertation, text data might be in verbal, print, or electronic form and might have been obtained from narrative responses, open-ended survey questions, interviews, observations, or print media, such as articles, books, or manuals, all of the typically applied to this research. The goal of content analysis is "to provide knowledge and understanding of the phenomenon under study". The authors define qualitative content analysis as a "research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns".

Conventional content analysis is used in this dissertation to design and describe typologies of humanitarian logistics since existing theory or research about it is limited. This research avoided using preconceived categories and instead allowed the categories and names to flow allowing new insights to emerge. Following the procedures the authors suggest for doing content analysis, data was read to derive codes by first highlighting the exact words from the text that appear to capture key thoughts or concepts. Next, notes of impressions, thoughts, and initial analysis were made. As this process continued, labels for codes emerged that were reflective of more than one key thought. Codes then were sorted into categories based on how different codes are related and linked. These emergent categories were used to organize and

group codes into meaningful clusters. Because data were collected primarily through interviews, open-ended questions were used. Data analysis started with reading all data repeatedly to achieve immersion and obtain a sense of the whole. By using a conventional approach, the research gained direct information from study participants without imposing preconceived categories or theoretical perspectives.

The authors also suggest that if existing theory or prior research exists about a phenomenon that is incomplete or would benefit from further description, directed content analysis is the right choice validating or extending conceptually a theoretical framework or theory. Indeed, the authors suggest that existing theory or research can help focus the research question and provide predictions about the variables of interest or about the relationships among variables, thus helping to determine the initial coding scheme or relationships between codes. This has been referred to as deductive category application. According to the authors, “using existing theory or prior research, researchers begin by identifying key concepts or variables as initial coding categories. Next, operational definitions for each category are determined using the theory”. Since the main strength of a directed approach to content analysis is that existing theory can be supported and extended, this dissertation also incorporates this approach in its methodology.

Summative content analysis is another useful method presented by the authors, and is implemented in this dissertation as well. Regarding this approach, this research started by identifying and quantifying certain words or content with the purpose of understanding the contextual use of the words or content. This quantification was an attempt not to infer meaning but, rather, to explore usage. In a summative approach to qualitative content analysis, data analysis begins with searches for occurrences of the

identified words by hand or by computer, which served as a guide in this dissertation when counting the occurrences of repetitive codes.

3.3 Phase I – Identifying the Actors

This phase identifies the actors involved in humanitarian action or so-called humanitarian response system distributing food aid to those impacted by natural disasters and the armed conflict (see Figure 4). Thus, because this study focuses on established structures of both response systems, actors either belong to Governmental Organizations, UN agencies, the Red Cross, Non-Governmental Organizations (both national and international) or Colombian Civil Defense. Irrespective of the humanitarian response system these actors belong to, its overall operational structure in charge of the national, regional and "last mile" distribution operations will be initially identified through the analysis of secondary information available from Internet documents, previous research and case studies found in the literature.

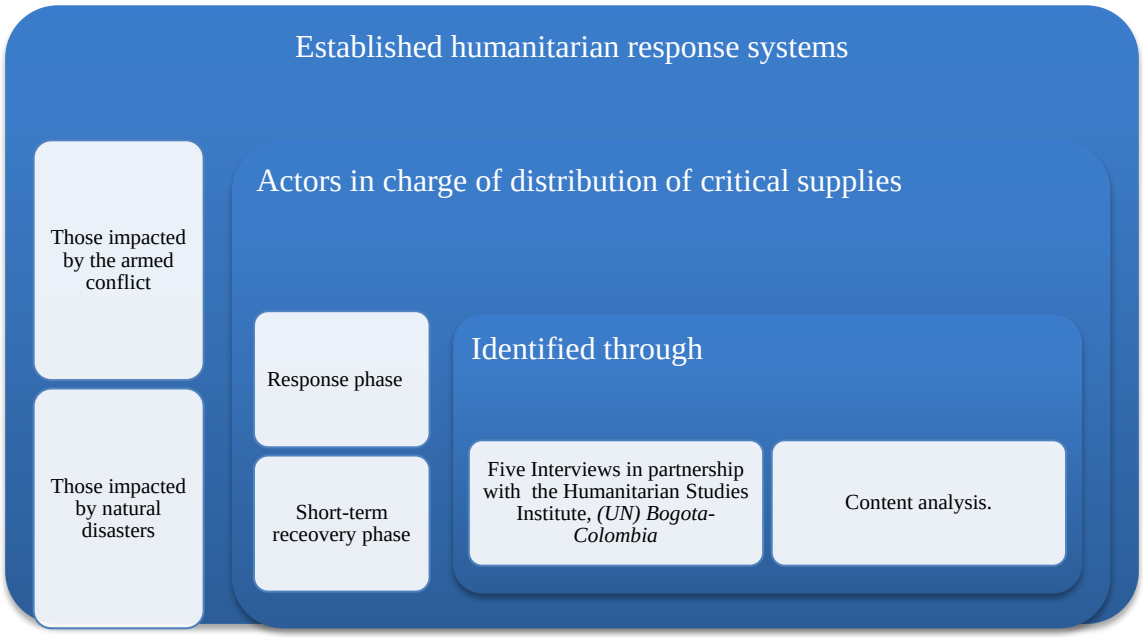


Figure 4. Phase I research

3.3.1 Content Analysis

Both public and private documents served as distinct sources for information. Documents accessible online came from the list of reports available on the website of the governmental organizations of each response system. The documents selected were identified based on their relevance to disaster response operations, but were limited to publically available online sources. This can be considered to be purposive sampling. Specifically, as a satisfying criteria, the chosen documents involved many information regarding the delivery process of food aid to the respective impacted population. Private documents came from Internet sources as well. In this respect, not only documents available online from NGO's and the Red Cross were considered, but also considered were those documents available "by request" through the respective

agency, which might have been recommended as a result of the interview process. The satisfying criteria for purposively selecting these documents were the same as public documents sampling approach.

Document analysis aims to collect any preliminary data that may serve as introductory inputs in the interviews. Hence, making sure to procure the right information from documents is crucial. In order to achieve this, memos were used to codify, conceptualize and refine the supply chains composition at an overall level.

3.3.2 Semi-structured Interviews

The protocol for the semi-structure interviews is documented in the Institutional Review Board (IRB) documents approved on November 13, 2014 (study title number 531674-1), and accessible in Appendix E. Entrée to these interviews was based on the affiliation with the INCAS (*Innovacion y Gestion de Cadenas de Abastecimiento*) research group at University of *Antioquia* (Colombia), and the Disaster Research Center at the University of Delaware. INCAS is currently revising potential partnership initiatives with OCHA, within which the Humanitarian Studies Institute (HSI) collaborates with academic institutions and practitioners. INCAS was able to facilitate the connections with the different parties in the humanitarian action in Colombia, thanks to the direct involvement with the HSI. Because designated personnel from HSI have previously led partnership initiatives among parties in the humanitarian action in Colombia, the support and commitment from this organization was crucial. The HSI showed interest in partnering in this research by asking their personnel in each of the branches located throughout the country to provide contacts, facilities and relevant information as requested. This certainly made both content

analysis and the individual interviews executable, as the mission of the HSI is to help close the research gaps between practitioners and researches.

Face-to-face interviews were preferred over other interview techniques such as focus groups or group interviews for instance for several reasons. First, any kind of group interview was challenging due to the imminent disconnection between multiple actors. Participants were asked to provide details about the food aid delivery process to those impacted people, which implied that sharing confidential information in the context of a group interview, for instance, could have been considered inappropriate for a particular organization. Secondly, since the objective is to outline the roles of the actors involved in distributing food aid, having a first approach individually rather than collectively with each organization helped facilitate the information flow at a first sight.

The potential organizations are limited to those whose headquarters are located either at the City of *Medellín* or *Bogotá* where most significant agencies have presence through their respective branches and from which significant distribution of food aid takes place. Such organizations must have either direct or indirect involvement in food aid distribution to either those impacted by natural disasters or the armed conflict.

The interviews were semi-structured with a certain degree of informality. The interview guide was exploratory since the articulation of the structured supply chains that currently supply those impacted people with food aid was the purpose of the method. Equally important are the recollections of specific shared events and experiences among the participants, which provided complementary information to assure that a wide spectrum of the supply chains was being characterized. Face-to-face

and telephone interviews were flexible as well. Hence, a brainstorming opportunity was also offered. This opportunity let the knowledge of participants play an important contributing role to the characterization. Some of the interview sessions were recorded, as well as notes taken in real time. One of the deliverables out of this method (Phase I) was a detailed list of contact information of specific personnel, actors and other important required information to characterize and sketch the supply chains involved.

3.3.3 Processing

Content analysis and face-to-face interviews were two separate sources of data in this phase. On one hand, content analysis helped identify actors in terms of organizations involved in the distribution of food aid for both those impacted by natural disasters and the armed conflict. This way, a preliminary outline built from the secondary sources was presented to the humanitarian agencies through the face-to-face and telephone interviews. For example, documents available on the Colombian Red Cross's official website determined that the organization has a strong participation in food aid distribution to those impacted by floods in rural areas, which was an important input to the interview session(s).

The inventory of actors from the content analysis was then conceptualized so that the supply chains they belong to were identified and characterized according to the theoretical framework of supply chains composition, found both in the literature and practice. Given that this phase aimed to outline the supply chains at an overall level, only two features of supply chains were considered when interrelating actors: national distribution operations and last-mile distribution operations. As a deliverable, a preliminary outline was written, representing the overall distribution process covered

by the actors involved depicting the geographical influence of its operations at a regional and local basis.

For such a purpose, a mapping tool using geographic information systems features supports all the outlines and sketches, showing both the geographic locations of actors as well as their connections and structure, not only regarding the results obtained in Phase I, but also in Phase II.

Complementary interviews provided updated and more precise information regarding the compositions of supply chains, which, because of the nature of secondary information, content analysis cannot provide. In this regard, because the interview guide actually targeted the confirmation of the actor's previously found in the content analysis, the information out from it was classified according to the two features (codes) mentioned above. As an emergence of ideas beyond the initial codes right after the data was collected and analyzed, an outline representing the absolute overall distribution process covered by the actors involved depicted the geographical influence of its operations at a national and local basis.

3.4 Phase II – Characterizing Supply Chains

Building on Phase I, in Phase II the carriers and forwarders, both contracted and owned, directly involved in distribution operations of food aid during the response and short-term recovery phases (immediate, emergency and transitory assistance for the IDP's response system), were identified through a set of semi-structured face-to-face and telephone interviews, as Figure 5 illustrates. Again, semi-structured interviews prevailed over group interviews because a more in-depth characterization of the operations was required, demanding even more confidentiality with the given information. In this sense, although more than one interview may have applied in the

same organization due to the variety of its distribution operations, the collection of single perspectives from interviewees provided a less-biased scenario than collective ones (group interviews) would. Similarly, structured interviews were not used, as a highly structured approach may have limited the emergence of empirical information. As opposed to the overall supply chain network drawn in Phase I, a detailed sketch of the regional and local supply chains of food aid, including the last-mile delivery operations for each actor is achieved in Phase II.

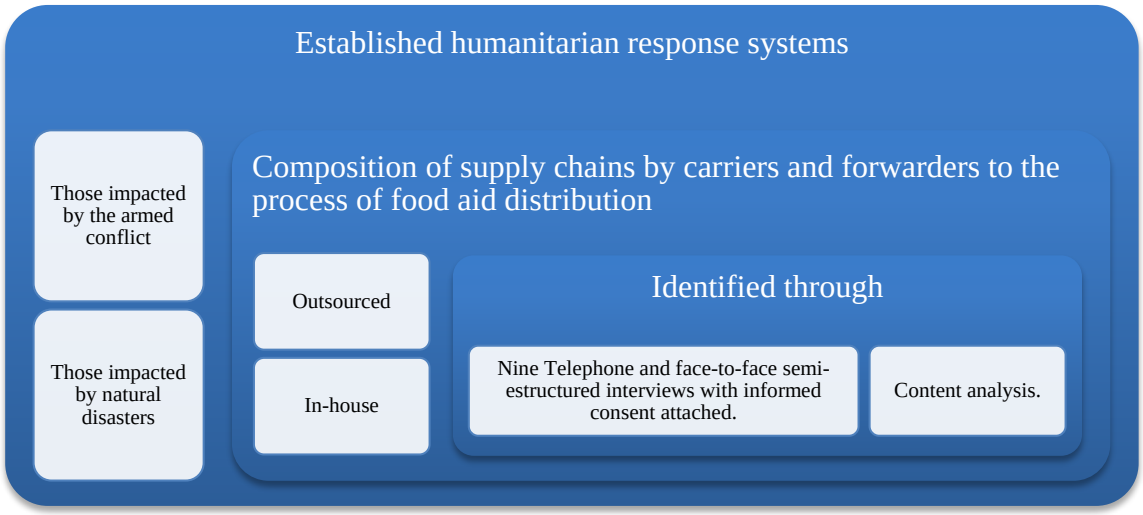


Figure 5. Phase II research

3.4.1 Semi-structured Interviews

The interview protocol, included in Appendix F defines the format and content. These sets of interviews took place with knowledgeable personnel from the following organizations (organizations that have names in Spanish are italicized for clarity):

- *Acción Social* through its applicable agencies in the organizational structure

- Office for the Coordination and Humanitarian Affairs (OCHA)
- International Committee of the Red Cross (ICRC)
- Colombian Civil Defense
- The World Food Program
- The *Unidad Nacional para la Gestión de Riesgo de Desastres* (UNGRD)
- *Unidad de Asistencia y Reparación de Víctimas* (UARIV)
- As many NGOs as identified in Phase I

Assuring the approachability of personnel from these organizations and developing the connections for the interview sessions of Phase I required being previously referred to the organization in question by the leadership of the Humanitarian Studies Institute.

At least one person from each organization identified in Phase I was interviewed. Since it was required that interviewees have broad expertise in the food aid distribution the organization involved handles, the selection within the organization was purposive to satisfy this requirement. Also, specific names recommended by the interview findings in Phase I were provided to reach these personnel.

The decision-making process on whether the interview took place by telephone or face-to-face was subject to the geographical location of the interviewed participants. Either way, the interview guide for this semi-structured interview was the same for all actors and addressees issues regarding geographical coverage, points of origin, and points of destination, among other examples. Face-to-face, semi-structured interviews took place either in *Medellín* or *Bogotá*. Thus, semi-structured interviews

with actors whose location was other than these cities took place by telephone or videoconference. As a final product from this phase, an exhaustive list of contact information, personnel and processes that speak to the composition of the supply chains was achieved. The interview sessions were documented through recording as well as notes taken in real time.

3.4.2 Content Analysis

Directed content analysis of classical supply chain characterization approaches took place, with special focus on supply chains being characterized in humanitarian contexts. Again, both public and private documents also served as distinct sources for sampling and, generally speaking, the systematic approach for accessing these documents was the same as that conducted for Phase 1. Content analysis in this Phase aimed to collect any preliminary data that may serve as introductory inputs in the interviews guidelines. Hence making sure to get the right information from documents is crucial. In order to achieve that, memos were used to codify, conceptualize and refine the supply chains composition at a more detailed level than the ones examined in Phase I.

3.4.3 Processing

Codes were used to help classify qualitative descriptions of the supply chain's characteristics provided by the interviewees: facilities (warehouses, points of distribution, etc.), parties (outsourced and in-house forwarders, carriers and shippers, etc.), geographic locations (urban or rural), set of commodities (wet food, dry food) and flows (unidirectional, bidirectional, multidirectional). Conceptual memos helped by adding or modifying emerging parties or actors that may even handle new elements

worth codifying. This way the absolute spectrum of supply chains in charge of food aid distribution is depicted so that the typologies could be identified in Phase III.

3.5 Phase III – Identifying the Humanitarian Logistics Structures

Phase III identifies the typologies of the humanitarian logistics (HL) structures as shown in Figure 6. This dissertation uses two additional instruments for identifying such typologies: structured interviews (surveys), which took place either in-person or by telephone, and summative content analysis. Both were combined to characterize the established humanitarian logistics structures that orchestrate the "last mile" delivery of food aid during the response and short-term recovery phases to both response systems separately.

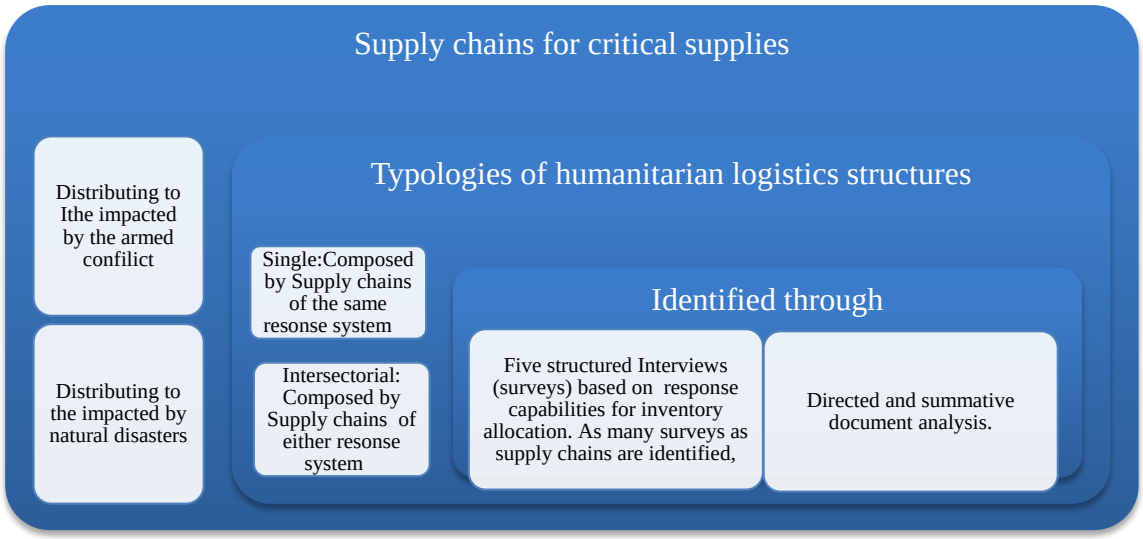


Figure 6. Phase III research

3.5.1 Structured Interviews

Again, the entrée to the organization for implementation of the instrument of analysis is the personnel designated from the executive directors in each organization, and was driven by the collaboration agreement achieved in Phase I. Thus, sampling was both purposive and snowball, as one person may have suggested another staff member to answer particular questions out of his/her knowledge boundaries on the process. The selection of the personnel in each organization who answered the interview was related to the number of people involved in both strategic and operational positions in light of the distribution process of food aid to the impacted people. The number and names of people surveyed was previously defined in Phase II.

Both face-to-face and telephone interviews applied. Face-to-face surveys were used for parties located in either *Bogotá* or *Medellín*, Colombia. Again, telephone surveys applied to parties geographically located at places other than *Medellín* and *Bogotá*. The standard interview guideline was driven by the capacities and locations of warehouses, points of distribution, and transportation assets (fleet characterization) for "last mile" distribution, and are accessible in Appendix G. In addition, the agility for quickly reconfiguring the supply chain in terms of manpower and facilities was considered. Similarly, the decision making process for configuring local distribution, the hierarchical structures and chain of commands, geographic coverage in terms of the most downstream impacted people up the most upstream supplier in the supply chain, lead times for last mile distribution, the procurement and replenishment process, manpower for loading and unloading operations, storing and materials handling, as well as any other applicable attribute, was also considered.

3.5.2 Content Analysis

Directed and summative content analysis took place in this phase. Through directive content analysis, approaches for identifying humanitarian logistics structures and classic outsourcing in supply chains were used as starting points. Again, generally speaking, the systematic approach for accessing these documents was the same conducted on Phase I and II. Content analysis in this phase aimed to collect any preliminary data that may serve as introductory inputs in the interviews guidelines. Memos were used to classify the humanitarian logistics structures. Next, frequencies of data attributes obtained from the structured interviews are achieved by counting the occurrences of a particular code.

3.5.3 Processing

Both qualitative and quantitative data were collected through the structured interviews. Qualitative data were used to code the supply chains identified in Phase II and they were grouped by their attributes. For instance, more than one supply chain targeted impacted population in rural and semi-rural areas, while others targeted for those impacted in populated areas. Or some supply chains presented commonalities in specific commodities to be distributed, for instance. Ultimately, quantitative data collected in the structured interviews was used to assess the performance improvement in the food aid distribution for a particular supply chain chosen, or in the best scenario, for a group of supply chains irrespective of the response system they belong to, provided the availability of the analytical model in the upcoming phases.

3.6 Phase IV – Performance Assessment of the Supply Chains

Since Phase III brings up the supply chain typologies already defined, Phase IV (see Figure 7) defines policy recommendations based not only on the best applicable practices from commercial and humanitarian supply chains given the humanitarian character of the supply chains under study, but also on a comparative performance analysis of the humanitarian logistics structures identified in Phase III. Such best practices are supported by the literature review that addresses both examples of commercial supply chains practices successfully implemented in humanitarian logistics, and practices that, despite the success in the private sector, are not yet applied to humanitarian logistics subject to the key features of these kinds of supply chains as presented by Holguín-Veras et al (2012b). It is important to stress that the policy recommendations for food aid distribution came from the research, rather than the literature review. The potential impact of these policy recommendations is then defined by assessing the performance of the alternative supply chain logistics structures, which represent the recommended policies.

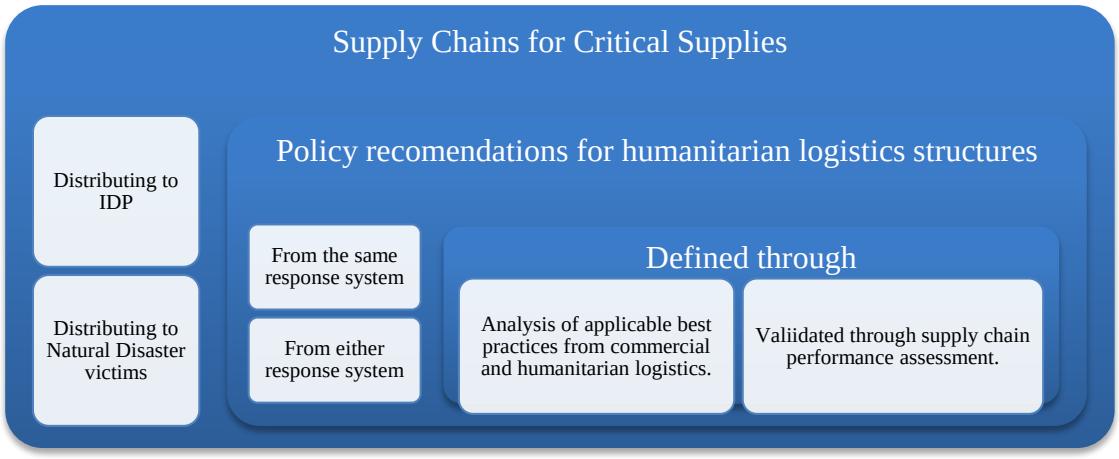


Figure 7. Phase IV research

3.6.1 Content Analysis

Conventional content analysis took place in this phase. The goal was to identify classic strategies for improving efficiency in the distribution process from both commercial and humanitarian logistics. Again, generally speaking, the systematic approach for accessing these documents was the same conducted on Phases I and III. Memos were used to classify all applicable strategies for improving performance up to the last mile when deploying food aid.

3.6.2 Processing

The qualitative evaluation obtained in this phase validates the policy recommendations exposed, but equally as important, feeds them back toward having the final policy recommendations whose assessment takes place in the final stage of this methodology. As illustrated in Figure 7, a single policy or a group of policy recommendations will be assessed by using the analytical model explained in the next session.

3.7 Using the Performance Assessment Tool

In order to inform the improvements from the policy recommendations resulting from Phase IV, an analytical model for humanitarian logistics is implemented (Pérez, 2011). Specifically, the analytical model is intended to serve as a pre-disaster planning tool for inventory allocation decisions during post-disaster operations where an external (deprivation) cost component is added to conventional logistics operational costs, in an attempt to minimize the total costs (operational and deprivation), or so-called social cost. The costs associated with the lack of access to a good (defined in the model as deprivation costs) are not naturally internalized by the

agencies or organizations delivering supplies to the population in need. This is, in this novel approach to humanitarian logistics, the optimal solution to the resource allocation problem is the strategy minimizing the total costs incurred in the disaster response, both operational and external. The strict consideration of deprivation costs in the decision making process for a distribution strategy implies giving representation to the loss in welfare associated with beneficiaries not having access to critical commodities on a timely basis. Ultimately, the model argues that it is necessary to incorporate deprivation costs in the formulations for humanitarian logistics to more realistically capture the social costs and benefits associated to the relief operations.

3.7.1 Limitations

Although the model is developed from the perspective of organizations active in the immediate response to disasters, in which the planner has to decide the amount and timing of any shipments to those impacted areas, certain limitations apply when attempting to assess the performance of the policy recommendations achieved in phase IV. First, the convergence of multiple supply chains to a disaster site at a system level involving multiple responders is considered by the model. This is operationalized by assuming one organization responds and the organization responding has multiple points of distribution In this respect, since the policy recommendations obtained in Phase IV aim to evaluate the performance of synergistic supply chains from the two response systems, additional assumptions may be required as a result of this novel research approach. In fact, as stated by Holguín-Veras and Jaller (2011), agencies such as the Volunteer Organizations Active in Disasters (VOAD) and the United Nations Joint Logistics Center (UNJLC) have emerged to exploit potential synergies and reduce redundancy, affirming that the coordination of multiple supply chains remains

a major issue in the response to extreme events. Second, the model focuses on the lower end of the humanitarian supply chain; this is the so called “last mile” fragment of the distribution subsystem comprising a local distribution center (DC) or staging area and the demand points at the disaster area. Points of supply at the national or international levels, from which the local distribution center may stock up, as well as the stakeholders at these levels, are not modeled. Third, because of the data collection process from the surveys in Phase III, the following data was available to run the model:

- Distribution center capacities, locations and initial inventory levels.
- Vehicle fleets including number and type of vehicles.
- Transportation networks including connectivity and link attributes (for example, length and travel time).
- Areas impacted by a particular disaster.
- Estimates of the number of beneficiaries: i) The amount and type of goods needed (consumption rates) and the resources initially available; ii) Initial deprivation time; iii) Deprivation costs (empirical deprivation cost function); iv) Material convergence; and v) Multi-commodity consolidation if applicable.

Since data regarding the disaster site and characterization of the impacted population is subject to the actual occurrence of a natural disaster where there is also internal displacement, historical data was used to simulate previous response operations as closely as possible.

In regards to defining an empirical deprivation cost function, this research implements a fair metric of human suffering that properly represents the particularities of the disaster scenarios under study. In this sense, this research implements a deprivation cost function that captures the cost of human suffering, assuming the same for all individuals. This is, from the standpoint of the humanitarian logistic process, all individuals are observationally identical.

3.7.2 Model Validation and Evaluation

Using Pérez (2011) model to make decisions on configuring inventory allocating strategies as an approach for assessing supply chain performances implies assuring that the model is actually producing consistent outputs of social costs and other related indicators. In order meet this requirement, this dissertation:

i. Used the original inventory allocation with a point-to-point distribution model developed by Pérez. Using the mathematical modeling developed by Pérez as a reference, the model was re-coded using AMPL (a mathematical programming language) to make runs using a free internet-based service for solving numerical optimization problems (NEOS Server, 2014), specifically, MINLP (mixed-integer, non-linear programming) problems.

ii. Using the AMPL code and NEOS, the first runs took place by using the input parameters and variables from the numerical example that Pérez used to obtain model results. The outputs obtained from running the model using these input parameters exactly matched the outputs obtained by Pérez. Consequently, from this point on, the dissertation counted on a complete tool to start running the model using different supply and

demand input parameters representing multiple supply and demand hypothetical scenarios.

3.7.3 Scenarios

Going beyond a simple exploratory approach representing a hypothetical situation, this dissertation defines scenarios that, although not based on a specific historical event, are considered to be feasible since they are drawn on the compilation of actual historic disaster events in Colombia to represent similar large-scale events likely to happen in the future. Based on this approach, this dissertation defines four hypothetical scenarios, which vary in terms of both supply and demand input parameters, as well as in terms of the disaster type (natural or manmade):

i. Hypothetical Scenario 1 takes supply input parameters representing a supply structure of the relief networks that distribute food aid to those impacted by the armed conflict. Demand input parameters are also purposively and conveniently selected by analyzing a repository of historic disaster events in the Caribbean region of Colombia. This scenario is referred to as the relief network, armed conflict hypothetical demand (RN-ACHD) scenario.

ii. Hypothetical Scenario 2 takes supply input parameters representing a supply structure of the relief networks that distribute food aid to those impacted by natural disasters. Demand input parameters are purposively and conveniently selected by analyzing a repository of historic disaster events in the Caribbean region of Colombia. This scenario is referred to as the relief network, natural disaster hypothetical demand (RN-NDHD) scenario.

iii. Hypothetical Scenario 3 takes supply input parameters representing a supply structure of the HL structures that would distribute food aid to those impacted

by the armed conflict. Demand input parameters are exactly the same to Scenario 1. This scenario is referred to as the humanitarian logistics, armed conflict hypothetical demand (HL-ACHD) scenario.

iv. Hypothetical Scenario 4 takes supply input parameters representing a supply structure of the HL structures that would distribute food aid to those impacted by natural disasters. Demand input parameters are exactly the same to Scenario 2. This scenario is referred to as the humanitarian logistics, natural disaster hypothetical demand (HL-NDHD) scenario.

3.8 Summary of the Methodology

The research involved:

i) Compilation, summarization and archiving of all relevant media articles, literature and reports that led to an initial identification of actors involved in food aid distribution for both response systems and to the magnitude of the impacts of manmade and natural disasters in Colombia.

ii) Content analysis that classifies actors and relief networks within each response system in order to build an initial identification and characterization of actor.

iii) Conduct of formal and informal interviews whether in-person, by telephone or videoconference to refine the identification process from content analysis and to enhance the understanding of the role that the actors were found to play when distributing food aid to beneficiaries.

iv) Compilation and archive of relevant technical reports both provided by interviewees and links suggested for download from their websites that give better illustration of the specific logistics operations run to deploy food aid.

v) Content analysis regarding the key logistics features through which the supply chains are characterized.

vi) Conduct of formal interviews whether in-person, by telephone or videoconference to refine and better elaborate and represent the flow process of food aid commodities along the supply chain.

vii) Content analysis of information provided to identify the level of outsourcing of the relief networks and actors identified, which guided the process to identifying HL structures and suggesting policy implications.

viii) Programming a mathematical code for taking an analytical model as a performance assessment tool to understand the impact that different supply structures may have when responding to realistic large-scale disasters.

ix) Understanding an inventory allocation model as a decision-making process tool for practitioners aiming to take, beforehand, the most from their established supply structures in post-disaster and regular operations.

In general terms, the research protocol promised that the identity of the participants would be kept confidential. The interviewees represented established organizations large and small, international and local, governmental and non-governmental. The interviewees were individuals at different positions within the organizations, from upper management to those at technical and operational levels. The organizations interviewed had different functions within the overall HL process, from procurement, transportation, and staffing, to the organization, care and distribution of critical supplies to beneficiaries.

Ultimately, this dissertation aims to successfully integrate appropriate qualitative and quantitative research strategies to follow future research suggested by Holguín-Veras et al (2012b) such as the: i) “Characterization of the HL structures that arise after major disasters”; ii) “Optimal coordination of the different HL structures”;

iv) “Inventory allocation models that incorporate deprivation costs”; vi) “Planning of points of distribution”; vi) “Effective incorporation of local social networks as an integral part of the response process”. vii) “Enhancing resilience of both communities and the social networks engaged in logistics”. viii) “Development of a response framework that allows seamless integration between the private sector, the community, and existing community structures’. ix) “The Coordination mechanisms among emergent and established HL structures”. In addition this dissertation also follows practitioner’s recommendations who have stated that: i) “access to food aid in Colombia for all find of beneficiaries is not guaranteed in a timely manner”. ii) research initiatives should also focus on specific conditions in developing countries. Lastly, this dissertation also develops a discussion and future research suggestions, which are novel in expanding and mixing strategies of conventional commercial logistics in the humanitarian logistics context and in guiding the implications of using existing analytical models in realist and large-scale scenarios.

Chapter 4

PHASE I RESULTS-IDENTIFYING THE ACTORS

The humanitarian response in Colombia is orchestrated by several relief organizations that vary not only in size, geographic coverage and affiliation type, but also in response type. Natural hazards are not the only threats that socially vulnerable citizens have to deal with since the armed conflict was raised more than 50 years ago. This "*doble afectación*" has caught the eye of several international NGO's, UN agencies and other major private organizations, all of whom have witnessed the humanitarian response that Colombian governmental organizations have provided to people being impacted by both natural and manmade disasters. In some cases, these witnesses have collaborated with the governmental response, but in other instances, they have been the only relief organizations who have assisted specific populations in remote areas where the humanitarian assistance from the state has been simply null or untimely. Reasons for such absence varies from the constraints that the armed conflict impose on governmental operators – who inherently are actors in the conflict itself – and on the infrastructure and other external variables that challenge the humanitarian assistance provided by law. Furthermore, the operational foundations that such law draws on when orchestrating humanitarian assistance could certainly be considered another constraint itself.

An emerging challenge is that some of these established relief organizations may execute humanitarian aid operations individually and merely in accordance to their own response capabilities, assisting beneficiaries during either PD-HL or R-HL

operations. Conversely, other established relief organizations in Colombia may have made an effort in integrating their logistic capabilities with others. Indeed, the fieldwork experienced in Haiti by Holguín-Veras et al (2012a) suggests that an integrated logistical structure should be set up by taking the most from storing, transporting and distributing capabilities of each actor, along upstream and downstream segments of the supply chain, particularly in identifying which actors can perform better in local distribution and which can do a better job transporting bulk aid to the disaster area and how to link both strengths.

Both individual and integrated approaches apply to the case of Colombia, where formal pre-disaster integration takes place to some extent through outsourcing and collaboration strategies among actors. Thus, the heterogeneity among relief agencies in Colombia may draw the heterogeneity of the supply chains through which humanitarian aid is deployed to both the natural disasters' and the armed conflict's beneficiaries. This phase elaborates on the identification of actors that orchestrate PD-HL operations, specifically, food aid that is distributed locally to beneficiaries from both manmade and natural disasters. Initially, such identification is based on secondary information found in open documents and reports available online, in complementation of individual interviews made to practitioners who have a significant experience directing humanitarian operations in Colombia. A strong emphasis is placed on presenting relief organizations that classify themselves as being a member of formal networks in contrast to those whose PD relief operations tend to take place individually.

Secondary information regarding facts and figures related to the aftermaths of both manmade and natural disasters in Colombia is introduced in order to

contextualize the humanitarian aid demand patterns that the armed conflict and natural hazards trigger together, as well as estimating the demand of those who have been concurrently impacted by both threats.

4.1 The Population Impacted by the Armed Conflict

The complex ongoing conflict between leftist guerrilla groups, the Revolutionary Armed Forces of Colombia (FARC), as well as the National Liberation Army (ELN) and the Colombian armed forces, which began in the mid-1960s, also involves right-wing paramilitary groups that became active in the 1990s. Both guerrilla groups claimed to be fighting against a violent government for the rights of Colombia's poor, promoting socialist values and a strong land reform agenda. Paramilitary groups initially grew out of the private armies of cocaine cartels in a bid to protect their illegal business interests from guerrilla groups, who had begun using the drug trade in order to finance their activities. The armed forces have been fighting the guerrillas and working to disarm the paramilitary in an attempt to forge political and social stability. Since the dispute for land is one of the most critical problems, the civil population has found itself in the middle of the confrontation, and as a result, land dispossession has triggered a large number of internally displaced persons (IDPs). Indeed, because of the armed conflict, there are persons who have claimed reparation for other causes, such as homicide of relatives, disappearance, loss of personal property, terrorist attacks, kidnapping, landmines, torture, recruitment of children, force abandonment and sexual crimes.

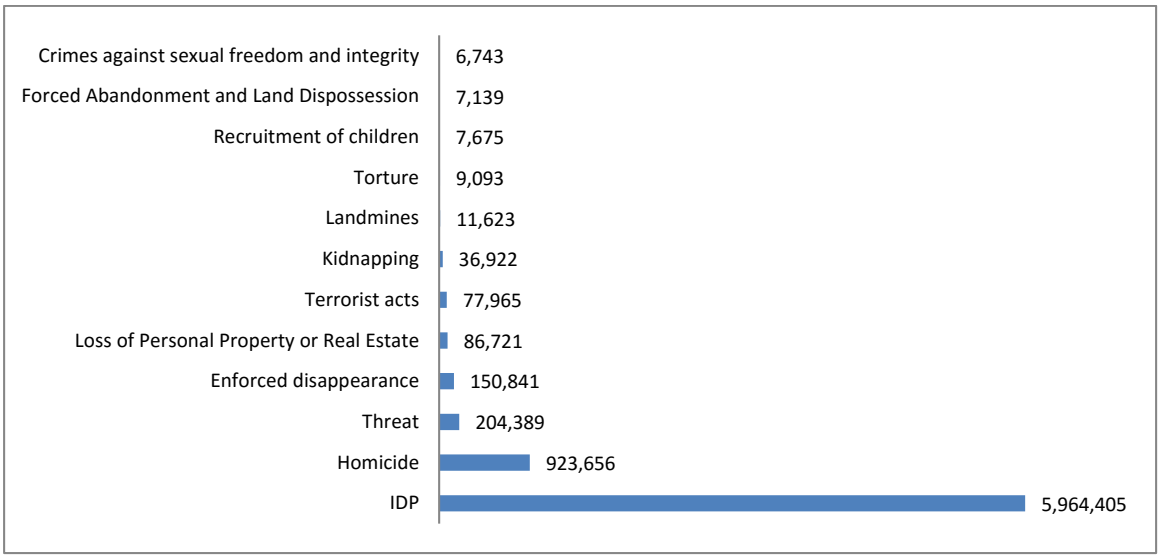


Figure 8. People impacted by cause from 1985 to 2014

With nearly 6 million people officially registered as internally displaced (IDPs), this is, 80% of total "victims" (see Figure 8 and Figure 9), it is a duty of the state to initiate a reparation and humanitarian assistance program to each of these "victims," according to the Victims and Land Restitution Bill or so called "victim's law" (ABColombia, 2011). Furthermore, IDPs have significantly increased in the last 10 years. As can be seen in Figure 10, 50% of total IDP's have been registered from 2004 to 2014, with a relative stable average of about 300,000 new IDPs each year from 2012 through 2014. Geographically speaking, 50% of total IDPs concentrate in only six out of the 33 Colombian provinces. IDPs are concentrated in Antioquia, Bolivar, Magdalena, Chocó, Nariño and Cesar, as shown in Figure 11.

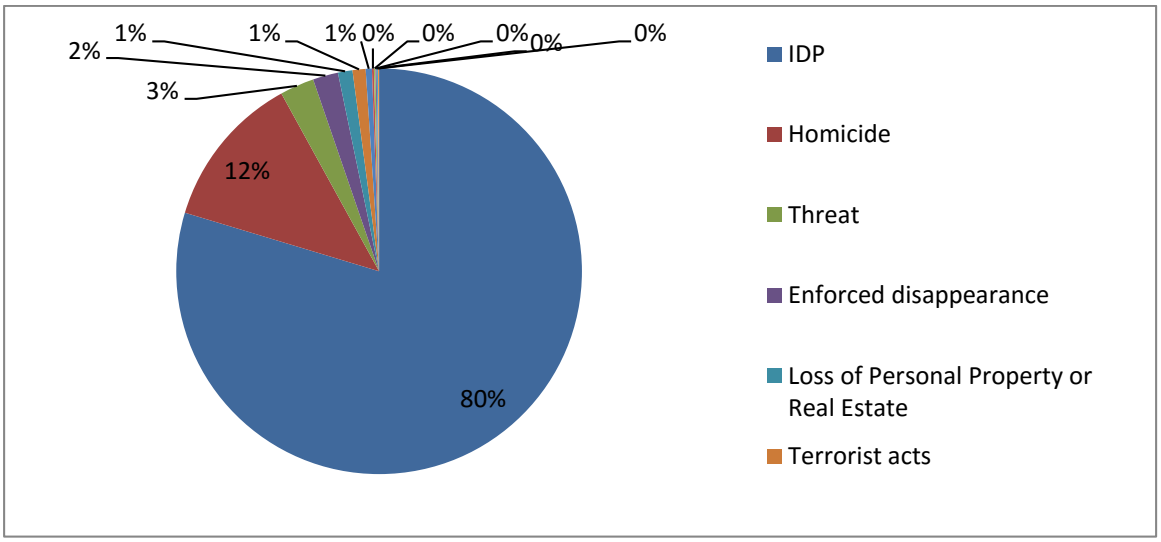


Figure 9. People impacted by major source

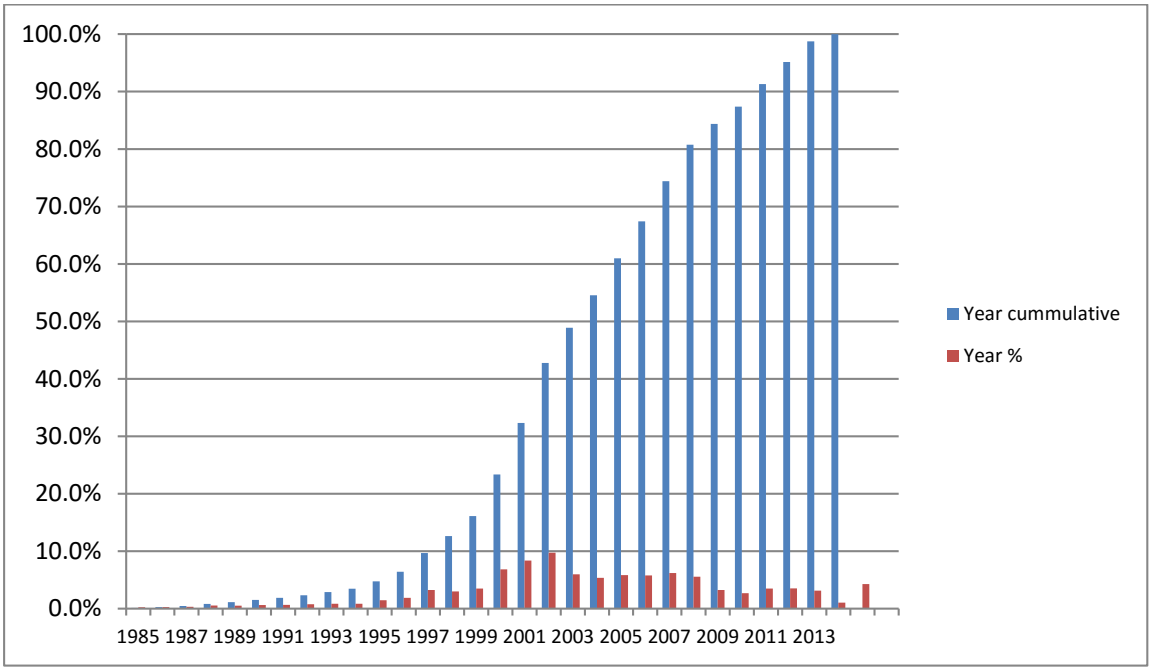


Figure 10. IDPs in Colombia 1985-2014

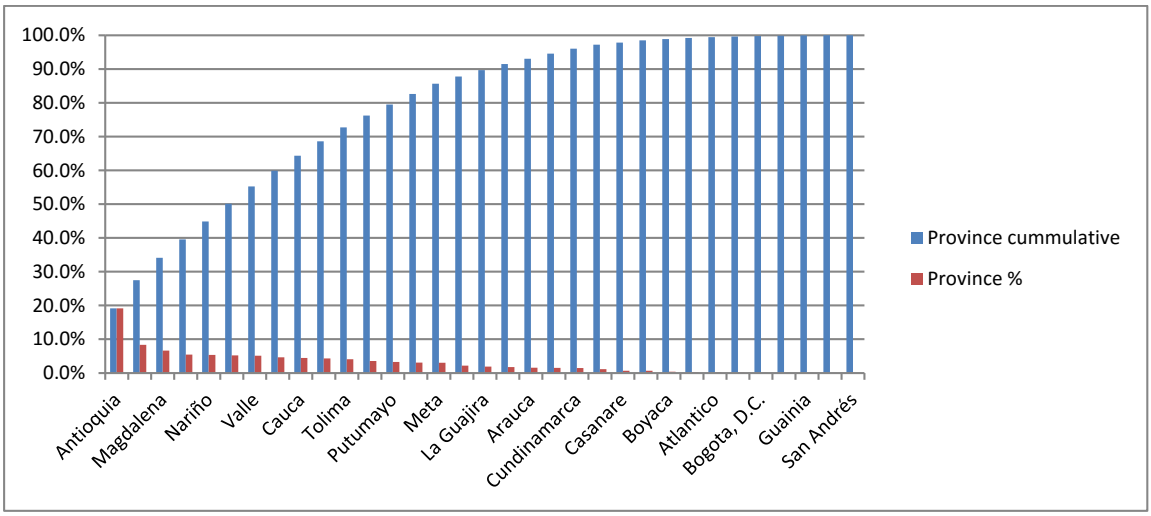


Figure 11. IDPs in Colombia by province

4.2 The Armed Conflict Response System

The reparation and assistance program for those impacted by the armed conflict includes registration, compilation of testimonials, financial reparation, physical and psychosocial rehabilitation, and special assistance for Afro-Colombians and other ethnic groups, as well as women and children. Once registered, IDPs receive immediate direct assistance in the form of benefits for three months, with a further three months of support available in cases of extreme need. Given the scope of this research, such immediate assistance is the focus in light of the concern with humanitarian aid, particularly food aid deployed to IDPs. From now on, these IDPs will be referred to as beneficiaries, when applicable.

4.2.1 Organizational Aspects

By law, local authorities in Colombia are responsible for implementing elements of the National Plan for Assistance to the Displaced Population and for designing and coordinating the response at a local level. Thus, municipal governments

must initiate the orchestration of food aid distribution under the frame of immediate humanitarian assistance to IDPs. In doing so, large cities typically designate and execute resources through a specific administrative department. In contrast, small towns located at remote rural areas may not be as well prepared to deploy the aid needed, neither financially nor operationally, meaning that their institutional capacity is insufficient (OCHA, 2013). Such matters of fact partially justify the presence of other type of relief organizations in such rural areas that do manage to bridge the gaps left in evidence by local governments. In addition, because many IDPs fear being identified when declaring themselves as "victims" before local authorities, the humanitarian aid provided from non-governmental organizations becomes crucial as well.

Because respect for international humanitarian law reinforces the legitimacy of the state, Colombian government is committed to recognize "the legitimacy of the humanitarian non-governmental organizations that develop their activities in conformity with the Constitution and the laws of the country. These organizations are understood as those that are inspired by the principles of humanity, impartiality and independence in order to provide, without any discrimination, assistance and protection to victims of natural disasters, of the internal armed conflict and other violent events with the goal of preserving these victims' physical health and dignity and support them to recover their economic capacity as soon as possible. These actions include, among others: attention to basic needs such as the availability of food and water; providing shelter and sanitary assistance; distributing medicines and provision of medical care; first aid training; accompanying persons and communities

at risk; and supporting productive and educational projects in vulnerable populations". (International Organizations Position Paper, 2011).

Consequently, although the local authorities have the obligation and main responsibility to provide humanitarian assistance, and for the adequate provision of this assistance, the activities realized by humanitarian non-governmental organizations in close coordination with the appropriate entities are extremely valuable, which serves as a foundation to fully identify the actors that deploy food aid to IDPs in Colombia irrespective of the affiliation type.

Furthermore, another justification for non-governmental organizations to orchestrate humanitarian aid to IDPs in Colombia lies in the fact that current rules state that any individual IDP claiming to have been displaced by paramilitary groups are not considered "victims" of the armed conflict under the 2011 Victims' Law, and as such are not eligible for land or financial restitution. Consequently, large numbers of persons displaced by paramilitary groups are claiming when they file for assistance that they were instead displaced by guerrillas, in order to qualify (Stirk, 2013). In contrast, those who don't claim so automatically become IDPs in need, whose humanitarian aid is to be provided by NGOs and private organizations.

4.2.2 Identification of Actors

Building on the initial classification of actors found from practitioners' reports and academic research in regards with humanitarian assistance to IDPs, and complementary to in-person interviews made to practitioners who distribute food aid to those impacted by the armed conflict, this research introduces an approach for

identifying those actors who have ongoing food aid distribution operations to partially alleviate the suffering of IDPs in Colombia.

Figure 12 below represents Finger's approach (2011) earlier cited in the literature review of organizational aspects, which highlights the coverage that exists in alleviating the needs of IDPs despite the fact that, in countries like Colombia, where the institutional capabilities are considered strong in comparison to similar conflicts in places like Myanmar, the intervention of international entities constitutes a complementary effort that still remains insufficient. In contrast, the figure also addresses IDP population that may be assisted by some or all type of actors as the black arrows indicates.

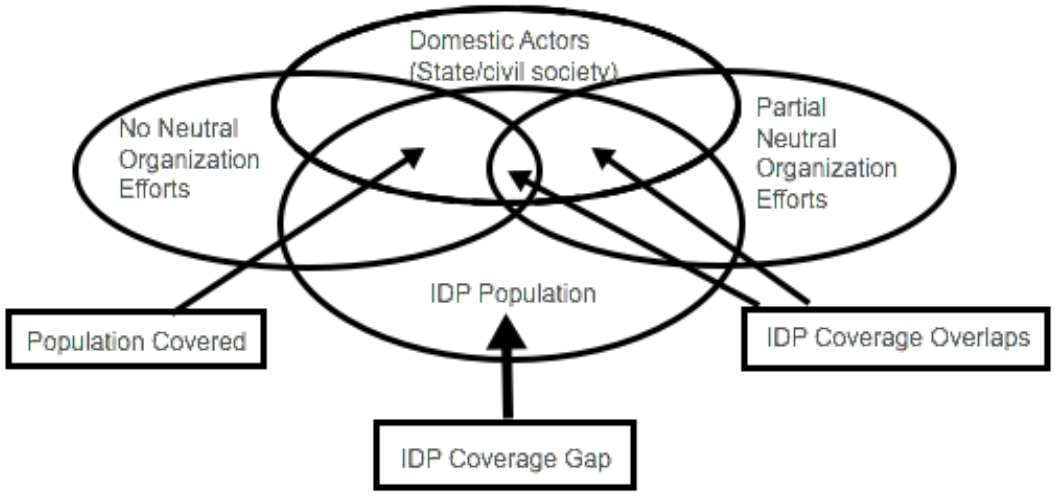


Figure 12. Humanitarian actors for IDPs.

As discussed in the literature review, Stirk (2013) presents a classification of actors directly involved in assisting IDPs in Colombia. Figure 13 synthetizes Finger's and Stirk's approach suggesting not only the list of humanitarian actors that assist IDPs' needs in Colombia but also classifying them according to its affiliation type.

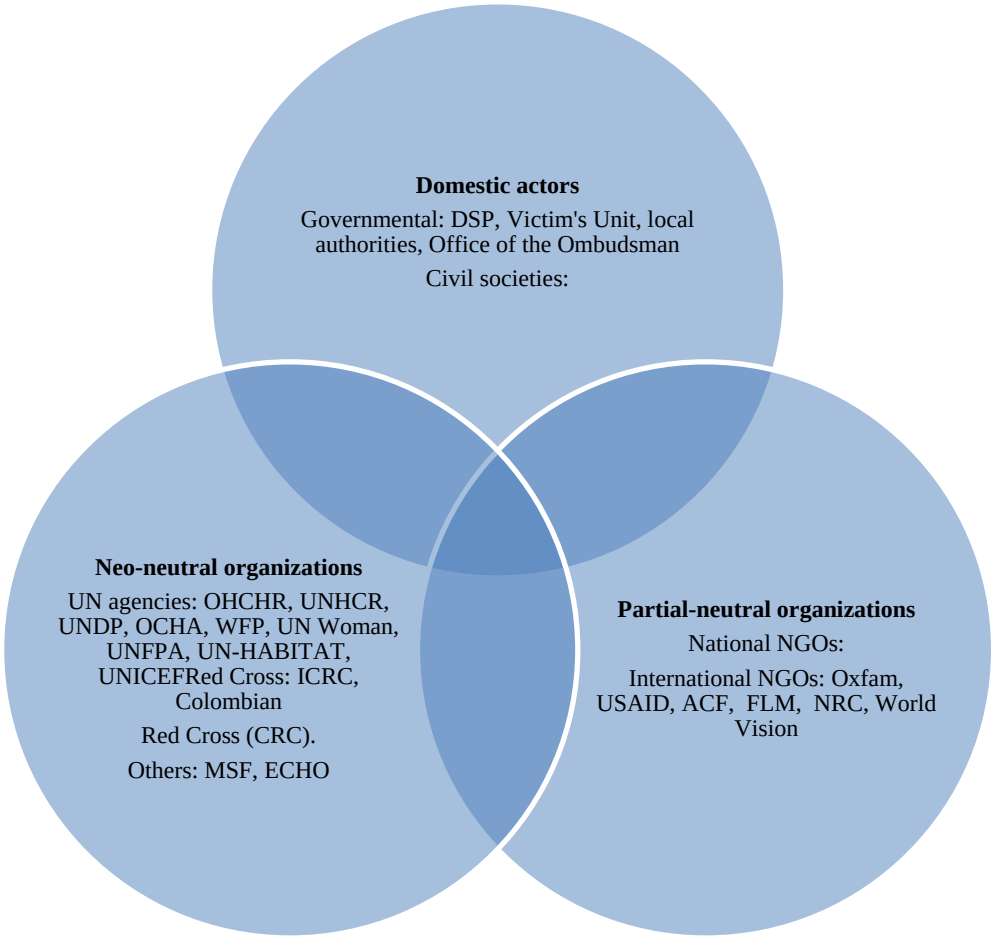


Figure 13. Preliminary classification and identification of humanitarian actors in the armed conflict. .

In order to continue scaling down and identifying the actors specifically performing food aid distribution to IDPs in Colombia among the list of actors assisting with all kind of humanitarian aid (sheltering, health, nutrition, etc.), an in-person interview took place to a staff member running an executive position of an organization of each classifying group from Figure 13. Each of the three interviews intended to validate the list of actors within each classifying group that run food aid distribution to IDPs by focusing on the following inputs:

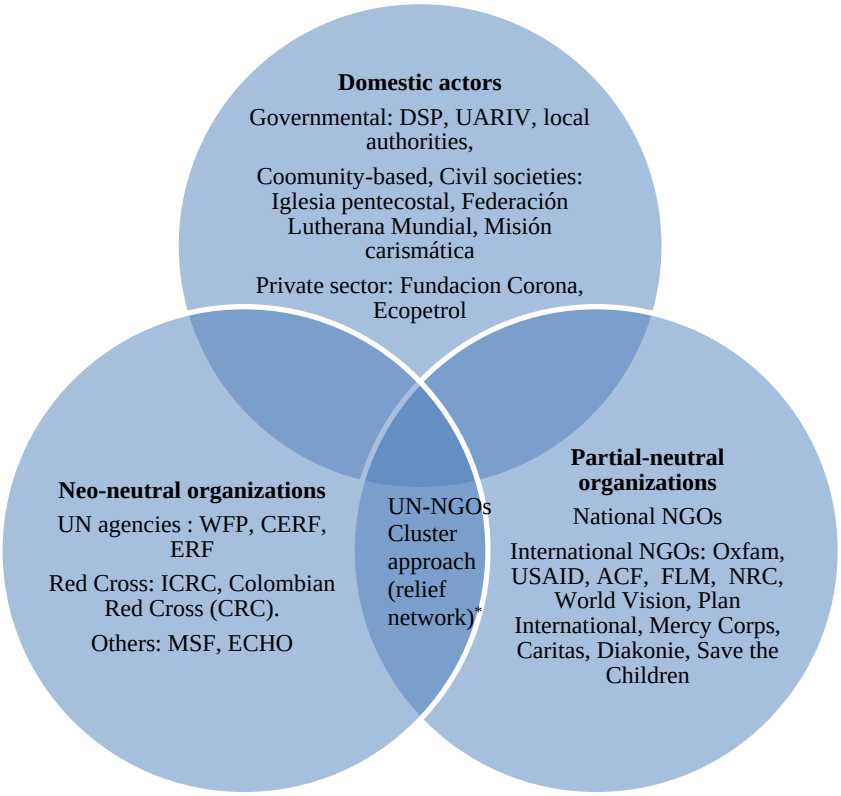
- Consistency of Figure 13 regarding the precision of actors directly involved in food aid distribution to IDPs, actors missing and actors not in charge of these this kind of operations.
- Rationale of the classification of actors presented on Figure 13 and suggestions on different classifications that may rise from the field.
    - Humanitarian Logistics phases covered when distributing food aid (response and short-term recovery).
- Disaster type that the organization in question may exclusively focus.
- Pull of food aid commodities distributed.
- Geographic coverage of logistics operations.
- Vulnerable population targeted when deploying food aid.

Building on the interview results, Table 1 below initiates the final identification and classification of actors distributing food aid to IDPs in Colombia, which is then summarized in Figure 14 below, representing an enhancement of the classification illustrated in Figure 13.

Table 1. Validation of identification and classification of actors distributing food aid to IDPs

Input	**OCHA (Neo-neutral organization)**	**World Vision (partial-neutral organization)**	**Local Authority-*Unidad Municipal de Víctimas de Medellín-UMV* (Domestic actor)**
Consistency of Finger and Stirk adaptation regarding ultimate actors that do distribute food aid	Appropriate actors: WFP (World Food Program), CRC (Colombian Red Cross), ICRC (International Confederation of the Red Cross), UARIV (*Unidad de Atención y Reparación Integral de Víctimas*)	Missing actors in the adaptation: Secretariado Nacional de la Pastoral Social, Save the children, Plan International, CERF (Central Emergency Response Fund), ERF (Emergency Response Fund), FFMM (Military), Police Department	Appropriate actors: UARIV, ICBF (*Instituto Colombiano de Bienestar Famililar*)
Classification's rationale	Appropriate	Missing classification: Private sector (*Fundación Corona,, Ecopetrol.Iglesia Pentecostal, Federación Lutherana Mundial, Misión Carismátic*a)	Appropriate
Humanitarian Logistics	Food aid is distributed in both instances disaster response and short term recovery	Food aid is distributed in both instances disaster response and short-term recovery. The situation delimits the transition from one stage to the other when assisting IDPs.	Food aid is distributed in both instances disaster response and short-term recovery. "Immediate assistance" and regular humanitarian logistics is provided as well
Disaster type	No discrimination in assisting any kind of disaster, manmade or natural	No discrimination in assisting any kind of disaster, manmade or natural	Displacement and all forms of impact that requires assistance as "victims of the conflict"
Geographic coverage	Strong presence in rural areas where institutional capacities are weak.	Urban: World Vision, Plan International. Rural: the rest of NGOs and UN agencies	Limited to IDPs located within each municipality
Commodities	Food aid kits and food security programs	Only food aid kits are handled by all kind of organizations.	Only food aid kits
Population targeted	Most vulnerable.	Most vulnerable. All IDPs from the state side.	All IDP population officially registered as "victims"

Although Figure 14 below refines Finger and Stirk's approach, it does not intend to represent 100% of the actors involved in food aid distribution to IDPs in Colombia. Instead, it aims to intersect previous analyses from practitioners and researchers with the objective opinion of staff from relief organizations who are knowledgeable of the dynamics around the distribution of this kind of aid. Thus, Figure 14 represents a significant number of actors from which the majority of supply chains from established organizations draw when it comes to distributing food aid in the last mile and during the response phase.



* The UN cluster approach comprises both neo-neutral and partial-neutral organizations, hence the intersection.
Figure 14. Final identification of actors distributing food aid to IDPs in Colombia.

4.3 The Population Impacted by Natural Disasters

Several technical reasons make Colombia vulnerable by default to certain hazards. From south to north, the Andes Range crosses Colombian territory, which makes this tropical country possess significant volcanic activity and impressive altitude variability along the range. Because of the presence of both the Atlantic and Pacific oceans on either side, the country is inherently impacted by any kind of meteorological phenomenon coming from any of these two bodies of water. Moreover, most Colombian citizens are settled in Andean urban areas, whose population exceeds 1 million, which consequently makes them vulnerable to several hazards derived not only from many natural circumstances, but also from a variety of social circumstances as a developing country.

When it comes to major floods, for instance, technically, La Niña has triggered most of them. This phenomenon, which is characterized by unusually cold ocean temperatures in the Equatorial Pacific (NOAA, 2012), has reached the Colombian Andean region due to its proximity to the Pacific Ocean. As a result, the unusual precipitation not only takes place in the most populated cities like *Bogotá, Medellín* and *Cali*, but also by tremendously increasing the flow of the Magdalena and Cauca rivers, which is detrimental to the population that lives along these two cross-country rivers. In addition, landslides are hazards that technically could be attributed to heavy rains as well, though not all devastating landslides in Colombia have been attributed to the high precipitation of heavy rainfalls. Instead, settlement and land use on steep sloping areas of urban population have caused imminent disaster in metropolitan areas, where the most socially vulnerable people have been usually the most impacted. As can be observed in Figure 17, 2010 and 2011 floods together triggered most of

those impacted population of the past six years, which certainly overwhelmed national response capacity.

As Figure 15 and Table 2 illustrates, when considering all the events to be assisted by the Colombian natural disaster response system, flood is the most frequent disaster event (42%), more than doubling landslides (19%) and non-armed conflict social issues (16%) associated to confinement of remote rural areas. Indeed, according to Figure 16, the total of impacted people from floods represent about 80% of total impacted population from natural disasters in Colombia from 2008 to 2014. In other words, about a half of the disaster events are flood-related, representing the vast majority of total impacted population over the last six years. As can be observed in Figure 17, 2010 and 2011 floods together triggered most of those impacted population of the past six years, which certainly overwhelmed national response capacity.

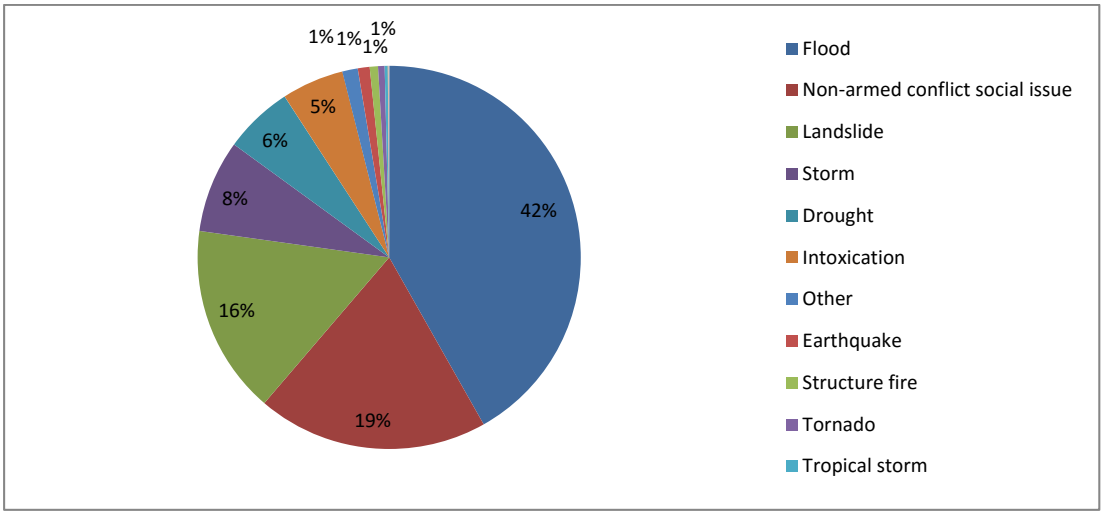


Figure 15. Disaster events from 2008 to 2014

Table 2. Top ten natural disasters in Colombia, sorted by numbers impacted

Disaster	Date	Total impacted
Flood	Apr-11	3,120,268
Flood	Sep-08	1,200,091
Flood	Oct-07	1,162,135
Flood	Mar-07	443,173
Flood	Jan-06	221,465
Flood	Sep-05	474,607
Flood	Oct-04	345,386
Earthquake (seismic activity)	Jan-99	1,205,933
Flood	Oct-86	250
Flood	Nov-70	5,105,000

Source: Walker et al (2011)

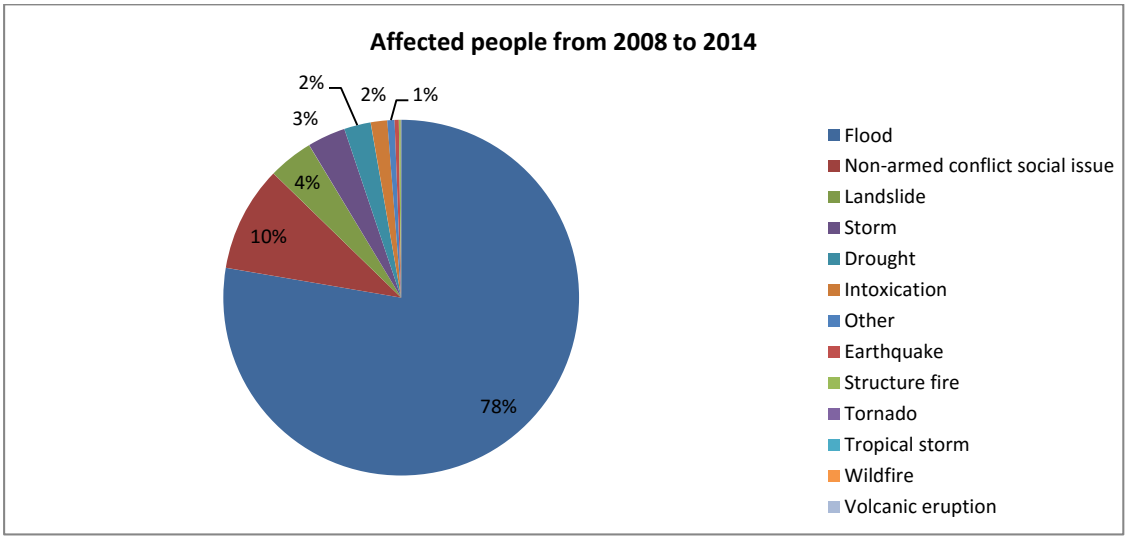
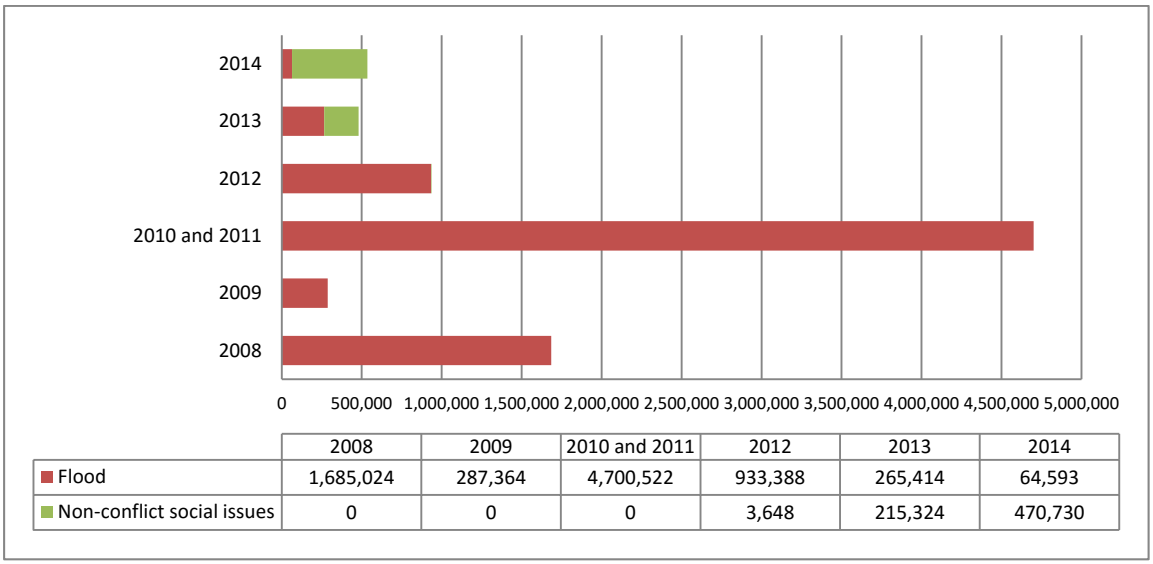


Figure 16. Impacted people from 2008 to 2014



	2008	2009	2010 and 2011	2012	2013	2014
Flood	1,685,024	287,364	4,700,522	933,388	265,414	64,593
Non-conflict social issues	0	0	0	3,648	215,324	470,730

Figure 17. Impacted by natural and anthropic disasters in Colombia

Geographically speaking, only six out of the 33 provinces – those being *Bolivar*, *Huila*, *Córdova*, *Chocó*, *Magdalena* and *La Guajira* – reported having natural disasters representing 50% of the total impacted population (See Figure 18 and Figure 19). In fact, a vast majority of these populations suffered from 2010 and 2011 floods as well. Colombia suffers more than 600 natural disasters a year, the highest rate of recurrent natural disasters in Latin America, with 85 percent of the population and assets located in areas exposed to two or more natural hazards (GDFRR, 2012).

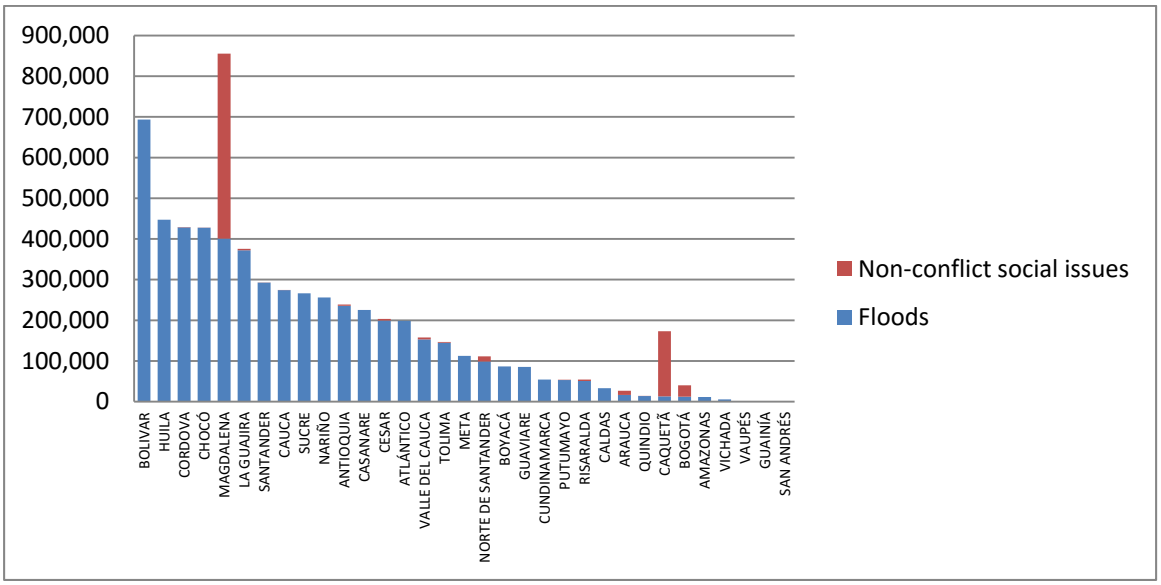


Figure 18. Population impacted by natural and anthropic disasters in Colombia from 2008 to 2014 by province

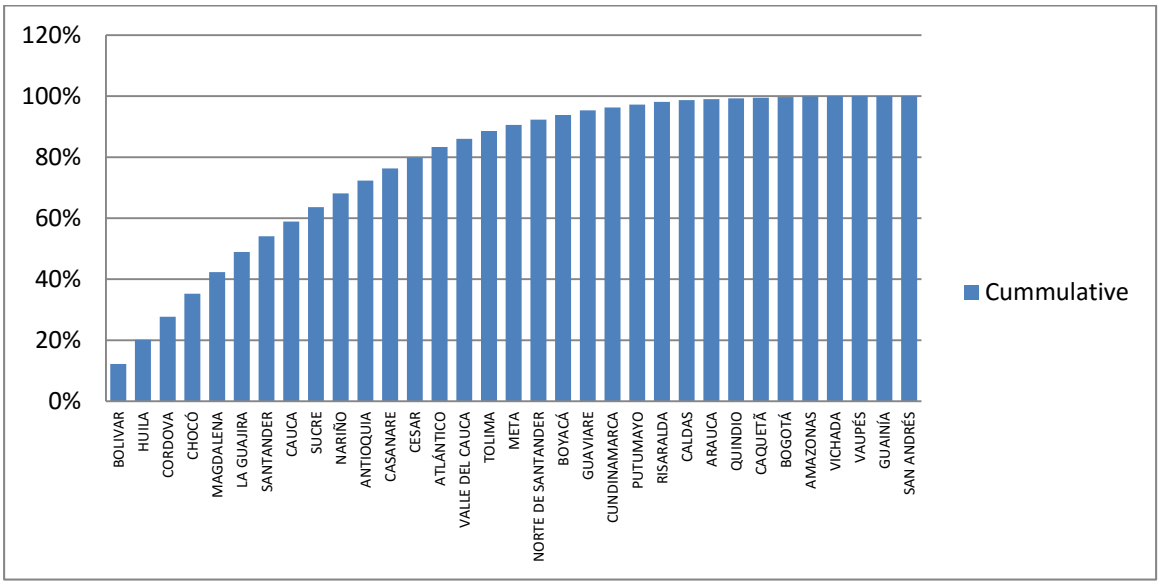


Figure 19. Cumulative population impacted by natural and anthropic disasters in Colombia from 2008 to 2014 by province

4.4 The Natural Disaster Response System

As with the assistance to those impacted by the armed conflict, governmental institutions in Colombia are responsible by law from responding to those impacted to natural disasters. With the passage of Act 1523 on 24 April 2012, the former organization for disaster response has been replaced by the "National System for Disaster Risk Management" (the "National System").

4.4.1 Organizational Aspects

The new National System seeks to organize public and private efforts in a highly participatory manner, focusing not only on disaster response but also on prevention. Act 1523 also created the National Council for Risk Management, which is tasked with developing relevant policies and approving the National Plan for Disaster Management and the Strategy for the National Response to Emergencies (International Federation of the Red Cross, 2014).

The Act sets out some broad principles on international disaster assistance. Given that it states that international cooperation should have a central objective of strengthening of the National System and the entities within it, there is not only an implicit acknowledgement of the international humanitarian action, but also the need for their capabilities. Additionally, the Act establishes that humanitarian aid should be provided in accordance with principles of quality, opportunity, pertinence and efficiency. The Act also requires that the Ministry of Foreign Affairs and the National Disaster Risk Management Unit (UNGRD) (the central institutional focal point on disaster risk management) to develop a strategic plan for the coordination of international assistance which is to cover legal, economic, physical, human and technical aspects of international cooperation.

In summation, Colombian regulation to natural disaster management not only requires that national entities make an effort in coordinating and collaborating among them, but also recognizes international humanitarian actors by trying to integrate them to some extent, despite the fact these international organizations do manage to operate independently in several instances (UNGRD, 2014). Given the evident existence of national entities responding to natural disasters, as well as the presence of international organizations, the next section pursues the identification of established actors involved in food aid distribution to those impacted by natural disasters in Colombia.

4.4.2 Identification of Actors

Following a similar approach to identifying actors assisting IDPs, the identification of actors assisting impacted populations from natural disasters builds on the initial classification of actors suggested by practitioners' reports and literature, complemented by in-person interviews made to practitioners who distribute food. Thus, this research introduces an approach for identifying those actors who have ongoing food aid distribution operations to partially alleviate the suffering of impacted populations from natural disasters in Colombia.

Figure 20 below illustrates the three-level approach suggested by Vitoriano et al (2013) and previously addressed in the literature review. Figure 21 represents Harvey & Harmer (2011) approach, also previously addressed in the literature review, where different actors in the immediate non-conflict disaster response are identified in the outer circles while regional organizational structures among actors are identified in the inner circle.

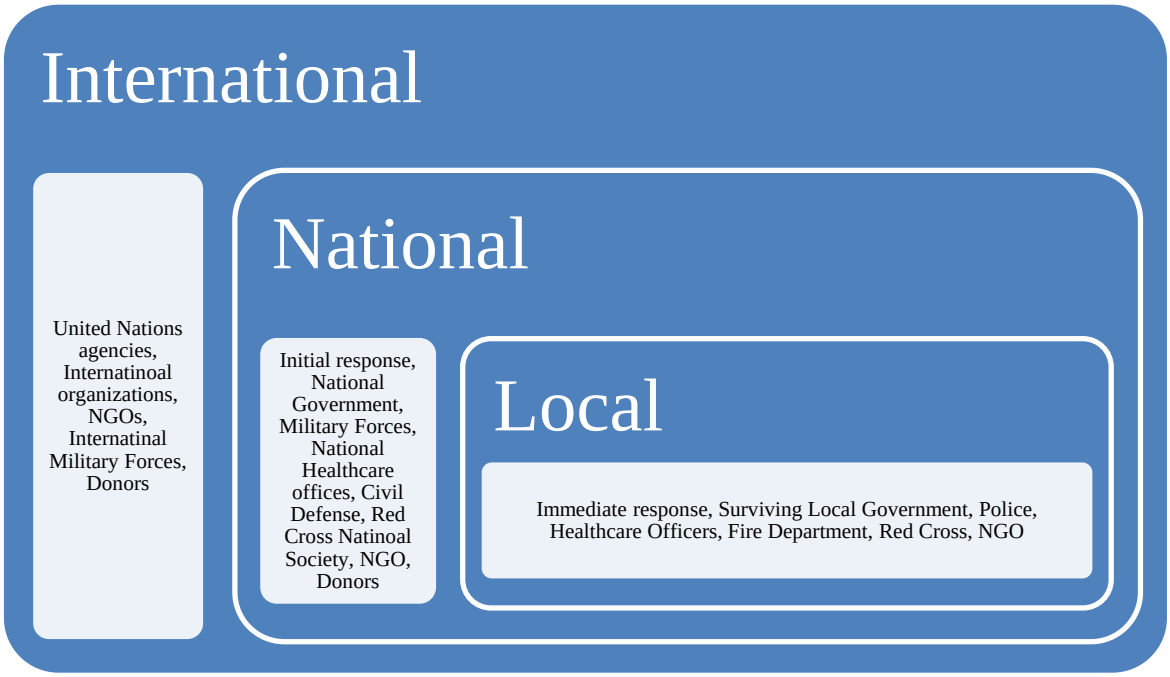


Figure 20 Classification of actors

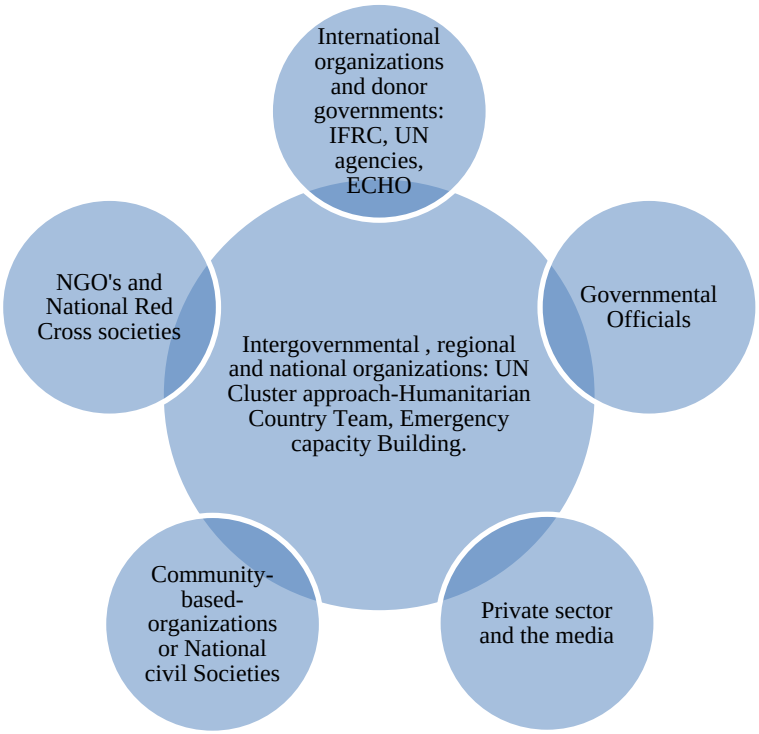


Figure 21 Actors in direct response and regional organizations.

Likewise, Figure 22 illustrates the classification derived from those actors in the Colombian Context that the IFRC classify as active when assisting impacted population from natural disasters.

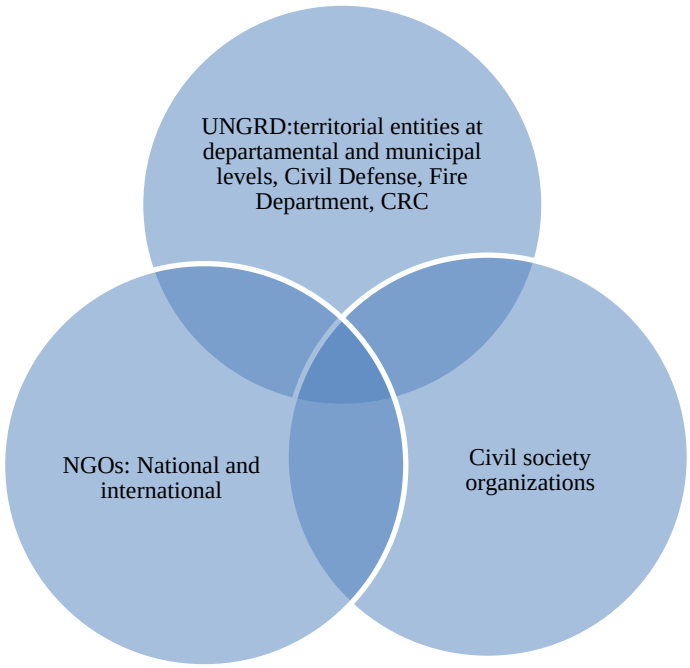


Figure 22 Classification of Colombian humanitarian actors by the IFRC

Considering that the approaches shown in Figure 20, Figure 21 and Figure 22 present both commonalities and differences, Figure 23 illustrates as many actors, as well as suggested classifications from Vitoriano et al (2013), Harvey & Harmer (2011) and the IFRC's (2014) in an effort to collect as many perspectives as possible and make them converge them in a single approach.

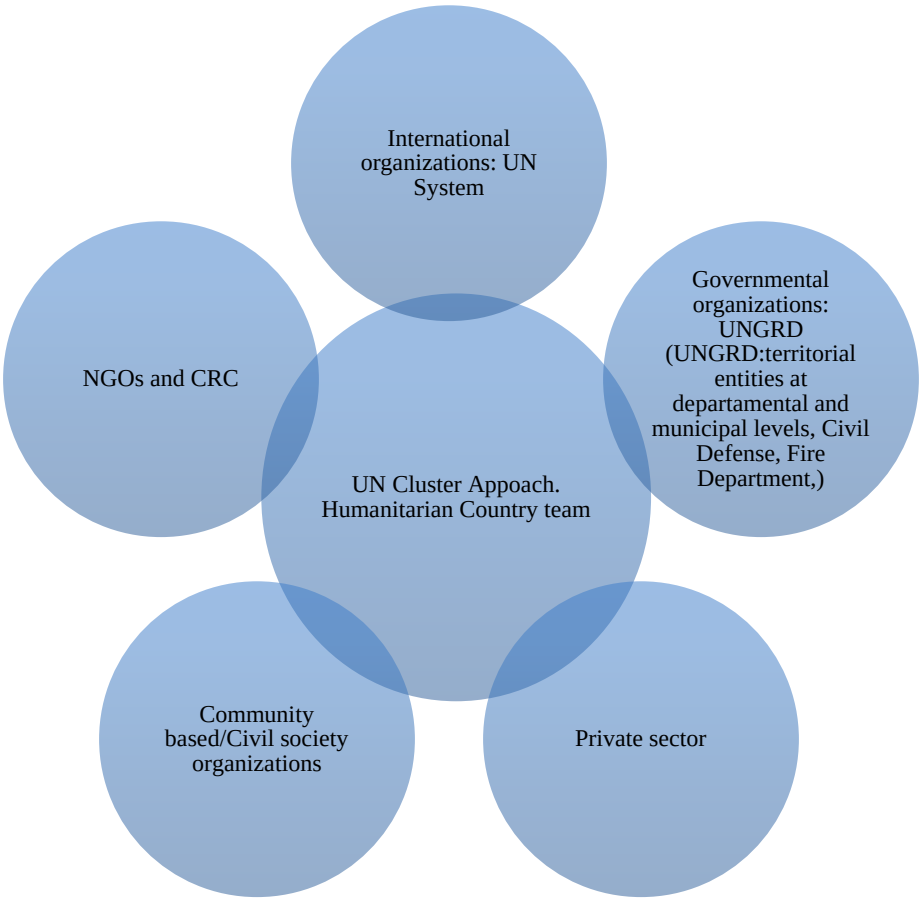


Figure 23 Preliminary identification and classification of actors

Now that actors responding to natural disasters have been identified from secondary information found in the literature and practitioners' reports, the following paragraphs elaborate on the in-person interviews through which the final schematic of actors distributing food aid is identified and validated. Based on referrals from actors identified in Figure 23, staff members in executive positions in two humanitarian organizations were interviewed about the pertinence, completeness and rationale of the

schematic of actors. The organizations interviewed were the Colombian Red Cross and the National Unit for Risk and Disaster Management (UNGRD). These organizations have leadership roles in the UN agency system and are integrated with the Colombian government agencies. Besides, each of the two interviews were intended to validate the list of actors within each classifying group that run food aid distribution to beneficiaries by focusing on the following inputs:

- Consistency of Figure 23 regarding the precision of actors directly involved in food aid distribution to populations impacted by natural disasters, actors missing and actors not in charge of these kinds of operations.
- Rationale of the classification of actors presented in Figure 23 and suggestions on different classifications that may rise from the field.
- Humanitarian Logistics phases covered when distributing food aid (response and short-term recovery).
- Disaster type that the organization in question may exclusively focus.
- Pull of food aid commodities distributed.
- Geographic coverage of logistics operations.
- Vulnerable population targeted when deploying food aid.

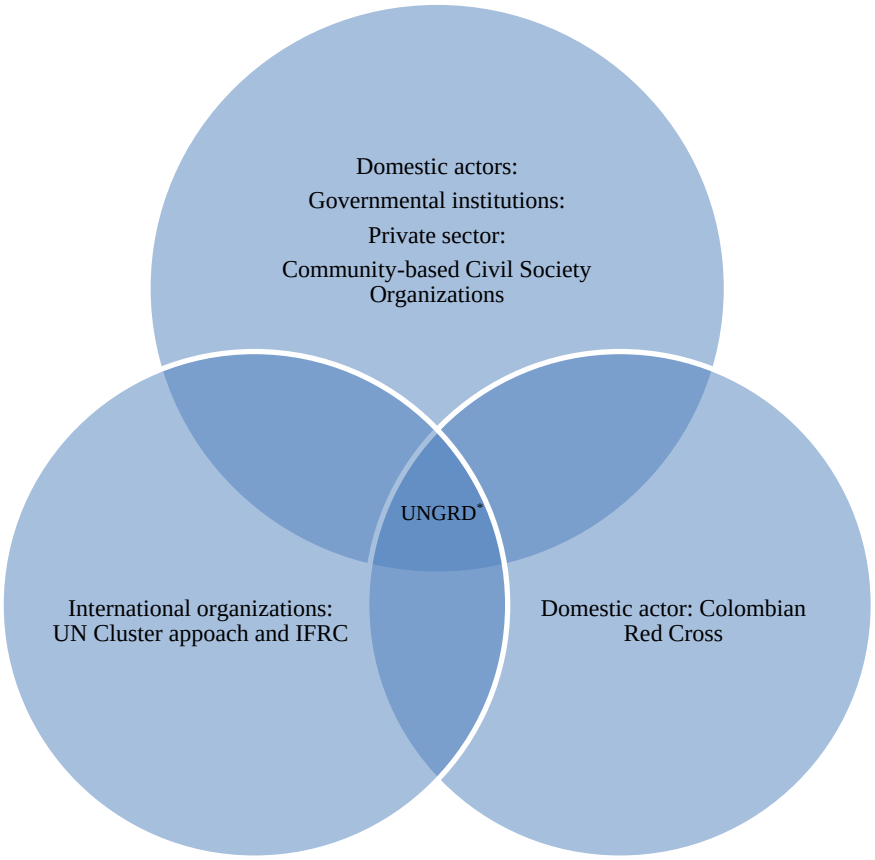
Building on the interview results, Table 3 below initiates the final identification and classification of actors distributing food aid to impacted population from natural disasters in Colombia, which is then summarized in Figure 24 once inputs of interviewees are taken into consideration.

Table 3. Validation of identification and classification of actors distributing food aid to those impacted by natural disasters.

Input	CRC	UNGRD
Consistency of Vitoriano et al, Harvey & Harmer and the IFRC's adaptation regarding ultimate actors that do distribute food aid	Appropriate actors. Although Red Cross provincial headquarters should be added.	Missing organizations: Operational entities (Military Forces, Air Force and Police Department) and private food aid suppliers contracted by the state. NGOs (OXFAM, Mercy Corps, ACH, World Vision, Caritas).
Classification's rationale	Appropriate	Appropriate
Humanitarian Logistics	Food aid is distributed in only during the response phase	Food aid is distributed in both instances response (up to 48 hours) and short term recovery (up to 3 months)
Disaster type	No discrimination in assisting any kind of disaster	Natural disasters and non-conflict disasters only
Geographic coverage	Strong presence in natural disasters prone areas	Strong presence of operational entities varies according to the region. Response capabilities are not equally spread out across the country.
Commodities	Food aid kits	Suppliers and operational entities handle only food aid kits.
Population targeted	No specific segment of population targeted when deploying food aid.	No specific segment of population targeted when deploying food aid.

Although Figure 24 below refines the work of Vitoriano et al (2013), Harvey & Harmer (2011) and the IFRC's (2014) approach, together with the inputs from practitioners, it is not intended to represent 100% of the actors involved in food aid distribution to populations impacted by natural disasters in Colombia. Instead, as discussed, it aims to intersect previous analyses from practitioners and researchers, with the objective opinion of staff from relief organizations who are knowledgeable of the dynamics around the distribution of this kind of aid. Thus, Figure 24 represents a significant number of actors from which the majority of supply chains from

established organizations draw when it comes to distributing food aid in the last mile and during the response phase.



* Although the UN Cluster approach hardly ever run disaster response operations synergistically with the UNGRD, in theory, this latter do intent to link the international humanitarian organizations to its network.

Figure 24. Final identification and classification of actors

Chapter 5

PHASE II RESULTS-CHARACTERIZING THE SUPPLY CHAINS

Having identified the actors directly involved in food aid distribution, Phase II elaborates on the characterization of supply chains derived from such actors. Following a similar approach to Phase I, a set of interviews determined the specifics of supply chains that were initially built from secondary information, made available by the respective actors. As the resulting supply chain attributes are identified, a mapping tool is used in this phase to show the spatial relationships among nodes representing the logistics assets from the organization itself or its third party providers, when applicable. However, given the constraints for accessing both primary and secondary information from 100% of actors identified in Phase I, supply chains from only five strategic actors are fully characterized. These are: the National Unit for Risk and Disaster Management (UNGRD), the Colombian Red Cross (CRC) and the Civil Defense (CD) from the natural disaster response system side, and the World Food Program (WFP) and the Unit for Assistance and Reparation of Victims (UARIV) from the armed conflict response system side.

Outsourcing operations throughout the supply chain is a common practice in the private logistics sector. However, despite the fact that scholars such as Holguín-Veras et al (2012a), have stressed that care should be taken when comparing key features between commercial and humanitarian logistics, established relief organizations outsource a variety of logistics operations to third parties, just like commercial logistics do. All together relief organizations and third party operators

create relief networks aiding those impacted by manmade and natural disasters in Colombia. Thus, these established relief organizations together create two humanitarian systems disconnectedly responding to manmade and natural disasters that are typically either recurrent and small or random and large.

This phase focuses on Regular (R-HL) and Post-Disaster Humanitarian Logistics (PD-HL), originally defined by Holguín-Veras et al (2012b, p. 498) as the most intensive form of logistics in the initial response and short-term recovery phases of an event. This phase also hypothesizes that characterizing the outsourcing opportunities throughout the supply chain can help to identify other opportunities to optimize the storage, transportation and distribution capabilities of actors, relief networks and humanitarian response systems. In addition, general policy implications are developed for achieving transverse logistics synergy among actors and relief networks belonging to a distinct humanitarian response system.

The heterogeneity among relief actors and networks in Colombia is rooted in the heterogeneity of the supply chains, through which humanitarian aid is deployed to both the natural disasters' and the armed conflict's beneficiaries. Consequently, this chapter elaborates on the identification of supply chains that orchestrate Regular and PD-HL operations responding to recurrent and multiple small-scale disasters, specifically, food aid that is distributed locally to beneficiaries, irrespective of the source of the need, during either manmade or natural disasters. This initial identification is based on secondary information found in open source documents either as per requested reports or reports available online, complemented with face-to-face interviews with practitioners who have significant experience directing humanitarian operations in Colombia.

As discussed, supply chains for only five strategic relief networks are fully characterized. These strategic relief networks are as follows:

- Armed conflict response system
    - International representing the UN Cluster approach[1]: World Food Program (WFP)
    - Domestic representing the institutional approach[2]: Unit for Assistance and Reparation of Victims (UARIV)
- Natural disaster response system
    - Domestic: Colombian Red Cross (CRC),
    - Domestic representing the institutional approach:
        - Civil Defense, and
        - National Unit for Risk and Disaster Management (UNGRD),

Field work identified actors, both domestic and international, that have relied on third parties for certain logistics operations when aiming to deploy food aid to beneficiaries. These third parties range from other humanitarian actors to operators and suppliers from the commercial sector. This phase is also based on interviews with individuals directly involved in the relief operations. The interviews took place both face-to-face in Colombia and by telephone. This information is complemented with media accounts and official reports.

The end product of this phase characterizes their supply chain logistics operations from upstream to downstream. The analyses' limitations stem from the fact

[1] Groups of humanitarian organizations, both UN and non-UN, in each of the humanitarian sectors or humanitarian action, e.g. water, health and food security.

[2] Groups of governmental humanitarian organizations.

that not all established actors and relief networks involved in food aid distribution in Colombia may have been identified, due to resource limitations. Hence the supply chains captured in the study are not guaranteed to represent the total universe. In addition, not all segments of the supply chains identified were characterized, due to some constraints found in the fieldwork when accessing specific information. However, because at least one supply chain of all actors and relief networks identified has been characterized along all its segments (upstream, midstream and downstream) and given the heterogeneity of proceedings in national operations, a significant representation of the supply chain's characterization at a national basis can be inferred.

The phase has two sections: section 5.1 introduces the armed conflict response system both graphically and descriptively. A mapping tool, typically used to characterize the flow of commercial supply chains, is used here to depict not only the warehousing and distributing facilities, but also the flow of food aid upstream through downstream. In addition, a descriptive summary of the interview findings complements the graphic views provided by the maps. Section 5.2 is broken down in two subsections as well, introducing natural disasters response system both graphically and descriptively.

5.1 The Armed Conflict Response System

As indicated earlier, the armed conflict response system is fully comprised of groups of established and emergent organizations (see Figure 14). However, due to accessibility and costs constraints, this research only captures the characterization of food aid supply chains of the World Food Program (WFP) from the group of international established institutions and the Unit for Assistance and Reparation of Victims (UARIV) from the established domestic institutions. The following

subsections elaborate on the magnitude of the logistics operations covered by these two organizations when deploying food aid.

5.1.1 The World Food Program (WFP)

Using an integrated approach to address food insecurity among highly vulnerable households impacted by displacement and violence, the WFP co-leads the food security cluster with the Food and Agriculture Organization of the United Nations (FAO) and the nutrition cluster with UNICEF. The clusters coordinate assistance in different areas and contribute to the enhancement of institutional capacities. The relief component provides a package for targeted highly food-insecure families that includes a general food distribution (GFD) ration. WFP fills gaps in relief assistance in areas where the presence, reach and institutional capacity of the government are limited. Immediately following displacement, beneficiary families receive GFD for two months. United Nations agencies, non-governmental organizations (NGOs) and community-based and religious organizations complement government assistance and fill gaps in various sectors. Details of the supply chain through which the UN cluster relief networks deploys food aid to those impacted by the armed conflict in the western and northern region are mapped in Figure 25 to show the connections and flows.

Note that, all maps can also be accessed electronically in color at the websites hyperlinked in the text. In addition, once accessed online, these maps can be zoomed in and zoomed out for observing details of the location of supply nodes as well as a further description by clicking nodes or circles. When viewing the maps electronically, follow the legends to understand the flow of commodities, the connection between nodes and their location along the supply chain segment:

- Circles represent nodes (typically storage or distribution facilities).
- The supply is described as going from upstream (sources of food aid) to downstream (distribution to recipients of food aid). The nodes are shaded using a green-red-yellow to indicate where, upstream or downstream, the nodes are located in the supply chain. As shown in the legend on the map, green nodes indicate an upstream location in the supply chain, whereas the yellow ones are downstream in the supply chain. Also, it should be noted that red circles or nodes, although not present in Figure 25, may show up in other maps to indicate mid-stream supply chain nodes.
- Directions of arrows indicate how food aid flows to and from locations. Just like the circle's colors, the green, red and yellow arrows indicate whether the flow takes place upstream, middle or downstream the supply chain respectively.
- Numbers within circles indicate the number of facilities located in the same city.

The map in Figure 25, which is also available online at http://srce.mp/1Ay3pat, illustrates the nodes representing the supply chain segments from upstream to downstream in the western and north region of Colombia where the UN (WFP) deploys food aid.

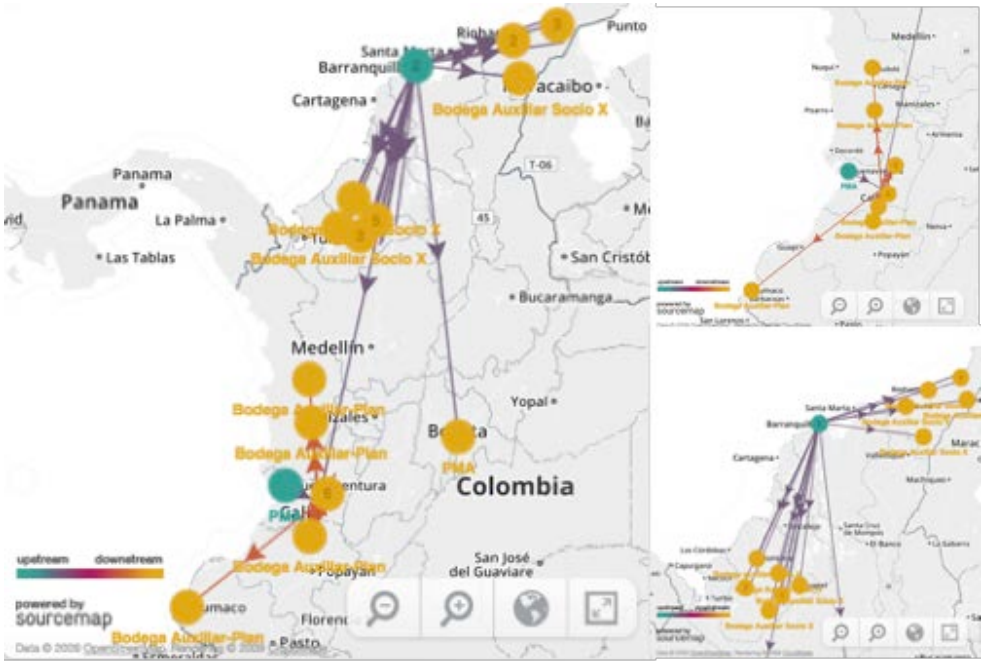


Figure 25 World Food Program distribution schematic in western Colombia.

5.1.2 Unit for Assistance and Reparation of Victims (UARIV)

Constituting the largest institutional body that assists those impacted by the armed conflict, the Unit for Assistance and Reparation of Victims (UARIV) acts as a relief network in the sense that it involves the local authorities or so called territorial entities to deploy food aid to beneficiaries. Once beneficiaries are registered as "victims", local or central governments designate the humanitarian assistance management to a specific body, which usually purchase food aid kits in the private sector food market and arrange delivery directly in the disaster area.

Figure 26, which is also available online at http://srce.mp/1vwc51y, illustrates a representation of both the last mile and the upstream of the food aid distribution by UARIV responding to IDPs from *Medellín* city in Colombia. Although the map only illustrates the situation in *Medellín* city and its surroundings, it represents the situation in the dozens of municipalities in Colombia.

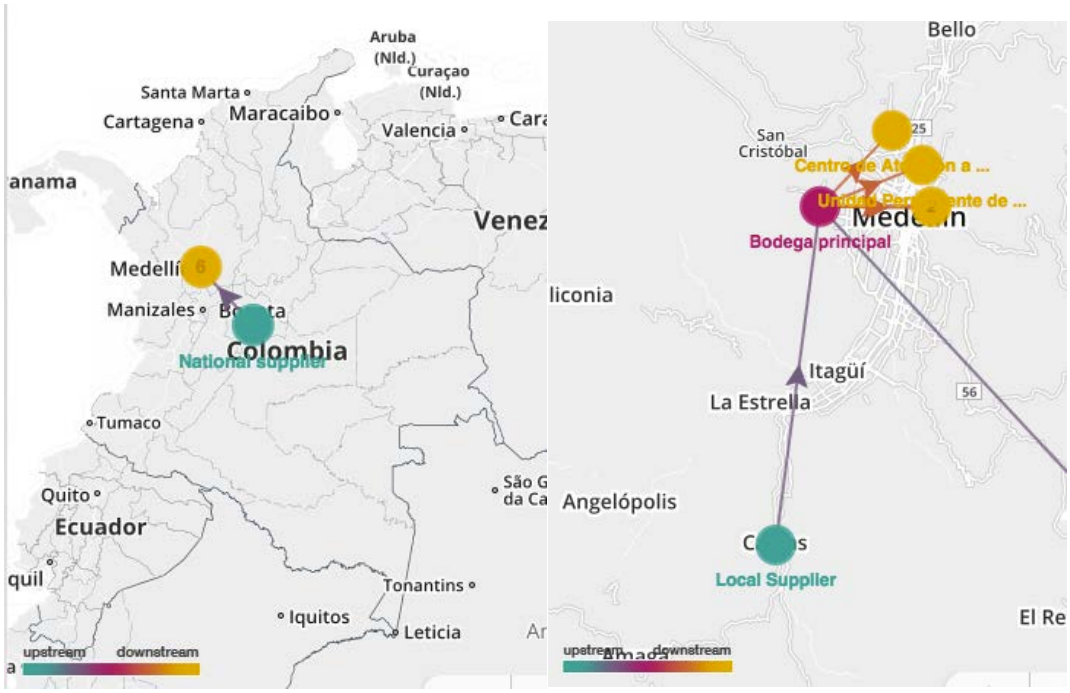


Figure 26. UARIV food aid distribution in *Medellín* city

5.1.3 Summary: Armed Conflict Outsourcing

Table 4 summarizes the findings from the interviews that enrich the representation of the supply chain characterization by highlighting the storage and distribution facilities, specifics on the food aid commodities moved and the manpower employed; all three features apply for the four supply chain segments defined in the characterization: upstream, midstream, downstream and beneficiaries. In addition, special focus is also given to specifics of the transportation links between the four segments.

Table 4. Armed conflict response system, supply chain outsourcing characterization

		International relief operations	Domestic relief operations
Supply chain segment	Feature	UN Cluster approach	UARIV
Upstream	Storing/Distribution facilities	Located at harbor cities, outsourced to a third party logistics (3PL) by the WFP	Located in proximities to the affected area and in the central region, run by local/central governments or a third party (private) and outsourced to private food market suppliers
	Food aid commodities	Imported bulk commodities from UN facilities in Panama	Food aid kits set up by Sphere's standards[3] purchased to food aid suppliers
	Manpower at facilities	Outsourced to a private third party logistics by the WFP	Outsourced or owned by the food aid supplier contracted
Link	Transportation mode	Road, outsourced to private carriers by the WFP	Road, outsourced to carriers or owned by the food supplier contracted
Midstream	Storing/Distribution facilities	Located at midsize cities, outsourced to private third party logistics by the WFP	Typically located in urban areas nearby the beneficiaries, rented to the real-estate market by the local government
	Food aid commodities	Bulk commodities	Food aid kits set up by Sphere's standards
	Manpower at facilities	Outsourced to a third party logistics (3PL) by the WFP	Owned by the local government
Link	Transportation mode	Road, outsourced to private carriers by the WFP	Road, owned by the local government
Downstream	Storing/Distribution facilities	Located in the affected area, so that rural and urban demand fulfillment is pursued, rented to the real-estate by outsourced NGOs	Typically located in the urban areas where food is directly handed to beneficiaries by a walking distance, temporary point of distribution privately owned
	Food aid commodities	Bulk commodities, packed in rations at this point	Food aid kits set up by Sphere's standards
	Manpower at facilities	Outsourced to NGOs	Owned by the local government
Link	Transportation mode	Road and Fluvial, privately owned by outsourced NGOs	Road, owned by the local government
Beneficiaries	Storing/Distribution facilities	Located in the disaster area by a walking distance from beneficiaries. Also called sub-points of distribution. Temporary and privately owned	Occasional food aid home delivery directly to beneficiaries, temporary point of distribution privately owned
	Food aid commodities	Food aid kits are configured as handed to beneficiaries (WFP standards)	Food aid kits set up by Sphere's standards
	Manpower at facilities	Outsourced to NGOs	Owned by the local government

[3] One of the most widely known and internationally recognized sets of common principals and universal minimum standards in life-saving areas of humanitarian response.

5.2 Natural Disaster Response System

Just like the response system for the armed conflict, the natural disasters response system is comprised of groups of established and emergent organizations (see). However, due to accessibility and cost constraints as well, this research only captures the characterization of food aid supply chains from either governmental or non-governmental organizations. These are the Colombian Red Cross (CRC), the Civil Defense, and the National Unit for Risk and Disaster Management (UNGRD). The following subsections elaborate on the supply chains of these three organizations when deploying food aid to beneficiaries.

5.2.1 National Unit for Disaster Management and Response (UNGRD)

Constituted by law, the National Unit for Disaster Management and Response (UNGRD) aims to coordinate the relief efforts not only domestically, but also internationally. Thanks to a legal framework that ensures the participation of all territorial entities when orchestrating all kind of relief to those impacted by natural disasters, the Unit makes an effort in managing the response capabilities at strategic and operational levels of the Colombian Civil Defense, Air Force, Military Forces, National Police Department, National Fire Department, the Colombian Red Cross, the private sector and the communities and the international relief organizations. In summation, Colombian regulations regarding natural disaster management not only require that national entities make an effort in coordinating and collaborating among them, but also recognize international humanitarian actors by trying to integrate them to some extent, despite the fact these international organizations do manage to operate independently in several instances (UNGRD, 2014).

Figure 27, which is also available at http://srce.mp/1oqBS9k, maps the distribution of food aid by UNGRD operational entities (Civil Defense and Police Department) and Figure 28, which is also available at http://srce.mp/1BN8Kdk, maps the food aid suppliers outsourced by the UNGRD. Although Figure 27 does not show the location of food suppliers outsourced to distribute food aid to those impacted by natural disasters, it does show all storage and distribution facilities made available by the police departments throughout the country. If 100% of the nodes representing outsourced food suppliers in the chain were depicted, the map on Figure 28 would look even more crowded, as food suppliers are contracted in the private sector, hence their locations are spread out as, for convenience, many suppliers may be contracted by the UNGRD throughout the country. In fact, the role of the UNGRD as a response system is to assist the network through the assets made available by the Civil Defense and the Police Department during disaster events, which because of their magnitude, merits support the food aid distribution from suppliers and donators downstream to local governments and beneficiaries.

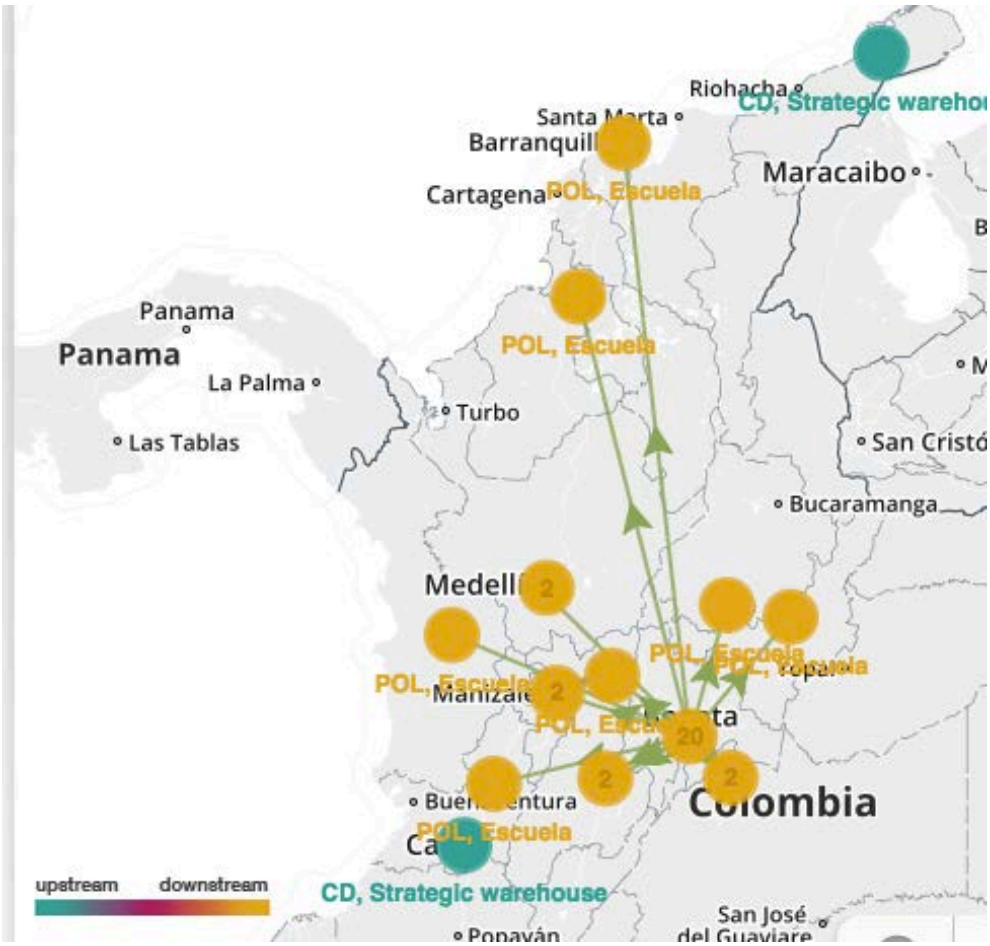


Figure 27. UNGRD food aid distribution to those impacted by natural disasters

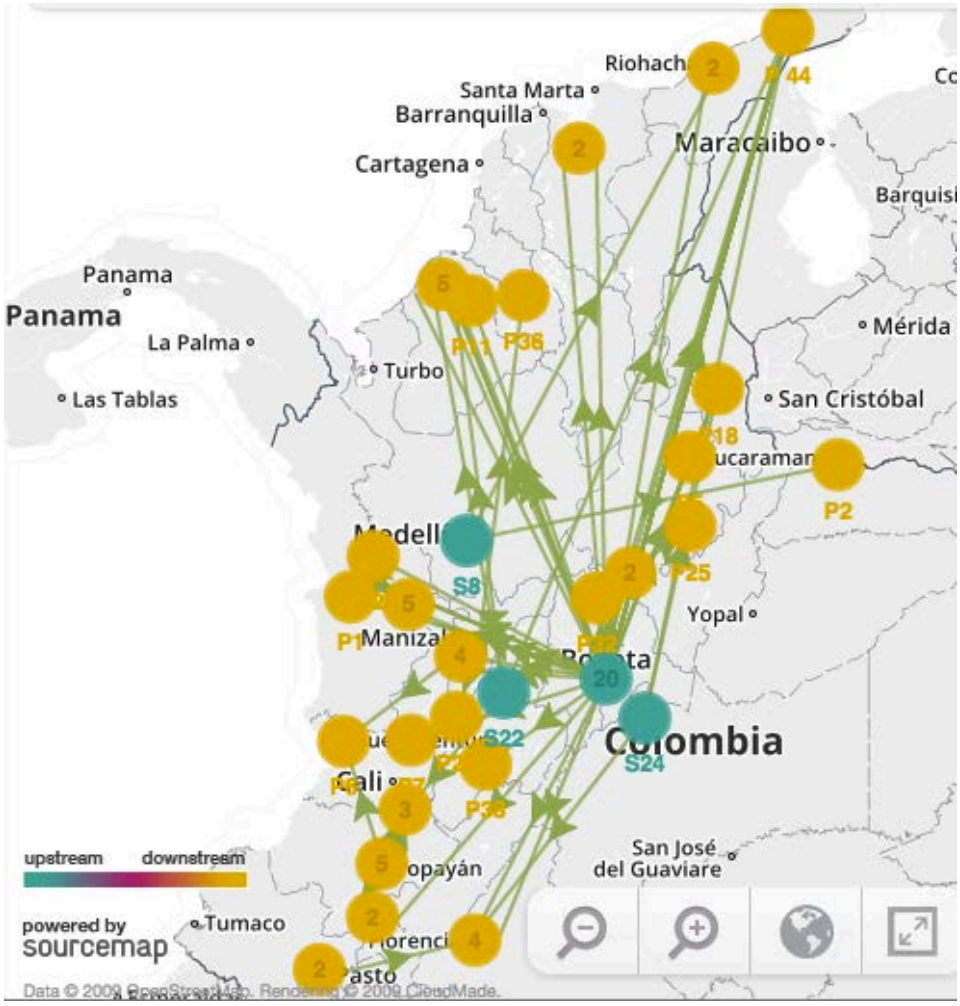


Figure 28. Food aid suppliers outsourced by the UNGRD in 2014

5.2.2 Colombian Red Cross (CRC)

Although it is part of the UNGRD, the Colombian Red Cross (CRC) as the national Red Cross society is a private organization. Because of its strong background in disaster relief and extensive and widely distributed response capabilities throughout the country, CRC deserves to be considered as an independent relief organization/network for supply chain characterization purposes.

Figure 29, which is also available at http://srce.mp/VAxuHa, maps the assets made available by the Colombian Red Cross (CRC) for the deployment of food aid distribution throughout the country. The map shows how large and widespread are the organization serves. Counting on the storage and distribution facilities managed by local branches in every Province, CRC presents a complex set of nodes where strategically located assets are part of the key policies.

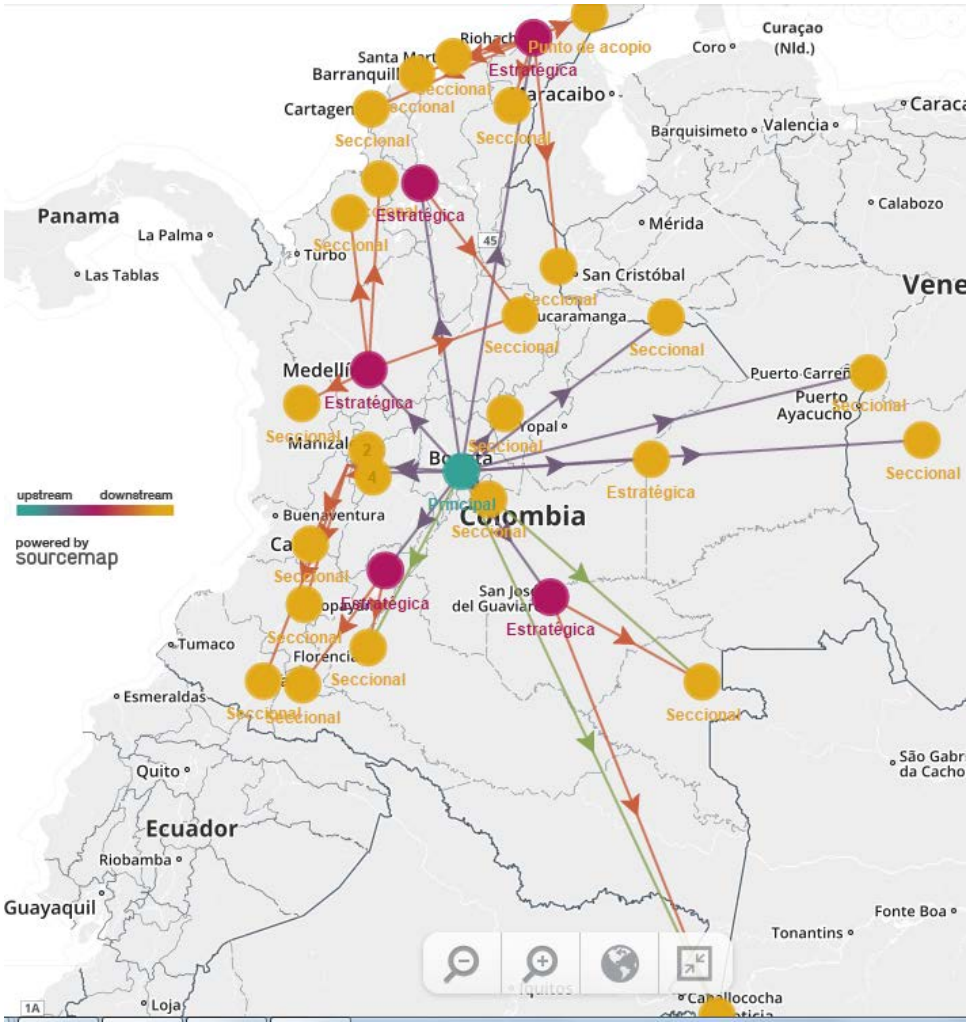


Figure 29. Colombian Red Cross food aid distribution to those impacted by natural disasters

5.2.3 Civil Defense (CD)

Also part of the UNGRD, Colombian Civil Defense is a governmental organization with an organizational structure also distributed throughout the country. As shown in Figure 30, which is also available at http://srce.mp/1I0JOpM, the Civil Defense has also strategically located a set of warehouses close to disaster prone areas and constitutes a key player for the UNGRD. For example, CD has set of strategic food aid warehouses in La Guajira to respond to the recurrent droughts in the region and serve the impacted population, as Figure 31 shows, which is also available at http://srce.mp/1QAfy9u. However, Civil Defense here is considered an independent relief network due to the significant amount of assets made available to the UNGRD in case of large-scale disasters, as well as its capability to cooperate with other governmental organizations regarding material convergence in response to the needs of those impacted by natural disasters.

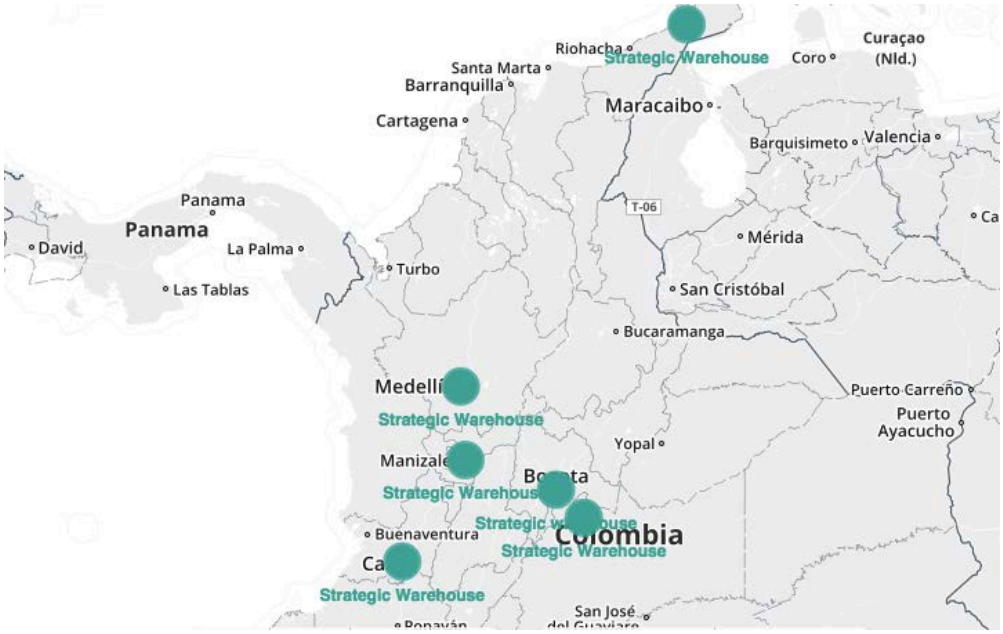


Figure 30. Civil Defense strategic warehouses

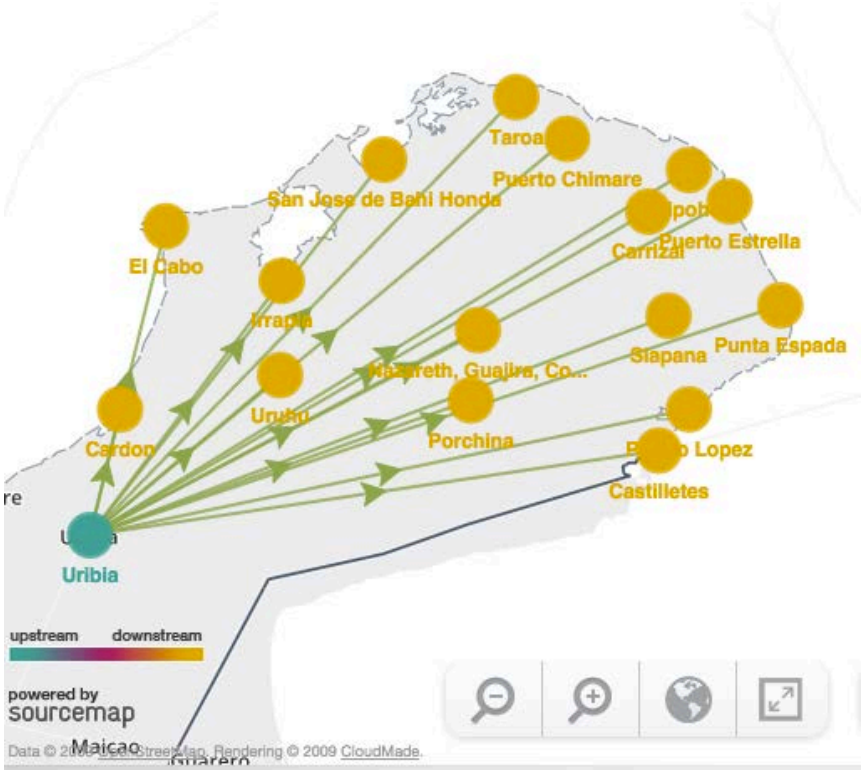


Figure 31. Populations impacted by droughts in La Guajira supplied by the CD

5.2.4 Summary: Natural Disaster Response System Outsourcing

Just like Table 4, Table 5 below summarizes the interview findings that enrich the characterization of the supply chain through which the food aid to those impacted by natural disasters is deployed.

Table 5. Natural disasters response system, supply chain outsourcing characterization

		Domestic relief operations	Domestic relief operations (Institutional approach)	
Supply chain segment	**Feature**	**Colombian Red Cross (CRC)**	**Civil Defense (CD)**	**UNGRD**
Upstream	Storing/ Distribution facilities	A central main warehouse, privately owned	Strategically located in smuggling-prone areas, privately owned	Mostly located in central region and occasionally in Province's capitals nearby the disaster area, run by central government and outsourced to private food market suppliers
	Food aid commodities	Food aid kits set up by Sphere's standards from material convergence (donations)	Food aid commodities from confiscated smuggled food	Food aid kits set up by Sphere's standards purchased to food aid suppliers
	Manpower at facilities	Privately owned	Privately owned and volunteers	Outsourced or owned by the food aid supplier contracted
Link	Transportation mode	Road, fluvial, aerial both outsourced to private carriers and privately owned	Road, privately owned or outsourced to local carriers by local governments	Road, outsourced or owned by the food supplier contracted
Midstream	Storing/ Distribution facilities	Strategically located nearby disaster prone areas, privately owned	Strategically located in disaster prone areas, privately owned	Located at the nearest municipality from the disaster area, temporary points of distribution run by the local governments
	Food aid commodities	Food aid kits set up by Sphere's standards from material convergence (donations)	Food aid commodities from confiscated smuggled food and purchased on the food market	Food aid kits set up by Sphere's standards purchased to food aid suppliers
	Manpower at facilities	Privately owned	Privately owned and volunteers	Privately owned by local governments or outsourced
Link	Transportation mode	Road, fluvial, aerial both outsourced to private carriers, territorial and privately owned	Road, Fluvial and aerial, privately owned or with support of Air Forces and the Army	Road, Fluvial, outsourced to local carriers

Supply chain segment	Feature	Domestic relief operations	Domestic relief operations (Institutional approach)	
		Colombian Red Cross (CRC)	Civil Defense (CD)	UNGRD
Downstream	Storing/ Distribution facilities	Located at most Province capitals and the closest municipality to the affected area (collection points), privately owned or rented to the real-estate	Located at Province's capitals and municipalities, run by the Civil Defense Headquarters in Provinces	Not applicable. Purchased food aid kits are directly transportation to the disaster area
	Food aid commodities	Food aid kits set up by Sphere's standards from material convergence (donations)	Food aid commodities from confiscated smuggled food and purchased on the food market	Food aid kits set up by Sphere's standards purchased to food aid suppliers
	Manpower at facilities	Privately owned and volunteers	Privately owned and volunteers	Privately owned by local governments or outsourced
Link	Transportation mode	Road, fluvial, aerial both outsourced to private carriers, territorial entities and privately owned	Road and Fluvial, privately owned or with support of the Army	Road, Fluvial, outsourced to the local transportation market
Beneficiaries	Storing/Distribution facilities	Located at the disaster area by a walking distance from beneficiaries, also called by the CRC as points of distribution. Outsource to the real estate if needed	Located at the disaster area by a walking distance from beneficiaries, temporary points of distribution privately owned	Located in the disaster area by a walking distance from beneficiaries. Temporary points of distribution privately run by local governments
	Food aid commodities	Food aid kits set up by Sphere's standards from material convergence (donations)	Food aid commodities from confiscated smuggled food and purchased on the market	Food aid kits set up by Sphere's standards purchased to food aid suppliers
	Manpower at facilities	Privately owned and volunteers	Privately owned and volunteers	Privately owned by local governments or outsourced

5.3 Analysis

Although the UN cluster approach is the only international relief network from the humanitarian response system studied here, the humanitarian mission of this relief network has responded to large-scale natural disasters in Colombia, as well as the armed conflict. The fact that the UN clusters deploy food aid distribution within both response systems is vivid recognition of how common logistics capabilities are required to respond to disasters irrespective of the kind, be they manmade or natural. The UARIV and the UNGRD, the official relief networks of each response system, contract suppliers to distribute food aid kits to local authorities and third parties. However, the humanitarian logistics know-how of these local authorities and third parties is not guaranteed further down the supply chain. Hence, strengthening logistics capabilities of local governments, such as adopting inventory management systems that respond to the demand patterns of those in need, or bridging the social fabrics to help overcome the transportation constraints imposed by the armed conflict and the geographic conditions in the last mile, would support better overall performance of the supply chain. Such strengthening would turn the local authority into an actual humanitarian actor able to logistically respond to both manmade and natural disasters.

This overall analysis exposes the evident need for policy makers and practitioners to understand the humanitarian response system holistically and managerially, and as a pull of opportunities for sharing logistics capabilities and networking parties towards logistic partnerships in light of effectively alleviating the suffering of those in need. In addition, this analysis also exposes the need for the humanitarian actors to continue evolving toward switching to humanitarian logistics practices, which although differ significantly with the private sector logistics, can support supply chain analysis tools that are applicable to both private and

humanitarian logistics as long as the appropriate dynamics are incorporated in the analysis.

Chapter 6

PHASE III RESULTS-IDENTIFYING HUMANITARIAN LOGISTICS STRUCTURES

As stated in chapter 3, Phase III presents structured interviews and content analysis findings, along with the analysis from which the identification of humanitarian logistics structures is drawn. The chapter is broken down into four sections. Section 6.1 describes both the natural disasters response system capabilities and the armed conflict response system capabilities captured by the survey. The surveys build on the level of the details exposed in the characterization of the supply chains in Phase II. Section 6.2 presents the summative content analysis of Phase II findings where the breadth and depth of outsourcing in the supply chains characterized serves as a focus to identify the humanitarian logistics structures presented in Section 6.3. Section 6.4 presents case studies, while Section 6.5 summarizes the chief features of the structures identified.

6.1 Response System Capabilities

In addition to previous findings presented in Chapters 4 and 5, the findings in Chapter 6 are based on the structured interview guide shown in Table 6. Given the specificity of the information requested (capabilities survey), this interview guide is included here as opposed to Appendix G, like other interview guides. The interview guide's Part A tells us about the items being supplied as humanitarian food aid, as well as important figures regarding the time the organization in question dedicates to

satisfy the food aid needs of those impacted. Parts B and C inventory all warehousing and distribution facilities throughout the supply chains, as well as the food aid handled and the demand magnitude of the typical populations in need. Parts D and E elaborate on the transportation capabilities regarding lead times, cargo and fleets. As stated above, the results are presented separately by the response system. These results appear in Table 7 and Table 8.

Table 6. Response capabilities survey

A	About the food aid supplied:
A.1	What commodities does your organization deliver? (Please differentiate kits from single commodities.)
A.2	Is there any consolidation of commodities when loading the trucks?
A.3	Historically, what is the average time that beneficiaries have had to wait for the very first food aid delivery to be supplied right after the disaster took place?
A.4	For planning purposes, over what period of time (in days) is food aid provided following a disaster?
B	With respect to the supply nodes (location of sources of food aid) from which your organization locally distributes food aid:
B.1	How many warehouses are currently set up? A warehouse is a facility where there is any kind of food aid storing prior to transportation and distribution.
B.2	Where are they located?
B.3	Historically, what have been the locations from which food aid is transported downstream the supply chain until it gets to the demand points?
B.4	For each supply node entered, what is the average initial inventory for each commodity?
C	With respect to the demand nodes or points of distribution, this is a temporary set-up of logistics assets from which large amounts of food aid commodities are directly handed to beneficiaries
C.1	How many Points of Distributions are set up?
C.2	Where are they located?
C.3	Historically, what are the locations where the beneficiaries have received food aid from your organizations, specifically from the supply nodes above?
C.4	For each demand node entered, what is the average initial inventory for each commodity?
C.5	For each demand node entered, what is the size of the targeted population in terms of number of people?
C.6	For each demand node and each commodity entered, what is the consumption rate (e.g. kg/hour-person) from the beneficiaries?

D	Demand vs. supply
D.1	What are the travel times in minutes between each supply node and each demand node?
D.2	What are the travel costs between each supply node and each demand node entered?
E	Considering the fleet of trucks available
E.1	What kind of truck does the organization count on when transportation aid to beneficiaries
E.2	How many trucks are there for each type?
E.3	What is the loading capacity for each type of truck?

Table 7. Natural disaster response system capabilities

Survey	**CRC**	**CD**	**UNGRD**
A	Food aid supplied		
A.1	Food aid kits (4445 Kilocalories for 5 people in to be consumed in 10 days), Personal Hygiene kit, Shelter kit, cooking utensils kit	Single commodities	Food aid kits (4445 Kilocalories for 5 people in to be consumed in 10 days), Personal Hygiene kit, Shelter kit, cooking utensils kit
A.2	Yes	Yes	Yes
A.3	Up to 24 hours	Up to 48 hours	Up to 48 hours
A.4	7 days. Just one delivery	7 days	Up to 3 months
B	Supply nodes		
B.1	8 warehouses. See Figure 29	6 warehouses. See Figure 30 and Figure 31	At least 24 warehouses. Or as many suppliers as identified nationally in the private sector
B.2	See strategic warehouses in Figure 29	See Figure 30 and Figure 31	See suppliers on See Figure 27 and Figure 28
B.3	See strategic warehouses in Figure 29	See Figure 30 and Figure 31	See populations on Figure 27 and Figure 28

Survey	CRC	CD	UNGRD
B.4	0, as inventory increases per donations requests	0 or a large number as it is subject to the smuggling merchandised donated	A large number as suppliers have commodities available in stock permanently
C	Demand nodes		
C.1	30 PODs	0	0
C.2	See PODs Appendix H	NA	NA
C.3	See Appendix H	Some of them are: *Guajira, Nariño, Norte de Santander, Putumayo*	See Figure 27 and Figure 28
C.4	0	0	0
C.5	See Appendix H	Guajira: 26,000 people impacted. See Figure 31	N/A
C.6	2,100 kcals/person/day - 10 per cent of total energy provided by protein - 17 per cent of total energy provided by fat	2,100 kcals/person/day - 10 per cent of total energy provided by protein - 17 per cent of total energy provided by fat	2,100 kcals/person/day - 10 per cent of total energy provided by protein - 17 per cent of total energy provided by fat
D	Demand vs. supply		
D.1	See Appendix H	NA	See Appendix H
D.2	Humanitarian travel costs are driven by commercial travel costs, which are regulated by a fixed average ton-km rate between an origin X and destination Y	Humanitarian travel costs are driven by commercial travel costs, which are regulated by a fixed average ton-km rate between an origin X and destination Y	Humanitarian travel costs are driven by commercial travel costs, which are regulated by a fixed average ton-km rate between an origin X and destination Y
E	Fleet		
E.1	Only 2 axles trucks	2 axle trucks and 3 axles truck with 2 axles trailer	N/A, although vehicles sizes range according to the trucks available in the private sector
E.2	A large number as they are mainly contracted	2 and 5 respectively. Privately owned	A large number as they are mainly

Survey	CRC	CD	UNGRD
	in the commercial transportation market. 1 ton truck and up to 3 light vehicles privately owned in most warehouses		contracted in the commercial transportation market.
E.3	Light vehicles, 1 ton, 3.5 tons and 4 tons	4 tones and 30 tons respectively	Infinite

As Figure 32 illustrates, the supply chain segments — upstream (US), midstream (MS), downstream (DS) and beneficiaries (B) — are represented by each of the labeled concentric rings. The lines connecting geometric symbols and radiating to and from the center represent the transportation capabilities between segments. Thus, geometric symbols represent the warehousing and distribution facilities for each of the five relief networks studied. For instance, the inner rings downstream represent the final set of facilities made available in the last mile to deliver aid, whereas the triangles represent the facilities found available upstream the supply chain.

Table 8. Armed conflict response system capabilities

Survey	UARIV	WFP
A	Food aid supplied	
A.1	2 kinds of Food aid kits. Type A for families of two members, Type B (42 kg of supplies) for families of 5 members to be consumed in one month	1 kit for the immediate response (1,004 kilocalories per day per person). 9.8 kg of supplies per person to be consumed in 40 days
A2	No	No
A3	Up to 72 hours	Up to 24 hours
A4	90 days. Three deliveries	80 days. Two deliveries
B	Supply nodes	
B.1	A large number as each municipality receiving IDPs may have configured one local warehouse at least. See Figure 26 as an example	16. See Figure 25
B.2	See main warehouse in Figure 26	See Figure 25
B.3	See Figure 26	See Figure 25
B.4	0	0
C	Demand nodes	
C.1	A large number as each municipality receiving IDPs may have configured one point of distribution at least. See Figure 26 as an example.	More than 16. See Figure 25 from which POD are set up after food aid leave small local warehouses to rural areas.
C.2	See PODs in Figure 26	See Figure 25
C.3	See downstream nodes in Figure 26	See Figure 25, and final beneficiaries on Appendix H
C.4	0	
C.5	10,982 people in the 4 demand nodes displayed on Figure 26 together from January through September 2014	See beneficiaries assisted, Appendix H
C.6	2,100 kcals/person/day - 10 per cent of total energy provided by protein - 17 per cent of total energy provided by fat	245 gr/day/person
D	Demand vs. supply	
D.1	N/A	See Appendix H
D.2	Humanitarian travel costs are driven by commercial travel costs, which are regulated by a fixed average ton-	Humanitarian travel costs are driven by commercial travel costs, which are regulated by a fixed average ton-km rate between an

Survey	UARIV	WFP
	km rate between an origin X and destination Y	origin X and destination Y. See Appendix H
E	Fleet	
E.1	Light vehicles for urban deliveries	Light vehicles for urban deliveries
E.2	Large number as they are mainly contracted in the commercial transportation market. 1 ton truck and up to 3 pickup vehicles privately owned in most warehouses	A large number of pickup vehicles as they are mainly contracted in the commercial transportation market.
E.3	1 ton	1 ton

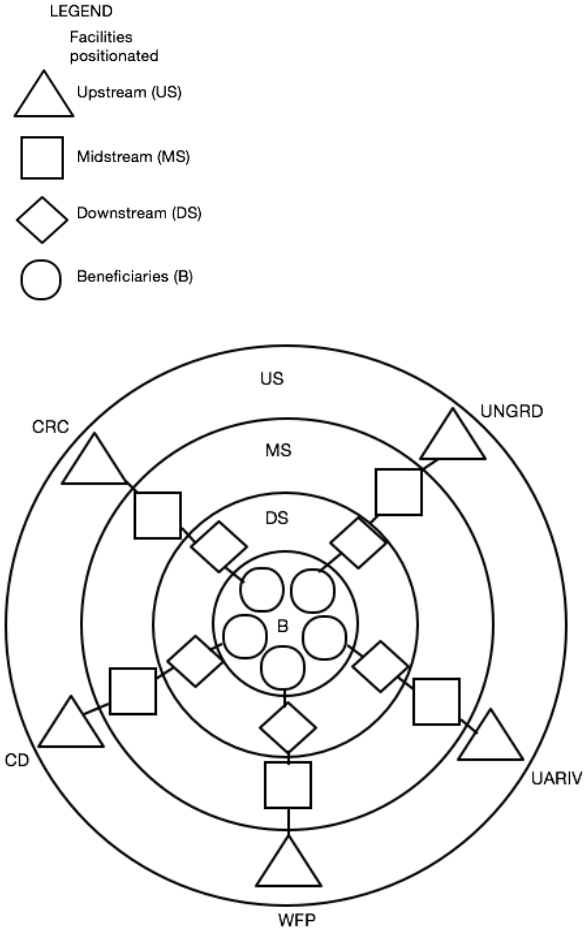


Figure 32. Humanitarian relief networks

Once the dynamics are understood for illustrating the capabilities captured in the surveys (Table 7 and Table 8), Figure 33 provides the specific number of warehousing facilities represented by each symbol throughout the segments in the supply chains analyzed. The aim of Figure 33 is to quantify the number of facilities in all supply chains, recognizing that the specifics being captured through the structured interviews (surveys) apply to all of them. Such quantification comes from the semi-structured interviews (Chapter 5), content analysis, and the structured interviews (when available). Thus, logistically speaking, due to the large number of food suppliers in the private market outsourced to supply food aid to disaster areas, the UNGRD provides a large number of warehousing facilities represented in Figure 33 as *x* in the upstream supply chain. These food suppliers then distribute aid to the local governments leading the response, and since literally any of the more than 1.000 municipalities can ask for food aid, the number of facilities in the middle supply chain is also represented as *x*. Likewise, since the number of PODs that local governments may set up when distributing food aid to beneficiaries is uncertain, the number of facilities in this segment of the supply chain is also represented as *x*.

CRC allocates its main warehouse in the city of *Bogotá* (upstream), seven (7) strategic warehouses throughout the country (midstream), thirty (30) locations throughout the country, and one in each province's capital, that could eventually serve as hubs for food aid distribution at a small-scale and undetermined number of points of distributions (*x*), which are set up based on demand. The Civil Defense operates five (5) strategic warehouses throughout the country (upstream) and one a single local warehouse near the Venezuelan border (midstream). Downstream in the supply chain, it allocates a large number of facilities that could eventually serve as warehousing

facilities located in each Colombian municipality, from which a large number *x* of points of distributions may be set up to respond to beneficiaries.

Likely, the WFP operates two main warehouses in coastal cities (upstream), two strategic warehouses located inland (midstream), 25 warehouses conveniently located and outsourced to NGOs downstream, and even a larger number of points of distribution down to beneficiaries (*x*). The number of assets through which the UARIV distribute food aid is significant throughout all supply chain segments and is characterized as *x*. As explained before, the UARIV outsources food suppliers in the private food market (upstream), which distribute food in regional warehouses managed by local governments (midstream). Local governments then manage other facilities (downstream) to store and distribute food aid directly or transport food kits to beneficiaries' homes or points of distribution. The number of municipalities that follow this approach is significantly large and this quantity is represented as *x*.

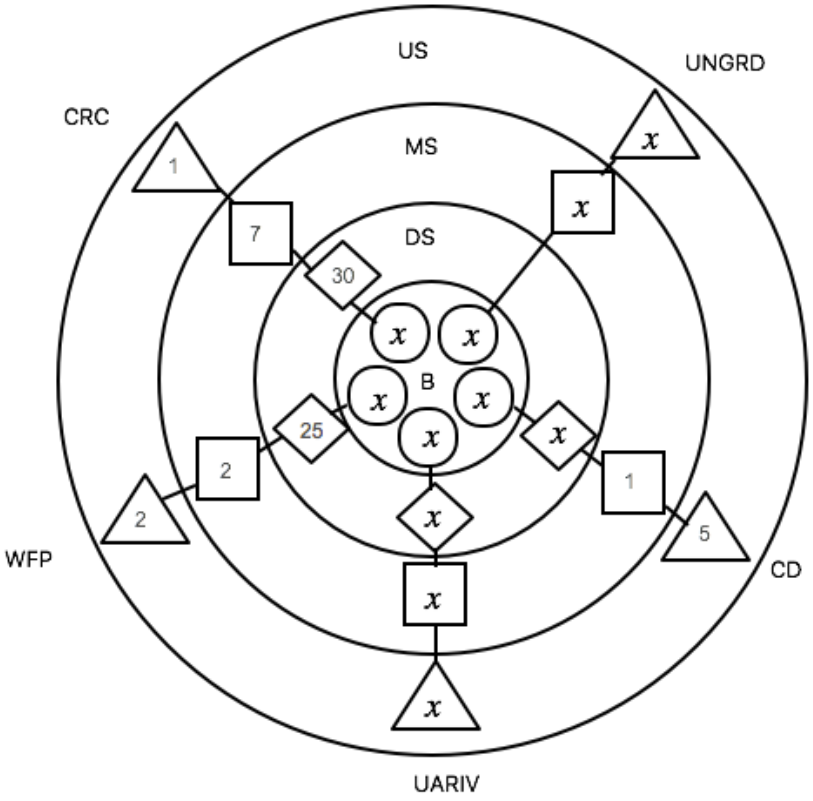


Figure 33. Warehousing and distribution facilities in the humanitarian relief networks identified.

To understand the limitations of our data collection effort, the following analysis is presented. Given the large number of multiple supply chains that can be derived from the facilities identified in the maps in Chapter 5, Figure 34 below shows only the number of storage and distribution facilities throughout all supply chains identified merely based on all information captured from completed structured interviews (surveys). Full details are included in Appendix H.

The information collected corresponds to historic disaster response operations recorded in private databases that were either directly shared with the interviewer or were captured through the surveys. That is, as the surveys took place with interviewees (see Table 6), the information provided (see Table 7 and Table 8) was

limited in the sense that it was extremely costly to apply the survey to all segments and all possible supply chains derived from the supply nodes of Figure 33. In fact, obtaining 100% of transportation and warehousing costs and other parameters pursued in the structured interviews (survey), given the magnitude of facilities exposed on Figure 33, could have been infinite. For example, for the UNGRD, it was possible to capture the location of 28 food suppliers (upstream), and 44 municipalities (midstream). However, it remains uncertain how many points of distribution were set up when responding to small-scale disasters in 2014, and this is the reason why the number of facilities remains infinite (∞). The Red Cross headquarters in the province of Antioquia provided complete information from upstream to downstream in the supply chain based in the central warehouse in *Bogotá* (upstream), the strategic warehouse in *Medellín* (midstream) and 16 different municipalities (downstream). However, the way food aid was distributed to beneficiaries remains unknown. Regarding the Civil Defense, it was possible to capture complete survey data for at least one facility in all supply chain segments, thanks to the records from the humanitarian response to the 2014 droughts in La Guajira. Of course, the number of facilities registered on Figure 34 is smaller than the ones appearing on Figure 33. This way, Figure 33 serves as a reference for potential future quantitative analysis that considers expanding the characterization of regular and post-disaster humanitarian logistics structures in Colombia.

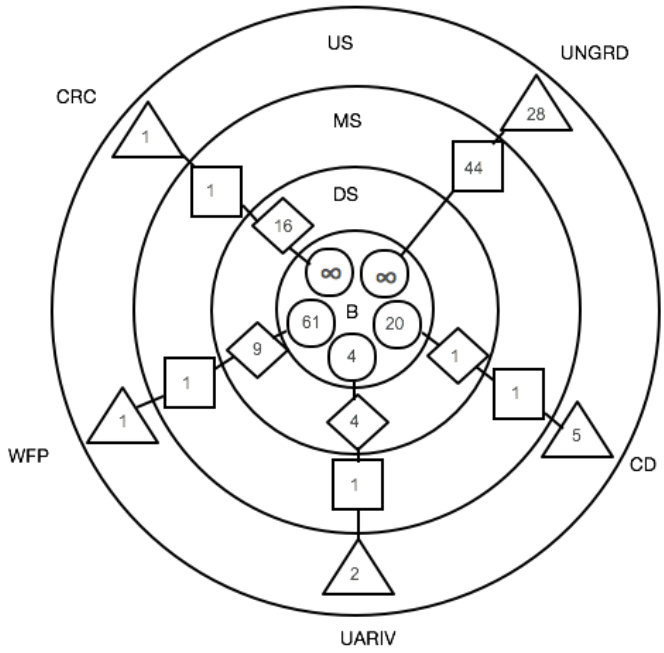


Figure 34 Number of data points based on the survey

Regarding the WFP, the survey responses included data from at least one facility in both the upstream and midstream supply chain. This data was provided along with nine facilities downstream in the supply chain and 61 temporary points of distribution to aid beneficiaries directly. The data relates to the food aid distributed as the immediate response to IDPs in the western part of the country in 2014. Finally, the UARIV also responded to the survey, providing response records to people impacted by the armed conflict in the city of *Medellín*. Thus, it is possible to count on survey data for at least one supplier (upstream), one warehouse managed by the municipality (midstream) and four (4) points of distribution throughout the city (downstream). In this case, all beneficiaries commute to such points of distribution.

6.2 Outsourcing Approach

Although Cottam et al (2004) state that there could be a deep discussion as to whether using third parties should be labeled as outsourcing or subcontracting, this chapter elaborates on the different extents of outsourcing identified throughout the established supply chains responding to both manmade and natural disasters when deploying food aid in Colombia, assuming that these third parties work "with" the relief organizations rather than stating that they actually work "for" them. Because this outsourcing may impact the overall performance of the supply chain, this section recalls the outsourcing concept addressed in the literature review (section 2.3.3). To better understand these impacts, we characterize the role of logistics actors, both humanitarian and private, from upstream to downstream in the supply chains. Starting with the identification of established international and domestic actors directly involved in food aid distribution during the immediate response and short-term recovery, and continuing with the identification of relief networks that these actors belong to when orchestrating food aid, the participation of logistics actors, whether private or humanitarian throughout the supply chain, is identified. Given the disconnect between the humanitarian response systems for those impacted by manmade and natural disasters in Colombia, commonalities and differences in these response systems resulting from contrasting transverse logistics actors and relief networks are highlighted in the next chapter.

Table 9 presents a snapshot of the results obtained from the set of interviews and content analysis made so far. For outsourcing identification purposes, the following coding have been defined:

- A1, A2 represents the primary actors in the armed conflict humanitarian response system,

- N1, N2, N3 represents the primary actors in the natural disaster humanitarian response system,
- PA, PB, PC, PD and PE represent the five private actors who provide logistical support,
- IA, IB, IC, ID, and IE represent the four institutional and one international actors, also providing logistical support.

Table 9. Outsourcing coding for humanitarian and private actors running logistics operations

Supply chain segment	Humanitarian Response System				
	Armed Conflict		Natural Disaster		
	International (UN Cluster approach)	Domestic (Institutional approach)	Domestic (Red Cross approach)	Domestic (Institutional approach)	
	WFP – A1	UARIV – A2	Colombian Red Cross – N1	Civil Defense – N2	UNGRD – N3
Upstream	A1, PC	PA	N1, PD, IA	N2, IA	PA
Link	PB	PA, PB	N1, PB, IA	N2, PB, IA	PA, PB
Midstream	A1, PC	PE, ID	N1, PD, IA	N2, IA	ID, PE
Link	PB	ID	N1, N2, PB, IA	N2, IB, IC	PB
Downstream	IE, PE	ID	N1, PE, IA	N2, IA	
Link	IE	ID	N1, N2, PB, IA	N2, IC, IA	
Beneficiaries	IE	ID	N1, PE	N2, PE	ID, PE
Facilities/links	A1	A2	N1	N2	N3

LEGEND

Actor	Organization/ Function	Code
Actors armed conflict humanitarian response (A)	WFP	A1
	UARIV	A2
Actors natural disaster humanitarian response (N)	CRC	N1
	Civil Defense	N2
	UNGRD	N3
Supportive transverse logistics actors – Private (P)	Food suppliers	PA
	Carriers	PB
	3PLs	PC
	Private sector	PD
	Real estate	PE
Supportive transverse logistics actors – Institutional (I)	Police	IA
	Air Force	IB
	Army	IC
	Local Authorities	ID
Supportive transverse logistics actors – International (I)	NGOs	IE

For example, in a natural disaster, the distribution of food aid to beneficiaries by the Colombian Red Cross is done by the Colombian Red Cross (coded N1) and private real estate (coded PE). By combining the coding with the supply chain segment and response system, Table 10 indicates how each of these logistics actors is involved in the humanitarian operation that the actual humanitarian actors, also grouped by the type of relief network, are responsible. Thus, the upstream segment of the supply chain displays the logistics actors that operate the facilities needed for deploying food aid to the disaster area. The midstream and downstream segments display the similar situation for facilities operated very close to, or in the disaster area, itself. Finally, the beneficiaries segment is defined to specifically refer to the operation of directly handing food aid to those impacted. Links between segments exclusively denote actors running transportation operations.

Table 10 shows the frequency of recurrence of outsourcing operations and the actors identified; it summarizes the number of times that an agency is directly operating either storage or transportation throughout the respective supply chain segment. For instance, Table 10 illustrates that Carriers, coded as PB in Table 9, directly operates the transportation for all actors in the upstream segment. Hence, Table 10 states that carriers indeed perform five transportation operations throughout such segment.

Frequencies shown in Table 10 allow further analysis on how the outsourcing takes place throughout supply chain segments and relief networks. Thus, Table 11, Table 12 and Table 13 below offer a different view, indicating which segments are outsourced the most and the least, as well as which relief networks are outsourced the most and the least. Likewise, it is possible to identify the third party functions that are

outsourced the most or the least. The analysis from these summaries is the springboard used to identify groups of established relief networks that share similar outsourcing patterns, demonstrating that the food aid deployment process operates in a different way to other established relief networks.

Table 10. Participation frequencies of logistics and humanitarian actors

Segment	WFP	UARIV	Colombian Red Cross	Civil Defense	UNGRD	Food Suppliers	Carriers	3PLs	Private sector	Real estate	Police	Air Force	Army	Local Authorities	NGOs
Upstream	1	0	1	1	0	2	0	1	1	0	2	0	0	0	0
Link	0	0	1	1	0	2	5	0	0	0	2	0	0	0	0
Midstream	1	0	1	1	0	0	0	1	1	2	2	0	0	2	0
Link	0	0	1	1	0	0	3	0	0	0	2	1	1	1	0
Downstream	0	0	1	1	0	0	0	0	0	2	2	0	0	1	1
Link	0	0	1	1	0	0	1	0	0	0	2	0	1	1	1
Beneficiaries	0	0	1	1	0	0	0	0	0	2	2	0	0	2	1
No. of logistics operations run	2	0	7	7	0	4	9	2	2	6	14	1	2	7	3

Table 11. Outsourcing summary by supply chain segment

Segment	Logistics operations run	Third parties involved	Logistics operations outsourced	% of Logistics operations outsourced
Upstream	9	7	6	67
Link	20	5	9	45
Midstream	22	8	8	36
Link	21	7	8	38
Downstream	18	6	6	33
Link	16	7	7	44
Beneficiaries	17	6	6	35

Table 12. Outsourcing third parties by relief network in each segment

Segment	WFP	UARIV	Colombian Red Cross	Civil Defense	UNGRD
Upstream	1	1	2	1	1
Link	1	2	2	2	2
Midstream	1	2	2	1	2
Link	1	1	3	2	1
Downstream	2	1	2	1	0
Link	1	1	3	2	0
Beneficiaries	1	1	1	1	2

Table 13. Outsourcing summary by relief network

Relief network	**Third parties involved**	Logistics operations outsourced	% of logistics operations outsourced
WFP	5	8	80
UARIV	4	9	100
Colombian Red Cross	5	15	68
Civil Defense	5	10	59
UNGRD	4	8	100

The number of parties involved in a logistics operation fluctuates between five and eight, according to the supply chain segment and specific outsourced operations (warehousing and transportation). The midstream segment contains the highest number of parties involved, considering both response systems. It can be also noted that 100% of the logistics operations characterized are outsourced to at least one logistics or humanitarian actor, which explains why neither the UARIV nor the UNGRD run their own logistics operations. Conversely, institutional actors like the Police Department and the Civil Defense present the highest numbers of logistics operations run. This reaffirms that these two institutions are at the cornerstone of logistics support for the UNGRD and potentially to the UARIV. Likewise, carriers are the most recurring non-official logistics actor, also reaffirming their key role in both humanitarian response systems, and exposing the importance of approaching this actor strategically and centrally when considering synergies that benefit reaching those in need.

The next section (6.3) identifies humanitarian logistics (HL) structures based on the approach of Holguín-Veras et al (2012a), which identifies three typologies of HL structures based on the extent to which they are connected to social fabrics. Still, the HL structures identified in this study are not based on the extent to which they are connected to social fabrics, not only because of the disaster events that the relief

networks under study respond to do not qualify as catastrophes, but also because the HL structures to be defined must be driven by the characterization of the supportive logistics facilities and actors pursued in this study.

It is worth clarifying that all the relief networks under this study do classify as Partially Integrated Efforts (PEIs) and Agency-Centric Efforts (ACEs), as discussed in section 2.4.1, according to the original HL typologies identified by Holguín-Veras et al (2012a). Indeed, given the recommendations of the original authors to maximize the efficiency of disaster response, the HL structures identified in section 6.3 comprise of relief networks intended to support the operations of an integrated logistical structure based on exploiting the particular strengths of both third parties (humanitarian or not) and in-house parties to transporting large volumes of supplies to beneficiaries. Although most of the relief organizations under this study do integrate third party actors in the downstream supply chain, such third party actors may not be emergent organizations or so called Collaborative Aid Network (CANs), as originally defined and recommended by the original of the HL structures approach. This being said, the approach for identifying the HL structures in this study draws from the extensive outsourcing analysis of the relief networks under study to understand the way networks are integrated from upstream to downstream in the supply chains. Furthermore, because outsourcing is a classical logistics strategy used in commercial logistics, as argued by Arif et al (2011), the findings are oriented toward how the integration within a relief network is shaped by outsourcing as a logistics strategy in the context of regular and post-disaster humanitarian logistics.

6.3 Humanitarian Logistics Structures

The five relief networks, described and characterized in Chapter 5 (sections 5.1 and 5.2), comprise the humanitarian response systems that represent the spectrum of parties performing humanitarian logistics. These relief networks are positioned in the supply chain segments previously defined — upstream, midstream and downstream segments. Hence, the humanitarian logistics structures are identified by the extent to which relief networks outsource their warehousing/storing and transportation operations throughout supply chain segments.

Although the five relief networks under this study may not belong to the same response system, they may implement the same outsourcing approach. Based primarily on the outsourcing summary presented on Table 11, the HL structures are initially identified according to the percentage that these relief networks outsource over the total logistics support (warehousing and transportation) operations they run throughout the supply chains. The analysis then starts by grouping not only the relief networks that happened to have similar percentages, but also have similar background characteristics, such as the affiliation type (private, institutional, domestic and foreign). It is evident then that both the *Unidad Nacional para la Gestión de Riesgo de Desastres* (UNGRD) and the *Unidad de Asistencia y Reparación de Víctimas* (UARIV) have the greatest percentage of supportive logistics operations outsourced (100%), demonstrated in Table 13. On top of this commonality, these two relief networks are the most centralized among the established organizations that respond to disasters, by law, in Colombia. Because these two relief networks share the above-mentioned characteristics that no others do, they are identified as the first typology of HL structured called Full Outsourcing Networks (FONs).

Continuing to classify relief networks on the basis of the outsourcing that supports the logistics operations they are responsible for running, Table 13 also shows that both the Colombian Red Cross (CRC) and the Civil Defense (CD) outsourcing strategy are positioned as the smallest as compared to the rest of relief networks. Although these two relief networks do not share the same affiliation type, as the CRC is a private organization, whereas the CD has an institutional background, they do share two strong commonalities that other relief networks do not: the high rate of supportive logistics assets ownership and the strong integration with other relief networks. Although the fact that these relief networks have the smallest outsourcing percentage may be directly correlated to the high ownership of supportive logistics assets, they are classified in the second typology of HL structures: Strong Supportive Networks (SSNs).

Last but not least, the World Food Program merits classification as a different relief network, not only because it has an intermediate extent of outsourcing (see Table 13), but also because it is the only foreign network to be analyzed and performs using a supply chain network incomparable to any other relief network. For these reasons the third and last typology of HL structures identified is called Hybrid Approach Networks (HANs), the classification used for the World Food Program.

The following subsections elaborate on the specificities that best describe each of the three regular and post-disaster HL structures identified.

6.3.1 Full Outsourcing Networks (FONs)

By relaying all warehousing and transportation operations to third parties, Full Outsourcing Networks (FON), such as the UARIV and UNGRD, are responsible for deploying food aid downstream as per demand request from local governments.

Indeed, these networks share an institutional character, as they are the bodies created by law to materialize humanitarian assistance to IDPs and those impacted by natural disasters, respectively. Logistically speaking, this typology of HL structure procures food aid kits from random food aid retailers (suppliers), whose corporate strategy is to supply the private food market, rather than satisfy the needs of those impacted by disasters. Kits are configured in multiple sizes according to the number of family members they are intended to feed. Suppliers then allocate the purchase orders at the location requested, which usually takes place in urban settlements. Surprisingly, the decision-making process by which suppliers are selected does not have anything to do with their location in relation to the proximity to the disaster area. In 2014 alone, nearly 66% of food suppliers contracted by the UNGRD were located in *Bogotá* or surrounding cites. Meanwhile, the disaster areas these suppliers should deliver to, were located more than 800 km away despite the fact that there were food retailers available locally. Furthermore, these available retailers were located less than 200 km from the disaster area.

Also, in this HL structure, transportation to the downstream supply chain is totally run by private carriers, implying that rates, fleet vehicles and workforce are governed by the private supply chain regulations. Moreover, although these vehicles are carrying out relief aid, they still must comply with the road mobility constraints, as lorries are not allowed to circulate in Colombia on certain roads at certain hours. Once suppliers deliver food aid kit orders at the location requested, the warehousing and distribution is administered by local authorities, or whichever third party they designate to continue deploying food aid to beneficiaries. Such local authorities or third parties, however, lack the logistical know-how to make objective decisions

regarding inventory allocation, routing and inventory management. For instance, the government of *Medellín* city is responsible for purchasing and administering food aid kits to assist one of the largest IDP populations concentrated in an urban setting. The government outsources this responsibility to a third party that has no logistics background at all and lacks tools to help minimize the human suffering of the IDPs, due to the need of immediate food assistance. Another characteristic that identifies this HL structure is the high capacity to deploy large volumes of food aid when needed, given the strong support of commercial food supply chains to deploy aid through actors further downstream in the supply chain. Although this HL structure is able to deploy food aid under both regular and post-disaster scenarios, it might not take the most from the pull system that theoretically drives their procurement approach. For instance, the UARIV occasionally authorizes the purchase of food aid kits to be provided by a supplier located in *Bogotá* to any city or town throughout the country as a result of a shortage that a local authority had reported because the demand wasn't covered well. Hence, although the replenishment process of this HL structure is pull-driven, the uncertainty derived from the appearance of new IDPs, for instance, may exceed the deployment capacity of local authorities in the light of the lead-time it takes between placing a new order to the moment it satisfies a sudden and unexpected demand. Moreover, this HL structure takes up to 72 hours to hand out the first food aid kit to the impacted people after their needs have been assessed, which is the initial deprivation time. However, the satisfaction this time limit, which is set by law, is not guaranteed at all times. Conversely, the FONs are very generous when it comes to defining a planning horizon to set the period of time over which immediate response

will be provided. This planning horizon may cover up to three months of food aid supply, which could be even larger if the situation demands it.

The Full Outsourcing Network is an HL structure that is also characterized by its great capabilities for penetrating upstream in the supply chain, obviously, because of the usual purchasing strategy to the private sector food suppliers. However, this typology is significantly weak downstream, as the food suppliers do not hand kits directly to beneficiaries. That is, the actor downstream responsible is usually the municipal government. These downstream actors have to guarantee the transportation in the last mile despite the challenges derived from the topographic conditions and access to vehicles that adjust to such conditions, especially when the distribution has to take place in rural areas. This may impact penetrability downstream, understood here as the capacity to enter supply chain segments (geographically speaking), because local governments usually do not devise transportation solutions before an event, as they are not a logistics party nor a humanitarian organization. If they do, the transportation solution is typically based on road transportation; despite the fact that impacted populations located in rural areas may only be accessible by river. This fact reveals another feature of the Full Outsourcing Networks, as their capability to partner their logistics operations with other humanitarian actors is null, except when coordinating material convergence with other networks like the Red Cross and the Civil Defense. Conversely, this HL structure exposes strong ties with the private sector to a great extent, when deploying food aid with purchased food kits, rather than donations, as it is case a majority of the time. One final feature of the FONs is their low capacity to project a neutral position when deploying aid in areas under the influence of the armed conflict. One reason to explain this feature is the actor's

responsibility for distributing food aid in the last mile, which again, is usually run by a private transportation carrier who may be associated to a party involved in a conflict, turning out to be banned to enter the area.

6.3.2 Strong Supportive Networks (SSNs)

With the lowest percentage of outsourcing operations among the relief networks under study, 59% and 68% for the Civil Defense and the Colombian Red Cross respectively, these two relief networks deserve to be grouped in the same typology of HL structures, as they both display why they are considered Strong Supportive Networks. Rather than basing the supply on a purchasing strategy to private food suppliers, the SSNs in Colombia base their supply on material convergence only. The Colombian Red Cross either configures food aid kits when single commodities are donated, or receives food aid kit donations from the private sector and primarily emergent organizations. Similarly, Civil Defense either collects donations from the private sector or from confiscated food items obtained from smugglers. Perhaps if these two relief networks didn't have the warehousing and distribution infrastructures they have (see Figure 29 and Figure 30), the food aid supply strategy would be Full Outsourcing Network oriented. Moreover, due to the fact that the warehousing and distribution structure of these two relief networks is fairly spread-out throughout the country and strategically located, these networks can easily access rural areas from a facility location perspective, which happens to be the disaster prone areas as well. Indeed, thus HL structure was the only one found having warehouses strategically either close to disaster prone areas or at a location where distribution downstream to highly populated areas was facilitated. This typology of HL structure is not only supportive regarding the huge warehousing network of

facilities, but also supports transportation as they also own a few vehicles in all supply chain segments. In addition, the logistics support of this HL structure may be significantly enhanced when needed, due to the connection between the Civil Defense and the Colombian Air Force and Police Department. In the case that larger scale disasters occur, and as long as the impacted area is free of any conflict, both the Police Department and the Air Force — and even the Naval forces — support the multimodal transportation capabilities of this HL structure, which allows this structure, among all HL structures identified, to be the most capable of overcoming the transportation restrictions imposed in the last mile by the complex topography of the rural area those impacted population may be. Strong Supportive Networks also make a difference on the staff directly involved in humanitarian logistics operations, because the CRC and the CD directly hire warehousing personnel, who could be also outsourced to a third party while still working in their facilities. Occasionally, when responding to larger scale and sudden on-set disasters, this HL structure is very capable of recruiting volunteers to perform distribution operations in the last mile, especially in areas under the influence of the armed conflict. This structure is also characterized by extensive experience deploying food aid over the history of Colombian disasters, which has helped in gaining a logistics know-how reputation, especially regarding material handling at warehouses and managing distribution operations at the disaster area.

Typically, the demand that the Strong Supportive Networks aims to meet takes place when larger scale disasters occur, deploying post-disaster humanitarian operations that go beyond regular humanitarian logistics. When this is the case, this HL structure activates its great capabilities to call for large material convergence at their warehousing facilities, making demand to be typically pull-driven. However,

initial inventories at their facilities may not be null, as they may have food aid kits or single commodities derived from previous material convergence campaigns. In these cases, demand may be seen as push-driven instead.

As can be seen in Figure 29 and Figure 30, the relief networks that comprise this HL structure present a significant amount of warehousing facilities that are fairly spread-out, making penetrability in all supply chain segments fairly straightforward. This feature is further reinforced when points of distributions are backed up by local Red Cross and Civil Defense support, which although may not be warehousing-oriented, do enhance distribution capabilities with manpower. The Strong Supportive Network, as the HL structure with a great reputation for its willingness to cooperate with other structures, is continuously called upon to deploy aid in collaboration with other humanitarian actors. Indeed, both the Colombian Red Cross and the Civil Defense play a crucial supportive role to the UNGRD when their deployment capabilities are called to supplement response capabilities of the natural disaster response system. One final characteristic of this structure is related to the power between the private sector and emergent organizations for assembling resources when massive material convergence is needed. Ranging from single commodities to be assorted in food aid kits to already configured kits, this HL structure is not food supplier procurement-based, as is the Full Outsourcing Networks.

Although this structure possesses a model logistics support body, the time beneficiaries have to wait for the first food aid delivery to come may not be shortest among the relief networks studied. Initial deprivation times may range from 12 to 48 hours depending on how far or how accessible the impacted area is in relation to the strategic warehouse. However, when it comes to defining the time frame over which

this structure is able to cover continuous food supply to the impacted population targeted, the SSN turns out to have the shortest planning time horizon as it guarantees such supply for one week only. Thus, this is only the very immediate food assistance.

Although the Civil Defense may not have the same neutrality the Red Cross counts on when it comes to deploying food aid in disaster areas under the influence of the armed conflict, the Strong Supportive Network has found to be remarkable when it comes to ease of accessibility, thanks to this feature. The next section (6.4) presents a case study showing that even the Civil Defense is able to overcome the fact that it is often seen as an official actor, and the organization enjoys a neutral image, as well when performing food aid distribution in the last mile, thanks to its great capabilities to integrate the local population in the distribution strategy.

6.3.3 Hybrid Approach Networks (HANs)

Based on a unique set of features, another HL structure has been identified not only between the pure outsourcing structure (FONs) and the most self-sufficient structure (SSNs), but also showing several innovative characteristics in the humanitarian response. With 80% of logistics operations being outsourced to a third party, the Hybrid Approach Network (HANs) still takes advantage of outsourcing. However, this HL structure carefully chooses the third parties involved in outsourcing, avoiding partnering with actors that do not have a background in humanitarian aid.

By taking advantage of being a UN agency, the international experiences of the WFP is immediately noticed in the upstream elements of its food supply chain when responding to manmade disasters in Colombia. Its source of supply relies on imported bulk food, which turns out to be cheaper than buying food commodities from domestic suppliers. This is also supported by the proximity to Panama, where a regional

strategic WFP warehouse is located and from which food aid is imported. A very common technique in commercial logistics is “postponement”, which according to Boone et al (2007), refers to the procrastination of a certain activity until the very last possible moment in the supply chain, so that a performance enhancement is achieved. Despite the character of regular HL operations the WFP runs in Colombia, postponement is successfully carried out in the supply chain by distributing single commodity packed rations upstream and keeping the same single packaging downstream, so that the actual food aid kit is configured and handed to beneficiaries as single commodities.

The Hybrid Approach Network in Colombia exclusively covers rural areas impacted by the armed conflict deploying food aid to IDPs. The geographic areas covered are the typical areas where the response of other HL structures is null, typically because of access restrictions due to the armed conflict or lack of empowerment from local authorities. Two corridors are targeted by this HL structure, as can be seen in Figure 25. Along these corridors, warehousing and distribution facilities are administered by NGOs, which locate points of distributions (PODs) in spots accessible to impacted areas. Another unique feature of this structure is the fact that the local community is strongly involved in the decision-making process, as to where to locate warehouses and points of distribution, because the feedback from local leaders has been taken into account in such processes, making this structure fairly integrated with the local population. The WFP also enjoys neutrality from being a foreign (UN) HL structure along with close integration with the local population, which enhances its capacity to penetrate the impacted areas. From upstream to downstream, this HL structure is fairly penetrative, by making sure the appropriate

actors are involved in the respective supply chain segment. However, evidence of partnerships with the private sector was not found, except for the outsourcing of warehousing and packing operations upstream in the supply chain. Regardless, the integration to other HL structures is not an outstanding feature of this HAN either because despite the fact that the vast majority of logistics operations are performed by NGOs, the deployment usually takes places autonomously, sometimes disconnectedly with the FON who may collaborate and cooperate for a holistic response.

Whereas warehousing and transportation operations are typically run by a 3PL upstream, NGOs collaborate to run warehousing and transportation operations midstream and downstream. The manpower running warehousing is directly hired by the corresponding NGO, while drivers are subcontracted to a forwarder despite the fact that vehicles are also owned by the NGO. When it has been the case that the last mile distribution has to take place by water, the corresponding NGO also typically rent boats. Still, given the strong connection to the local population, this Hybrid Network Approach assembles volunteers to run distribution operations when needed. One more hybrid characteristic of this HL structure is the duality of guaranteeing the outsourcing to NGOs that have an extensive expertise in humanitarian operations while still having reputable logistics know-how.

Although humanitarian aid is not the focus of the WFP in Colombia, they do deploy food aid as an immediate response when they detect populations in need, as long as the operational restrictions derived from the topography can be overcome and safety is guaranteed. Demand planning of immediate food aid response is typically push-driven, as it is not the response focus of the WFP. In fact, differing from other HL structures, the Hybrid Outsourcing Network only provides immediate food

assistance for 80 days, split in two deliveries. However, because of its high penetrability and partnerships with the humanitarian actors, this structure is not only among the most efficient in providing food aid for the very first time once the population impacted has been identified (up to 24 hours), but also has a great potential for scaling up the response magnitude if needed. Inventory availability is fairly good at regional warehouses in spite of the push inventory system.

6.4 Case Studies

Case studies surfaced in the interviews when interviewees were asked open-ended questions that permitted them to provide information that, although not specifically pursued, did provide insight worth documenting and provided context for more illustrations to support the foundations from which the HL structures were identified. Thus, the following two cases studies, based on the interviews with representatives of the Colombian Civil Defense and the Police Department, are introduced. Both cases portray the way structured organizations deal with constraints found in the last-mile distribution of food aid and how they end up being overcome with collaboration with local communities.

6.4.1 Droughts in the Desert

La Guajira, one of the 32 departments of Colombia, is located in the northwest desert region of the country and about half of its population is made up of indigenous groups (mainly *Wayúu*), with high levels of poverty. In 2013, slightly more than 50 percent of the population of La Guajira was considered in poverty. The decrease in rainfall in recent years in La Guajira due to El Niño exacerbated the regular dry season, triggering serious negative effects on the levels of food and nutritional

security, as well as the overall health of the population. The lack of food and water has impacted more than 63,000 people, most of who are concentrated in the municipalities of *Riohacha, Uribía* and *Manaure*.

To respond to this situation, multiple organizations such as the WFP and the Civil Defense (representing the UNGRD) started deploying food aid to most of the demand spots illustrated in Figure 31. Having the strategic warehouse located in *Uribia*, an extremely isolated town impacted by the drought, the challenge was to assure the last-mile distribution to the demand areas, overcoming the challenges due to the terrain of *La Guajira*. The impacted area is actually a desert where transportation between most populated areas has to take place by four-wheel drive vehicles, which the Civil Defense lacked. The challenge was deploying the food aid kits that have been configured from material convergence (private sector donations and confiscated food items from smuggling merchandise coming from Venezuela), to satisfy the needs of the impacted population. Given the lack of four-wheel vehicles to outsource from commercial logistics in the area, the Police Department, the aforementioned party providing significant transportation assets to the UNGRD, and in collaboration with the municipality of *Uribia*, contracted multiple four-wheel drive vehicles and drivers from a local carrier called *Cooperativas de Transporte*, as they were the only transportation solution allowed to enter the region despite the spectrum of private carriers available in the market. Individuals associated with this carrier owned most of the 50 outsourcing vehicles and were from the *Wayúu* community ultimately. Paradoxically, such *Cooperativas de Transporte* are also directly involved in transporting the smuggled merchandise (food and gas) coming from Venezuela to the region and, despite the fact that the Police Department is aware that these carriers

perform illegal transportation operations in the area, their services turned out to be essential as the priority was to support the humanitarian response.

Not surprisingly, there are some organizational aspects attached to this particular situation that are unique. Typically, the impacted population is indigenous; they are the *Wayúu*, who although are settled in one of the 32 administrative and political provinces (state) of Colombia, are also governed by their own ethnic rules and political structure. This means that the territory is literally split by different communities who, despite the fact that they are not legally empowered to govern their territories, are rightfully autonomous to do so. In other words, even when a disaster occurs, such as the recurrent droughts in the region, they are the ones who decide who can enter their territories, and who gets permission to provide aid, which sometimes has nothing to do with the Colombian armed conflict, addressed in this research.

It can be difficult to distinguish the border between the legitimacy of their indigenous culture and the illegality, as several cases have related the *Wayúu* to smuggling activities in the region (Ortiz, 2004). This complex background explains why the Police Department, in collaboration with the local legal government, decided to utilize the HL structure that supports the smuggling in this area. When outsourcing a set of carriers being known for transporting smuggling merchandise from Venezuela, humanitarian responders were actually outsourcing the only logistics provider acknowledged and accepted by the indigenous communities. Besides, these carriers run four-wheel-drive vehicles with Venezuelan license plates, the only ones capable of traversing such desert territory. Counting on more than 30 years of expertise, these carrier's drivers were the only ones knowledgeable of the off-road routes that abound in an area where no road map can be drawn by a GPS, but where trees, cactus and

rocks are the only guiding marks left available once wheel paths are gone. Indeed, the HL structure derived from smuggling, or the *Wayúu* logistics structure, has remained as the first available to keep deploying humanitarian aid in the region as new droughts occur.

The economy in *La Guajira* has been strongly driven by smuggling over the last decades (Cerrejon, 2008). In fact, the flow of cash in the region is strictly attached to this illegal practice. A vast majority of food supplies and gas comes illegally from Venezuela and, although water is not typically brought illegally, it is also supplied thanks to the same smuggling carriers. As a final remark, the issue regarding the reasons why the private carriers in question are not prosecuted in spite of their illegal background related to smuggling, is out of the scope if this study. However, authorities are aware it is very likely that these carriers are going to keep moving smuggling merchandise once their humanitarian mission has been completed. Indeed, although there are records of those vehicles previously associated to smuggling activities, potential prosecutors were encouraged to be lenient, because as the impact of the imminent humanitarian response they could deploy over the potential persecution they could initiate was significant. Ultimately, despite the fact that the Civil Defense and the Rescue Division of the Police Department first approached the Cooperatives, a “don’t ask, don’t tell” situation ended up taking place in the field. Besides, officials wore humanitarian uniforms as opposed to the conventional distinctive police uniforms. This way, the Cooperatives implicitly diminished the threat of persecution the Police Department represented and the Police Department conveniently absolved the illegal practices of the Cooperatives. In summation, a truce was achieved in the name of humanitarian response.

Furthermore, they are seen by local authorities and by the *Wayúu* community itself as the only structure able to boost the flow of goods under a humanitarian or a regular scenario before the evident lack of alternative solutions to be put on the table. Turning into *Cooperativas de Transporte Indígenas* (Indigenous transportation cooperatives) rather than being individual carriers, almost as some sort of self-defense mechanism, they have managed to be protected by the legitimate *Wayúu* political structure avoiding, and thus, have avoided any potential persecution by the legal system. Additionally, since smuggling has been part of a daily life in the region, mainly due to the uncontrolled proximity to the Venezuelan border, community members have no prejudices on allowing these carriers to deliver food aid, because in other instances, they are the ones who have supplied the community with high priority goods like water and gas. Conversely, outsiders like local and central governments are more likely to have a different view and to acknowledge their weak capabilities to cope with their own HL structure by ultimately legitimizing what is actually considered illegal.

6.4.2 Wildfires in the Andes Mountains

In September of 2012, more than 5,000 hectares burned in *Argelia, Cauca*, a southwestern Andean province in Colombia. The wildfire, lasting 15 days, took place in an area under the influence of the armed conflict. Although it is not officially known whether the wildfires were intentionally started for a specific purpose and who might have been responsible for it, it was evident that the unfolding response actions would involve the intervention of the armed conflict actors. According to governmental sources, the local fire department refused to cover the impacted area, alleging that there were not optimal safety conditions due to the presence of armed

conflict actors (guerilla groups). Although the impacted area was 100% rural and no population was directly impacted, the threat of an even bigger expansion was imminent, increasing the likelihood of reaching small populations and causing huge ecological consequences. However, although there was not a settled civilian population in the area, it was believed that guerilla members could have been directly impacted by these wildfires since members are usually spread-out uphill by quadrants. An institutional intervention was then necessary to stop the fires and in order to avoid spreading to local communities. The mayor of the municipality stated that it was impossible to use special helicopters to extinguish the fire because, although most of them were available, they had Air Force and military logos and colors on them. Hence, they may have been attacked by the guerrillas mistaking them for a military troop intervention, as opposed to serving a mission to drop water from the air.

Land access was also unsafe, due to the presence of landmines along riversides (Propia, 2012). Consequently, the Air Force, Civil Defense and the Red Cross started to plan their operations in the area and brainstorm a strategy to peacefully, safely and successfully enter the area.

Figure 35. Volunteers in Andean wildfire. Source: Colombian Civil Defense

Given the leadership, the Civil Defense suggested assembling the locals who had voluntarily joined forest brigades in the past as see Figure 35 illustrates (*Defensa Civil Colombiana*, 2012), and were recognizable among community members. This way, there would be no doubt that they were not outsiders. These locals were knowledgeable of the social dynamics of the community and could even communicate with conflict leaders, because they knew how to make it while keeping a neutral position. These indigenous people could also serve as a conciliatory and neutral body to obtain any consent from any armed conflict actor that would eventually demand it. Aware of who would be the armed conflict actor that eventually would hinder the fire extinguishing operations, these indigenous forest brigades started direct contact with guerrilla (FARC) members. Initially, the indigenous forest brigades requested consent to enter in exchange of guaranteeing that no military crafts and troops would enter the area, and that, instead, they would be the only ones permitted to do so. It is unknown, however, whether that consent would have benefited the guerrilla groups themselves, as they could have been impacted by the wildfires. Having succeeded with their

request, the indigenous forest brigades, who were guided by locals able to avoid landmine paths along the trails to reach the wildfire, started the extinguishing operations under the support of the Civil Defense and the Red Cross. After having walked for over three days and camping inland and uphill, dozens of volunteer members of the indigenous brigades mobilized equipment by horses and mules.

6.5 Summary

Table 14 and Table 15 below aim to summarize the features and capabilities of the three HL structures identified. Table 14 presents the features described in detail in section 6.4, and when summarizing the feature in question, a comparative view is available by reading each feature by HL structure horizontally. The percentage of logistics operations outsourced is presented, turning the quantitative information of Table 13 into a qualitative assessment. The supply source feature speaks for the actors who initiate the supply chain upstream. The commodities feature compares both the variety and the manner they are obtained. Geographic coverage is meant to contrast the rural and urban focus. Transportation and warehousing capabilities are presented in terms of the actor who runs it. Manpower capability is addressed contrasting self-employed, outsourced and volunteer personnel involved. The logistics know-how capability qualitatively assesses how well the HL in question incorporates successful logistics practices. Humanitarian background speaks for how good the HL structure in question is integrated with the humanitarian sector when running logistics operations. Demand system distinguishes between pull and push systems used by the HL structure. Penetrability as a capability is explained in terms of how much access the HL structure has to enter all supply chain segments. Finally, humanitarian and private

sector partnership capabilities are dimensioned in terms of how large the structure involves humanitarian actors and corporate actors, respectively.

Table 14. Key features of FONs, SSNs and HAN

Feature	**Institutional relief** **Full Outsourcing Networks (FON)**	**Domestic relief** **Strong Supportive Networks (SSN)**	**Foreign relief** **Mixed Approach Networks (MAN)**
% of logistics operations outsourced	The largest possible	The smallest	Fairly large
Supply source	Domestic and Private food retailers	Individual and corporate donors	International bulk food providers
Commodities	Procured range of food aid kits	A single kit configured from material convergence	Range of food aid kits configured on the go
Geographic coverage	Highly widespread with urban focus	Highly widespread with rural focus	Conveniently widespread with rural focus
Transportation	Totally run by private carriers in all supply chain segments	Typically run by privately owned fleet vehicles in all supply chain segments	Typically run private carriers upstream and privately owned vehicles downstream
Warehousing	Totally run by food retailers upstream and local authorities downstream	Totally run in privately owned warehousing facilities, especially upstream.	Totally run by 3PL upstream and NGOs downstream
Manpower	Mostly outsourced to the private market	Mostly volunteers and directly hired	Directly hired mostly typically backed up by volunteers
Logistics know-how	Good upstream and very poor downstream	Good throughout all supply chain segments	Fairly good throughout all

Feature	Institutional relief Full Outsourcing Networks (FON)	Domestic relief Strong Supportive Networks (SSN)	Foreign relief Mixed Approach Networks (MAN)
			supply chain segments
Humanitarian background	Fairly poor	Fairly good	Fairly Good
Demand system	Both sudden and recurrent and pull-driven only	Sudden and typically pull-driven	Recurrent and typically push-driven
Penetrability	Fairly small in downstream segments	Fairly large in all segments	Fairly large in all segments
Humanitarian partnership	Typically null	Typically large	Typically large
Private sector partnership	Typically large	Typically large	Typically null

On the other hand, Table 15 introduces a qualitative measure using a Likert scale, which indicates how the capability in question favors the decrease in the deprivation caused by not alleviating the needs of the impacted population on time. Implicitly, as opposed to Table 14, which uses dimensions that may not vary along HL structures, dimensions on Table 15 are mutually exclusive, implying that the same dimension cannot show up more than once when assessing the same capability along HL structures.

The following capabilities are summarized:

- Initial deprivation time: The time beneficiaries have to wait for the very first food aid ration to arrive.
- Planning horizon: Period of time over which food aid supply aims to be guaranteed continuously to beneficiaries.

- Supply nodes proximity to the next segment: Warehousing and distribution facilities' closeness to the next segment downstream the supply chain.
- Deployment under larger scale scenarios: Extension of existing warehousing and distribution facilities.
- Multimodal transportation: Use of more than one means of transportation when deploying food aid.
- Vehicle availability downstream: Guarantee of counting on the appropriate vehicles in the last mile.
- Inventory availability: Effectiveness to access food aid commodities to start deployment.
- Neutrality to deploy aid in conflict areas: Acknowledgement as a non-armed conflict actor when deploying humanitarian aid, or consent to enter a specific area despite being an armed conflict actor.
- Integration with other structures: Involvement of other HL structures when performing any logistics operations.
- Integration with the local population: Involvement of locals, individually or collectively, to deploy food aid in the last mile.

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Table 15. Summary of HL structures' capabilities to decrease deprivation

	Institutional relief	Domestic relief	Foreign relief
Capabilities	Full Outsourcing Networks (FON)	Strong Supportive Networks (SSN)	Mixed Approach Networks (MAN)
Initial deprivation time	(---)	(--)	(-)
Planning horizon	(+++)	(---)	(++)
Supply nodes proximity to next segment	(---)	(+)	(++)
Deployment under larger scale scenarios	(+)	(++)	(+++)
Multimodal transportation	(---)	(+++)	(+)
Vehicle availability downstream	(+)	(+++)	(++)
Inventory availability	(+++)	(-)	(++)
Neutrality to deploy aid in conflict areas	(-)	(+++)	(++)
Integration with other structures	(++)	(+++)	(-)
Integration with the local population	(---)	(++)	(+++)

Note: Scale: least favorable (---) and most favorable (+++)

Chapter 7

PHASE IV RESULTS-POLICY RECOMMENDATIONS

This chapter offers two approaches for analyzing the HL supply chains and suggesting policy recommendations aimed at making the supply structure available to respond to larger scale disasters. Section 7.1 presents an analysis and policy implications based on the response system discussed in Chapter 5. This approach aims to enhance logistics capabilities supporting the same supply chain segment among relief networks supplying the same response system; in other words, these policy implications seek to enhance logistics performance within each response system separately. In contrast, section 7.2 presents analysis and policy implications based on the HL structure presented in Chapter 6. This approach aims to enhance performance by grouping logistics capabilities based on similar HL structures, which are technically and hypothetically available to form a set in the same supply chain segment. Figure 36 and Figure 37 illustrate the analysis and policy implications approach of section 7.1 and 7.2, respectively.

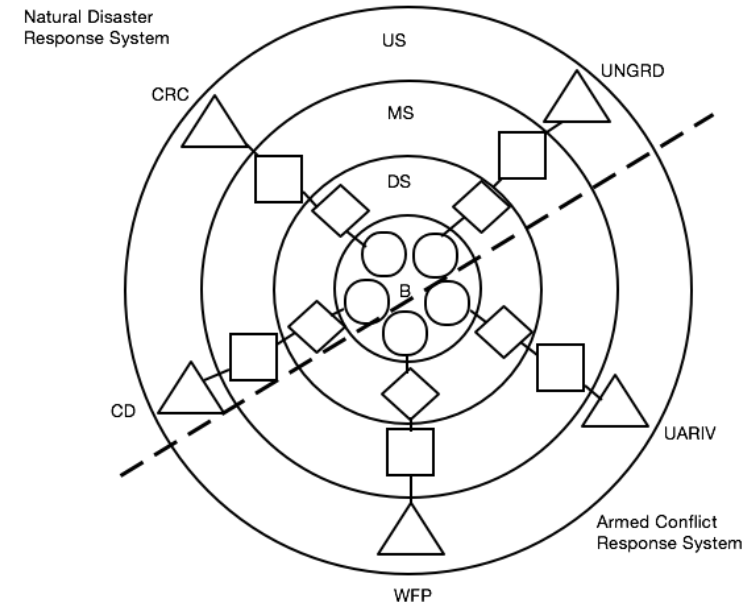

Figure 36. Schematic of policy implications by response system

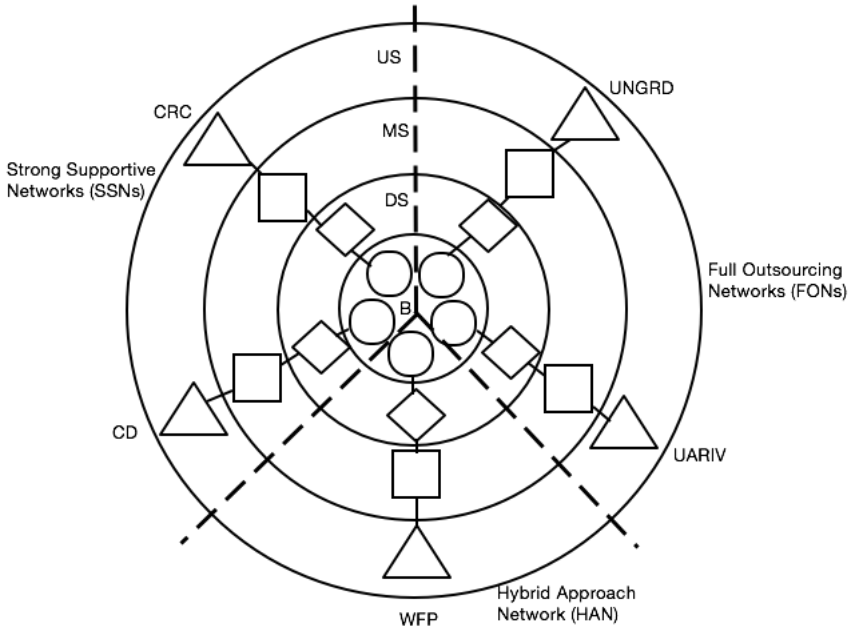

Figure 37. Schematic of policy implication by HL structure

7.1 Analysis and Policy Implications: Response Systems

Given the supply chain characterization previously exposed and the relative rigidity within the relief networks belonging to the same humanitarian response system, the above-mentioned case studies may be seen as preliminary examples on how much the relief networks and HL structures need to work collaboratively. Hence, pursuing policies oriented toward maximizing the synergies between all actors involved is recommended. Although the two case studies, presented in section 6.4, specifically highlight the role of local communities to solve transportation constraints in the last mile, they are vivid testimonies about the importance of having logistics capabilities openly available to all relief networks, in case a large-scale disaster were to occur, or if a specific disaster event demanded it.

In this section, the armed conflict response system and the natural disaster response system are analyzed side-by-side within each supply chain segment in question in order to encourage collaboration between the relief networks that comprise them. This is under the assumption that a more efficient overall performance may be achieved if logistics capabilities of either relief network system in the same segment were shared or added in case a large-scale disaster occurred. Consequently, a pull of supportive capabilities is no longer presented by relief network or HL structure, but instead by a supply chain segment in which capabilities are totally shared and made available by the response system when larger scale disasters demand a significant capabilities expansion.

7.1.1 Upstream

The armed conflict humanitarian response system, represented in this analysis by one international relief network (the UN cluster approach) and one domestic relief network (the National Unit for "Victims" Response and Reparation – UARIV approach), uses a variety of significantly different strategies to manage facilities through which food aid is deployed. On one hand, the UN cluster approach imports all of its food aid commodities from the UN humanitarian response depot located in Panama, through harbor cities located at both the Pacific and Atlantic coast. Relying on the storage and materials handling by a Third Party Logistics (3PL) company in these coastal cities and under the supervision of the World Food Program, the bulk of food aid is then transported by road carriers to strategic warehouses located at inland cities. On the other hand, the UARIV approach not only fully relies on the domestic private food markets when starting the food aid deployment operation, but also directly purchases food aid kits to food suppliers under the supervision of local and central governments. These suppliers may transport food to requested locations using their own fleet or outsourcing road transportation to carriers. Such evident differences bring along challenges and implications for the upstream supply chain for the armed conflict response system. Some of these are:

- Future collaboration between the two relief networks is encouraged in order to support response to potential larger scale manmade disasters. This collaboration would be subject to resolving the differences in strategy that are a consequence of either lower costs or shorter lead times, or other operational bonuses that lead the one to purchase bulk food aid internationally and the other one to purchase food aid kits in the domestic food market.

- The fact that the UARIV approach contracts private food suppliers all around the country may be a crucial factor to shorten lead times to the midstream supply chain. However, the interview findings revealed that proximity to the impacted area might not be the driving factor for local and central authorities to choose the supplier; the supplier's selection is driven by other kinds of interests.
- Local and central governments typically outsource the food aid inventory management to a third party once purchased from suppliers. The interviews revealed that such third parties may lack the knowledge and tools that help them make the right decisions about how much to order and how often, given the volatility of demand patterns of those in need, which certainly translates to longer deprivation times for beneficiaries. Although the UN cluster approach does not do a much better job managing the inventory to ensure more stable and shorter deprivation times, the fact that they have no obligation by law to distribute food aid, as the UARIV does, means that the distribution strategy is based on a set deterministic demand pattern. Hence, managing an inventory system that is easy to keep under control means they fulfill 100% of the needs of the impacted population targeted.
- Outsourced carriers are the vast majority of transportation providers for both relief networks in this segment, which could be positive for achieving competitive transportation rates that benefit local authorities and the WFP. However, for the UARIV relief network, economies of scale opportunities may also be disregarded as the number of disconnected suppliers spread out in the national territory increases.

The natural disaster humanitarian response system is represented in this analysis by three domestic relief networks; these are the Colombian Red Cross (CRC), Civil Defense (CD) and the National Unit for Disaster Management and Response (UNGRD). Although the CRC and the CD are part of the organizational framework of

the UNGRD, they are treated here as independent relief networks due to their own capabilities to deploy food aid from upstream to downstream in the supply chain. Another striking factor that distinguishes these three relief networks is the preferred sources for acquiring food aid commodities. Just like the UARIV, the UNGRD purchases 100% of the food aid kits that local authorities request when declaring the national calamity status. Conversely, although differing from the supplying source as well, the CRC and CD fully rely on material convergence when setting up the food aid kits or commodities to be deployed to beneficiaries. CRC typically acquires donations from the private sector and individuals and organizations that make up the social fabric. The CD acquires commodities from the Colombian Tax and Customs Organization (DIAN), which donates food commodities confiscated in smuggling-prone areas like international borders. However, an important commonality in this segment is that carriers are typically contracted to move aid to midstream in the supply chain despite the fact that privately owned transportation fleets are also operated by the CRC and CD in larger scale disasters, and also logistically supported by the Police Department. A challenge and implication out of these differences and commonality is:

- The fact that each relief network supplies from different sources and under completely different legal frameworks strongly challenges logistics partnership among the networks due to their commodity-oriented supply chain strategy, despite the fact that beneficiaries are awaiting to relieve the same humanitarian needs. However, under the occurrence of larger scale disasters, these differences should not overshadow the crucial logistics capabilities that, if not shared as much as possible, would impede logistics capabilities balancing, overwhelming some while underusing others in specifics segments of the supply chain.

7.1.2 Midstream

When it comes to the armed conflict humanitarian response system, once the bulk of food aid arrives at the warehouses in the inland cities, the UN cluster approach remains outsourcing both the warehousing and the transportation to the next segment to carriers by contracting a 3PL. In contrast, the UARIV delivers food aid kits to a new actor in the segment, the local authorities. By owning or renting warehousing facilities, local authorities typically proceed with materials handling and manage transportation downstream with a fleet of vehicles. Consequently, although in the same segment, both relief networks differ significantly, since the UN cluster approach continues taking the most from economies of scale by still managing bulked food aid commodities, while the UARIV approach is already transporting food aid kits to downstream in the supply chain. Using technical logistics terms, the UN cluster approach sticks to postponement methods until very far downstream in the supply chain (last mile). This notable difference brings up challenges and implications for midstream in the supply chain of the armed conflict response system, one of which is:

- Being in the same segment, the UN cluster approach (WFP) forwards the total national distribution strategy to only two depots, while the UARIV does forward distribution to several dozen depots given the multiple suppliers contracted. Future collaboration between these two relief networks is encouraged to synergistically respond to larger-scale, manmade disasters caused by the armed conflict. Hence, it is worth checking, for future research and policy implications, whether completely migrating both relief networks to any of the following strategies would bring performance improvement in terms of operational and deprivation costs: i) Leveraging economies of scale by distributing bulk food aid from a single supplier and sticking to postponement strategies; ii) Completely migrating to a multiple supplier approach with food aid kits already

configured at this point; iii) A combination of both, this is, each approach partially applying to each relief network.

Relying on strategic warehouses located in disaster-prone areas, the natural disaster humanitarian response system represented by the CRC and the CD, manages their own storing and materiel handling operations where material convergence is the focus of operations in these facilities. Meanwhile, the UNGRD migrates to a new logistics actor as the contracted suppliers are asked to deliver food aid kits at facilities either privately owned by local governments or rented real estate. Transportation to downstream in the supply chain represents a key difference in this segment as well. Fully delegating the distribution process to private carriers and the local distribution capacities of the social fabric, local authorities differ from the CRC and the CD, as they not only delegate on carriers and social fabrics, but also support on their own distribution capabilities and that of other institutions, like the Police Department, Air Force and the Army. One challenge and implication from these key differences is that at this segment of the supply chain, if the CRC and CD strategic warehouses were located in proximity to the disaster-prone areas, there may be a great chance for local authorities to take the most from the CRC and CD logistics support. However, because purchased food aid kits are typically distributed to local authorities instead, and due to the disconnection with these two institutions with food suppliers, this possibility is almost unattainable.

7.1.3 Downstream

In regard to the armed conflict humanitarian response system, this supply chain segment presents another important difference for the relief networks responding with food aid to manmade disasters. The UN cluster migrates to a new logistics actor by

relying on an NGO from this point on and all the way to the beneficiaries' hands. This is when re-packing rations for each commodity is carried out, so that food aid kit configuration takes place in the last mile supply chain segment. Meanwhile, the UARIV approach continues delegating both the storing and distribution to a third party, under the supervision of local governments. However, one commonality is the fact that both approaches typically transport commodities to beneficiaries by using privately owned vehicles in the last mile. A challenge and implication for these segments is:

- Trusting a humanitarian NGO as a logistics operator, as opposed to relying on a third party whose experience in managing food aid distribution under humanitarian contexts is typically null. This may be a key issue for explaining any differential performance between the two relief networks.

A cornerstone difference within the natural disaster humanitarian response system in this segment is the existence of dozens of facilities that the provincial headquarters of the CRC and CD own for all kind of humanitarian operations. Although the CD have representation in almost 90% of Colombian municipalities, and the CRC have presence in every province's capital municipality, and despite the fact that not all of them are guaranteed to facilitate humanitarian logistics operations for food aid distribution if needed, these are supporting pieces in the network. In contrast, local authorities, delegated by the UNGRD, don't count on any other facility to break down the distribution directly to beneficiaries. As a result, the challenge is thus:

- In light of the occurrence of larger-scale disasters that required the involvement of the CRC and CD network located downstream from the strategic warehouses, it is worth exploring the direct connection between the UNGRD

suppliers/carriers with any of these facilities before reaching local authorities and third parties. This would represent any performance improvement in the overall supply chain.

7.1.4 Last Mile (Beneficiaries)

Two striking differences are easily detected in this segment. The UN cluster, represented at this point by the NGO, on one hand, does not use a civil facility as such when performing distribution to beneficiaries' hands, since this process takes place in the distribution vehicle itself, typically in rural areas. In addition, all commodities are re-packed in individual rations, so that food aid kits are configured and handed to beneficiaries. In this regard, the postponement tactic is effective until the very last moment in the supply chain. On the other hand, the UARIV approach does use a facility, typically a shelter located in urban areas, to distribute food aid kits to beneficiaries' hands. Some challenges and implications for this segment include:

- Fully relying on the domestic food supply market intrinsically exacerbates the risks associated to disruptions in the last mile distribution due to the lack of neutrality of the carrier and supplier when delivering to communities under the influence of the armed conflict.
- Food suppliers and carriers contracted by the UARIV primarily focus their distribution in urban areas, while distribution in remote areas is under the leadership of the UN cluster approach. One question remains to justify this fact: Do suppliers and carriers find it difficult to operate the local distribution in rural areas, due to potential inabilities to overcome non-conflict restrictions associated with the logistics operation itself? For example, accessing beneficiaries only reachable by fluvial navigation or by multiple small cargo capacity four wheel drive vehicles.

Reaching disaster locations while minimizing and facilitating beneficiaries' accessibility to aid is a commonality for the relief networks ending the supply chain for the natural disaster humanitarian response system. In fact, all of the relief networks analyzed typically resort to setting up a point of distribution, or sub-point of distribution, utilizing a civil facility, whether rented on the real estate market or privately owned. Additionally, although carriers play an important role in the last mile distribution, institutional support is equally important as the CRC, CD, Police Department, Armed Forces and the Army count on an important transportation fleet to serve distribution operations. Still, a challenge and policy implication for the natural humanitarian response system at this segment is:

- Despite the strong institutional capabilities that the UNGRD count on for food aid distribution capabilities in the last mile, these are strongly constrained, as the disaster area may have limited access to non-neutral humanitarian actors in areas under the influence of the armed conflict. Hence, it is worth exploring how the institutional capabilities are complemented and/or replaced with other local distribution capabilities like the ones offered by the social fabric.

7.2 Analysis and Policy Implications: HL Structures

Drawing on the descriptions of the current logistics operations for each response system, some policy implications are presented based on an approach that bridges between commercial and humanitarian logistics practices in the manmade and natural disasters context. Further, these logistics practices take into account the specificities of the HL structures identified. Policy implications are identified and

presented in light of courses of action that could benefit overall performance by grouping logistics capabilities and practices from any HL structure in the same supply chain segment in order to serve as a model to others. This way, the analysis and policy implications are driven by supply chain segment, just like the policy implications of response systems are developed in section 7.1.

7.2.1 Upstream

Hybrid Approach Networks (HANs) like the World Food Program (WFP) may be a model to follow in this segment because of its unique approach to procurement and materials handling of food aid commodities. The approach used by HANs may be worth exploring for application to Full Outsourcing Networks (FONs) in the sense that, despite the fact that international sources of procurement may delay delivery times to beneficiaries, alternative domestic sources of procurement should be considered. For instance, FONs may choose the locations of their food suppliers based on the proximity to the impacted area, rather than arbitrarily and frequently choosing food suppliers located in distant locations like *Bogotá*. Implementation of postponement techniques by HANs provides evidence to the extent at which HL structures can successfully adopt strategies typically used in commercial supply chains. Rather than procuring food aid kits to food suppliers, FONs may explore bulk procurement and, concurrently, launch an actual partnership and collaboration strategy with their suppliers, so that there is actual outsourcing and less subcontracting.

7.2.2 Midstream

FONs identified lack of supply nodes in this segment. Although additional supply nodes may apparently improve the linkage between upstream and midstream

actors, this strategy may also hinder the implementation of logistics collaboration strategies between these two. FONs, as opposed to SSNs and HANs, which by appealing to strategically positioned distribution points and to third parties knowledgeable in humanitarian logistics respectively, manage to have a strong midstream structure. Hence, FONs may explore closing this gap by, as an example, involving third parties (humanitarian or commercial). These third parties, which feature a strong logistics background, are capable not only of breaking down the network by locating facilities when needed, but are also able to serve in transferring logistics know-how to local governments.

7.2.3 Downstream

The Full Outsourcing Networks identified (FONs), which are the official relief networks of each response system (UARIV and the UNGRD), subcontract suppliers to distribute food aid kits to local authorities and third parties. However, the humanitarian logistics know-how of these local authorities and third parties is not guaranteed downstream in the supply chain. Hence strengthening logistics capabilities of local governments, such as adopting inventory management systems that respond to the demand patterns of those in need, or bridging the social fabrics to help overcome the transportation constraints imposed by the armed conflict and the geographic conditions in the last mile, would support better overall performance of the supply chain. Such strengthening would turn the local authority into an actual humanitarian actor able to logistically respond to both manmade and natural disasters.

7.2.4 Last Mile (Beneficiaries)

Assuring accessibility to beneficiaries implies overcoming technical constraints in the last mile due to the geographic locations of the population impacted. Also, counting on a fixed facility structure facing beneficiaries assures accessibility, which FONs naturally lack off, unlike SSNs and HANs. Both SSNs and HANs typically succeed in assuring such accessibility by distributing food aid from strategically located points of distribution by the use of privately owned vehicles, as long as demand does not exceed supply. FONs, however, have to typically improvise the last mile configuration. For instance, UNGRD delegates the last mile distribution to local governments, recognizing that the means by which food aid is deployed may be uncertain. As one way to deal with such uncertainty and to appropriately proceed based on improvisation, FONS should count on SSNs not only when food aid kits are configured through material convergence, but also when distributing food aid procured to provide food suppliers, which is true in most of the cases.

Evidently, despite the fact that each HL structure identified presents weaknesses and strengths, most of the policy implications presented above imply the intervention of FONs through courses of actions to follow from SSNs and HANs or the collaboration with the one or both SSNs and HANs. Moreover, FONs represent the reliable structure for a vast majority of food aid being deployed to both those impacted by natural disasters and the armed conflict.

This overall analysis exposes the evident need for policy makers and practitioners to understand the humanitarian response system holistically and managerially, and as a pull opportunity for sharing logistics capabilities and networking parties toward logistics partnerships in light of effectively alleviating the suffering of those in need. In addition, this analysis also exposes the need for the

humanitarian actors to continue evolving toward switching to humanitarian logistics practices, which although differ significantly from commercial logistics, can support supply chain analysis tools that are applicable to both commercial and humanitarian logistics, as long as the appropriate dynamics are incorporated in the analysis

Chapter 8

PERFORMANCE ASSESSMENT METHODOLOGY

As a foundation for suggesting an approach to enhancing the overall performance for the armed conflict and natural disasters response in Colombia, this chapter contextualizes the dimensions and implications of the most striking disaster events that have occurred in Colombia's recent history. Based on a deep understanding of the features that define the magnitude and extent of the historical humanitarian operations demanded in Colombia, this chapter also develops a justification for using hypothetical scenarios that, although built from realistic case studies, would enhance performance derived from running HL structures presented in Chapter 6 by taking a representation of the policy recommendations presented in Chapter 7 when responding to larger-scale disasters. The performance is then compared to the results from operating the relief networks presented in Chapter 5.

This chapter is broken down into eight subsections. Subsection 8.1 analyzes historic large-scale disasters and presents the likelihood of new disasters in the future due to the armed conflict in Colombia. Section 8.2 analyzes historic data on natural disasters and presents large-scale disasters likely to come from natural hazards in Colombia. Section 8.3 introduces the hypothetical scenarios, which are drawn from Sections 8.1 and 8.2.

Section 8.4 reviews the assessment instrument, an optimization model through which the scenario is simulated. The limitations, decisions to be made, assumptions made, as well as inputs and outputs are presented in detail.

8.1 Large Scale Disasters Due to the Armed Conflict in Colombia

As discussed in section 4.1, if the issue of large-scale disasters derived from the armed conflict were highlighted, the individual and massive internal displacement derived from the armed conflict should be focus-centered. The data analyzed in section 4.1 and shown in Figure 8, Figure 9 and Figure 10, show that internal displacement is by far the largest disaster derived from the armed conflict. Also, it can be inferred that 50% of total IDPs have occurred in the last 10 years, and that 50% of IDPs are concentrated in only five of Colombia's provinces. Given that the data on the armed conflict does not provide as much detailed information as the data for natural disasters, this section presents an analysis of indicators that lead to identify characteristics of the events resulting in internal displacements that have caused the largest deployment of humanitarian aid in Colombian history.

Pursuing a similar approach to that used in section 4.1, Figure 10 again serves as a reference to identify any increase of IDPs from 1985 through 2014 significantly higher than the cumulative number of IDPs in other years. Similarly, according to official records analyzed by Ibañez (2009), 2000, 2001 and 2002 are the years with the highest percentage increase, counting for over 33% of the total number of IDPs, which responds to a period of heavy conflict in the country. Although after 2002, as displacement decreases, the average of new IDPs each year is 300,000 up to 2013. The number of IDPs is not only large, but has also steadily expanded across the country. By 2002, the number of municipalities affected by out-placement (expelled residents), had risen to 949, affecting more than 90% of the country's municipalities, as Ibañez (2009) concludes.

Although displacement seems to affect all of the country's municipalities, impact is more substantial in some regions than in others. When the intensity of

displacement is calculated, that is, the percentage of the displaced population in relation to total population, one finds that some municipalities have lost more than half of their population. Some of the most dramatic examples are *Bojayá (Chocó)* with an intensity of 94.7 percent, *Cocorná (Antioquia)* with 93.8 percent, *El Tarra (Norte de Santander)* with 82.4 percent, *Peque (Antioquia)* with 77.5 percent, and *Riosucio (Chocó)* with 76.1 percent. In fact, as can be observed in Figure 11, *Antioquia* is the province with the higher number of IDPs in Colombian history, surpassing *Bolivar*, *Magdalena*, *Chocó* and *Nariño*. Moreover, 10 percent of Colombia's municipalities have lost close to one-fourth of their population as a direct consequence of forced displacement. Pressure indicators, which calculate the arrival of displaced populations in relation to the native population, likewise indicate the difficulties faced by mid-sized cities in absorbing large migration flows. The pressure indicators for selected department capitals demonstrate this: *Mocoa (Putumayo)* 33.3 percent, *Quibdó (Chocó),* 26.4 percent, *Sincelejo (Sucre)* 24.6 percent, *Florencia (Caquetá)* 20.3 percent, and *San José (Guaviare)* 18.5 percent. Between 1999 and 208, all of these municipalities, which already have difficulties attending to their own population's needs, have received about one person per year for every five locals (Ibañez, 2009).

For the most part, people migrate individually, and few move outside the country's borders. Close to 80 percent of displacement in Colombia is individual. The highest levels of mass displacement were reported from 2000 to 2002, when attacks on municipalities, and the resulting combat, were common. Individual displacement has been predominant and rising since then (Ibañez, 2009).

8.1.1 Large Scale Disasters Likely to Come From the Armed Conflict in Colombia

Despite the fact that the armed conflict in Colombia is likely end due to the current peace negotiations, IDPs will continue to demand humanitarian aid because of the social conditions they experience in both rural and urban areas. The following paragraphs are taken from Højen (2015), which contextualize the reasons why humanitarian response resulting from the armed conflict is likely to continue even if a complete cease-fire is achieved:

- "Most displacements take place in remote rural areas of Colombia where armed conflicts are common, and the majority of IDPs are composed of Indigenous people and Afro-Colombians…- Almost all regions have experienced displacement caused by violence and conflict and intra-urban displacement is also increasing due to violent gang conflicts…- Nonetheless, the prevailing pattern is displacement flowing from rural to urban settings".
- "Despite the fact that Colombia has earned the status of an 'upper middle-income economy' and that economy is thriving beyond expectations compared to its regional neighbors, the growing number of displaced persons does not appear directly correlated to its overall economic situation."
- "As argued by the World Food Program (WFP), all IDPs in Colombia belong to the 32.7 and 10.4 percent of the population living in poverty and extreme poverty in 2013"...-, "the average monthly income of an internally displaced family represents a little over 41 percent of the official minimum wage, equivalent to US$63 dollars, which demonstrates that the distribution of wealth within Colombia is highly unequal and that a seemingly prosperous economy is not sufficiently benefiting IDPs".

- "The estimated abandoned or dispossessed land lost by IDPs is, until 2012, calculated to be as high as 6.8 million hectares. After leaving especially rural areas, approximately 80 percent of IDPs migrate to big cities looking for two things: the security of being anonymous to avoid being targeted again; and access to public services that are inaccessible in their home municipalities".
- "Many IDPs do not have the legal identification cards necessary to acquire health benefits, free education, or other services provided by the government. The UNHCR has discovered that the majority of IDPs experience severe psychological trauma from trying to cope with life in the big cities. They are not eligible for state services, live in poverty with a very low quality of life, cannot find jobs—especially on the formal labor market—since most are farmers and illiterate, and the *barrios* are haunted by violent gang activity—including those housing child gangs."
- "Colombia's IDPs crisis only exacerbates the social, economic, and political challenges that the country already is facing."

Under the frame of an optimistic scenario, IDPs would start decreasing in Colombia if the armed conflict ceases. However, because of the above-mentioned facts, aid deployment is likely to continue to respond to the millions of IDPs introduced in this section.

Section 8.2 also produces the foundations needed to characterize the demand for the most common large-scale manmade disasters in Colombia using an original content analysis approach. These foundations will draw the feasibility of the hypothetical armed conflict demand scenarios presented in the subsequent sections later in this chapter.

8.2 Large Scale Natural Disasters in Colombia

Based on an online data repository for disaster records in Latin America and other countries worldwide (Desinventar, 2013), the most striking disaster events that have occurred in Colombia are identified based on a quantitative assessment of indicators representing the severity of the disaster impacts. The indicators available in the repository are: deaths and missing, impacted persons (classified as wounded, evacuees, relocated, “affected”, and “victims”), homes destroyed and homes affected. Although this dissertation acknowledges that the definition of large-scale disasters is subject to discussion in the literature, the analysis introduced in this section merely relies on those events that can be considered significant based on a specific indicator.

Using disaster records from 1914 through 2013, the database was analyzed considering the indicators mentioned above. For each of the indicators there were as many records as disaster events entered in the database. For each record, the year, type of event, triggering agent, specifics on the population (death, missing, “affected”, “victims”, relocated, evacuees and injured, as originally categorized by the database) and the households (affected and homes destroyed) are provided. Next, after totaling each indicator by summing up the numbers of each event recorded, the percentage of each event is calculated so that a cumulative indicator is constructed to represent the cumulative percentage to date.

In order to illustrate the trends over time-event for each indicator, individual charts were plotted to identify the large-scale disasters — events with significantly higher measures of specific impacts compared to the rest of the events — which are considered to be large-scale events. The remaining events are classified as small-scale disasters because their measured impact was less than 1% of the total despite the fact that the occurrence of these kind of events represent more than 99% of total events

recorded. Figure 38 shows the cumulative percentage of deaths and missing people from natural disasters occurring between 1914 and 2013. It can be noted that 25% of deaths and missing persons was registered up to 1984 and that only in 1985 the cumulative percentage raises dramatically up to 75%. This is due the volcanic eruption of *Nevado del Ruiz* in the Andean region that took place in 1985 and counts as the largest disaster ever to happen in Colombia regarding deaths and missing persons. The lava mixed with mud and melting water coming from the glacier above the volcano literally eliminated the town of *Armero* from the map. Similarly, it can be noted that 14 years later (in 1999), there is another significant increase in the cumulative percentage. A 6.4 magnitude earthquake occurred in the coffee region, hitting the city of *Armenia* primarily, causing a 5% increase in the total number of deaths and missing persons. Finally, as the chart shows, the increasing trend remains fairly constant up to 2013, indicating that the volcano eruption in 1985 and the 1999 earthquake are the disasters that have caused the largest number of deaths and missing persons in the history of Colombia.

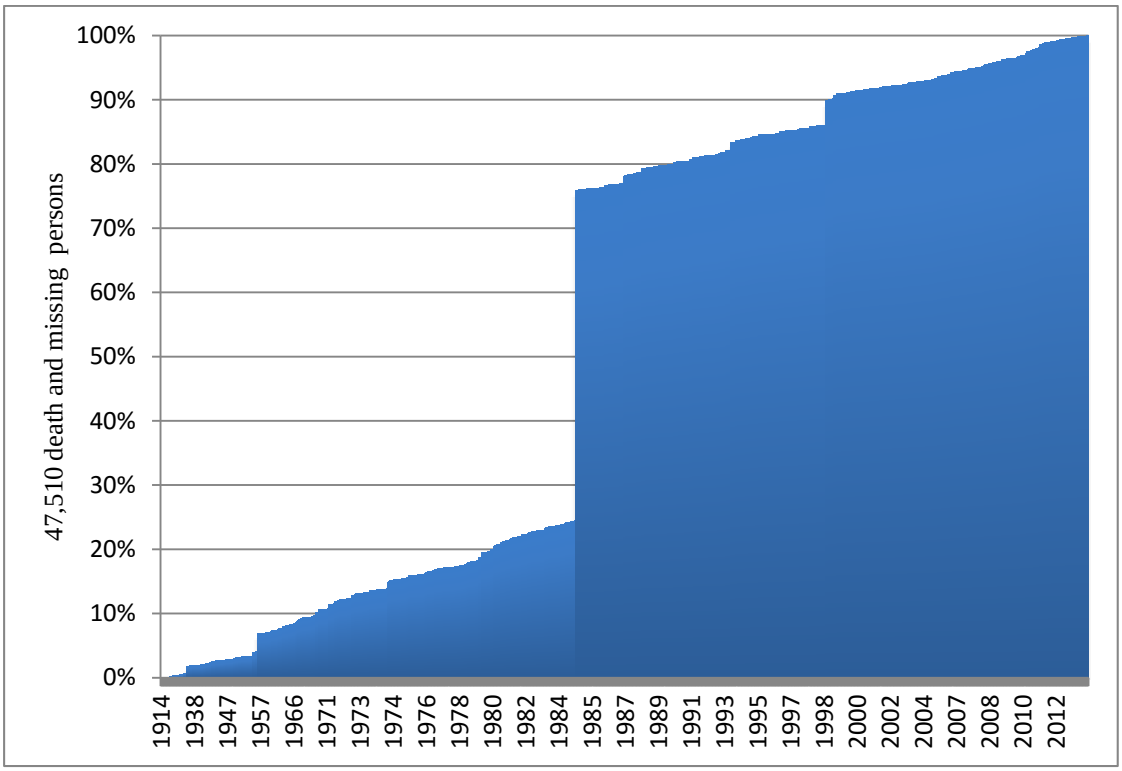

Figure 38. Cumulative of deaths and missing from natural disasters in Colombia

Using a similar approach for discovering which disaster events have impacted the largest number of people, and caused the most injured, evacuees, "affected", "victims" and relocated persons, Figure 39 shows that the years presenting a significant change in the overall trend are 1985, 1999, 2010 and 2011. These are: the 1985 volcano eruption and the 1999 earthquake, causing more than 1% of total impacted people of Colombian disaster history; and the 2010 and 2011 floods triggered by *La Niña*, together representing about 14%. These floods impacted the largest number of people in Colombian history.

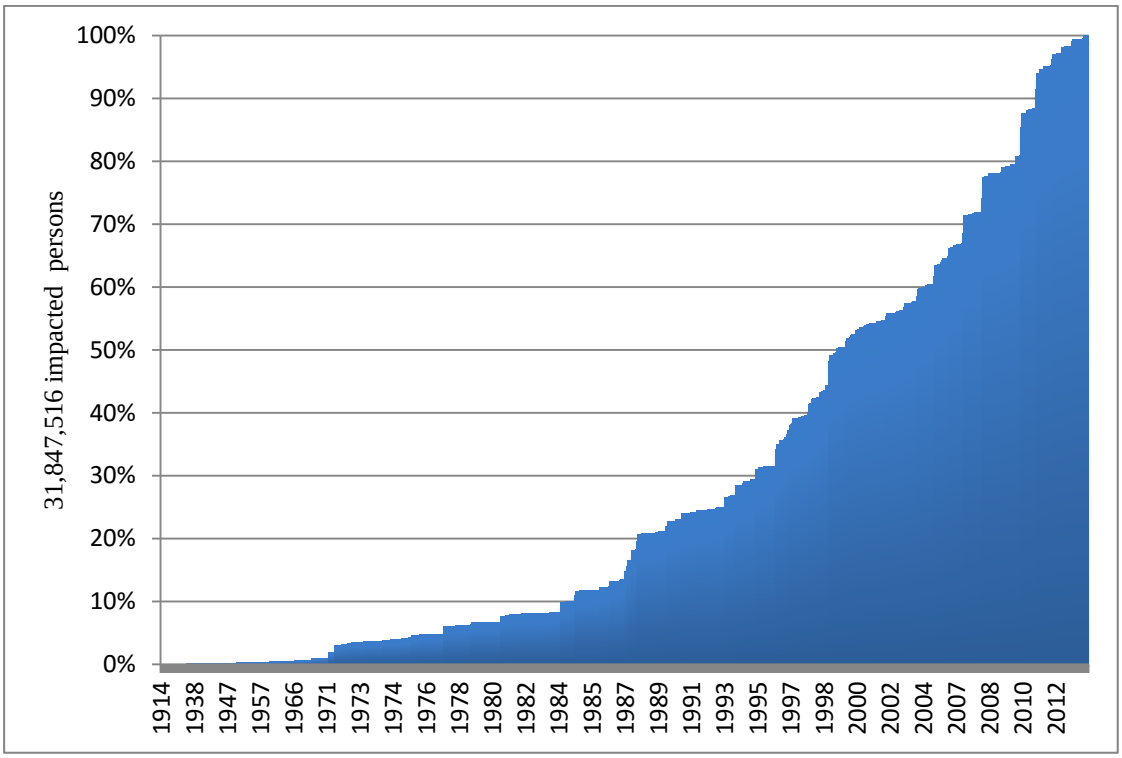

Figure 39. Cumulative of the impacted by natural disasters in Colombia.

Figure 40 and Figure 41 below illustrate how the 2010 and 2011 floods are the disasters that have affected the largest number of homes, accounting for about 40% of the total homes affected throughout the time period analyzed. In relation to the homes destroyed, the 1999 earthquake far surpasses other disaster events, accounting for 17% of total homes destroyed ever by a disaster occurring in Colombia. Indeed the 1999 earthquake is the disaster triggering the largest number of homes destroyed.

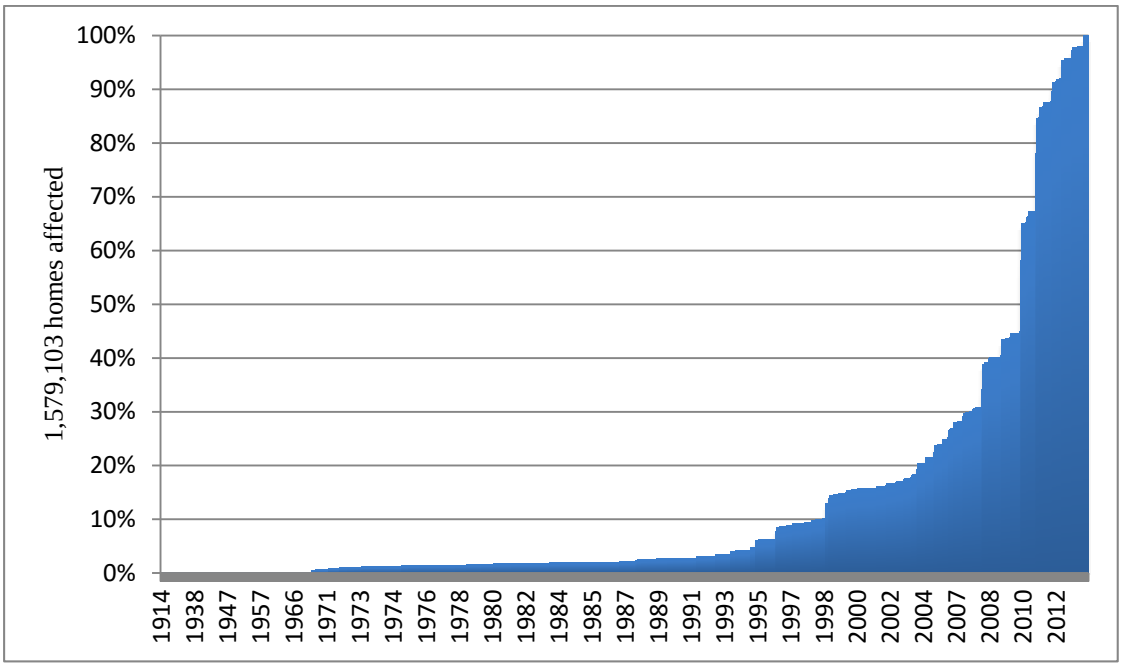

Figure 40. Cumulative of homes affected by disasters in Colombia

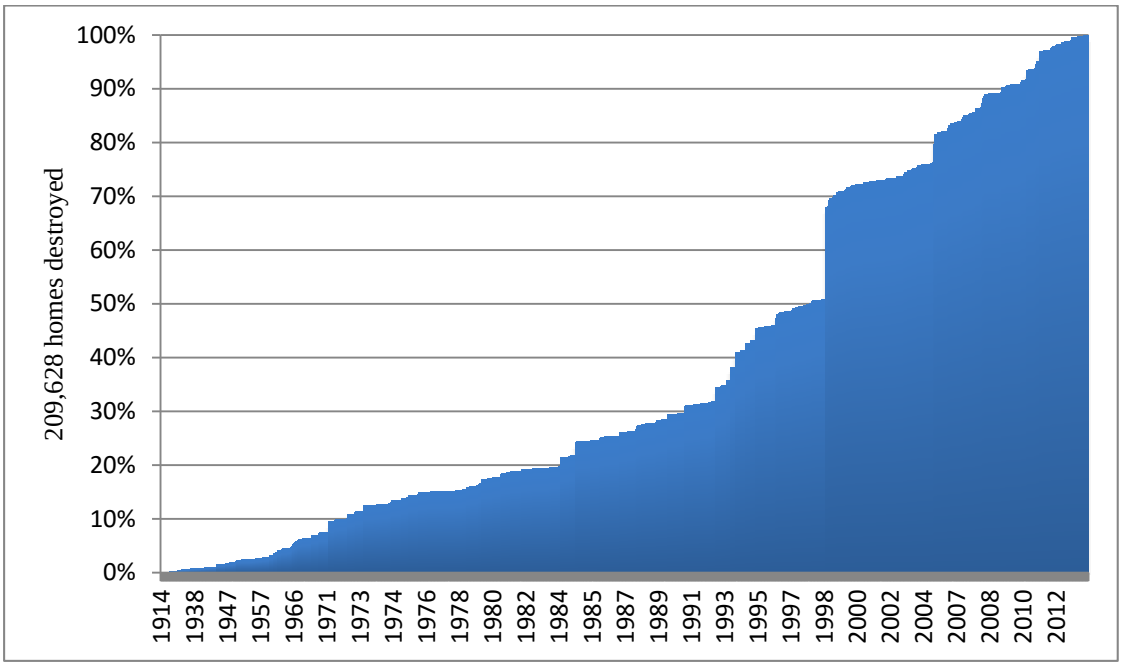

Figure 41. Cumulative of homes destroyed by natural disasters in Colombia

Table 16 summarizes the largest disasters identified for each indicator analyzed and contrasts such disasters with the rest of disasters, which are categorized here as small-scale disasters, given that they represented less than 1% of the total amount of each indicator when counting more than 2,570 disasters records available in the database (this is more 99% of the total disaster records). Care should be taken when contrasting the disasters events summarized Table 16 due to the nature of the disasters in question. The 1985 volcano eruption and 1999 earthquake were sudden onset, devastating events that required immediate humanitarian operations in response to the needs of the population impacted in two specific locations: these are *Armero* and *Armenia*, respectively. Conversely, the 2010 and 2011 floods were disaster events triggered progressively by a common triggering agent: the *La Niña* phenomenon. Lasting for several months, the rain flooded riverside towns and plantations, which were impacted over time. However, several devastating sudden landslides also took place, and were triggered by the same phenomenon. In either case, regardless of the number and extent of separate and specific disaster events that these agents triggered at different locations across the country, it is worth distinguishing the nature of the triggering agent and the disaster itself when comparing to previous large-scale disasters.

Table 16. Large and small-scale disasters in Colombia

Type of event	**Volcano eruption (1985)**		**Earthquake (1999)**		**Floods, torrential flows and landslides (2010-2011)**		**Small scale disasters (1914-2013)**	
	#	%	#	%	#	%	#	%
Deaths and missing people	24,442	51	1863	4	876	2	20,329	43
Impacted people	234,124	0.70	161,118	0.50	4,334,687	14	27,117,686	85
Homes destroyed	5,402	3	36,029	17	12,307	6	155,890	74
Homes affected	NA	NA	43,504	3	651,486	41	884,113	56

Although Figure 42 and Figure 43 demonstrate that floods and landslides are the hazards that have triggered the most disaster events in Colombian history, Figure 44 illustrates that floods alone have significantly caused the largest number impacted by a natural disaster in Colombia, again, mostly due to the events occurring in 2010 and 2011.

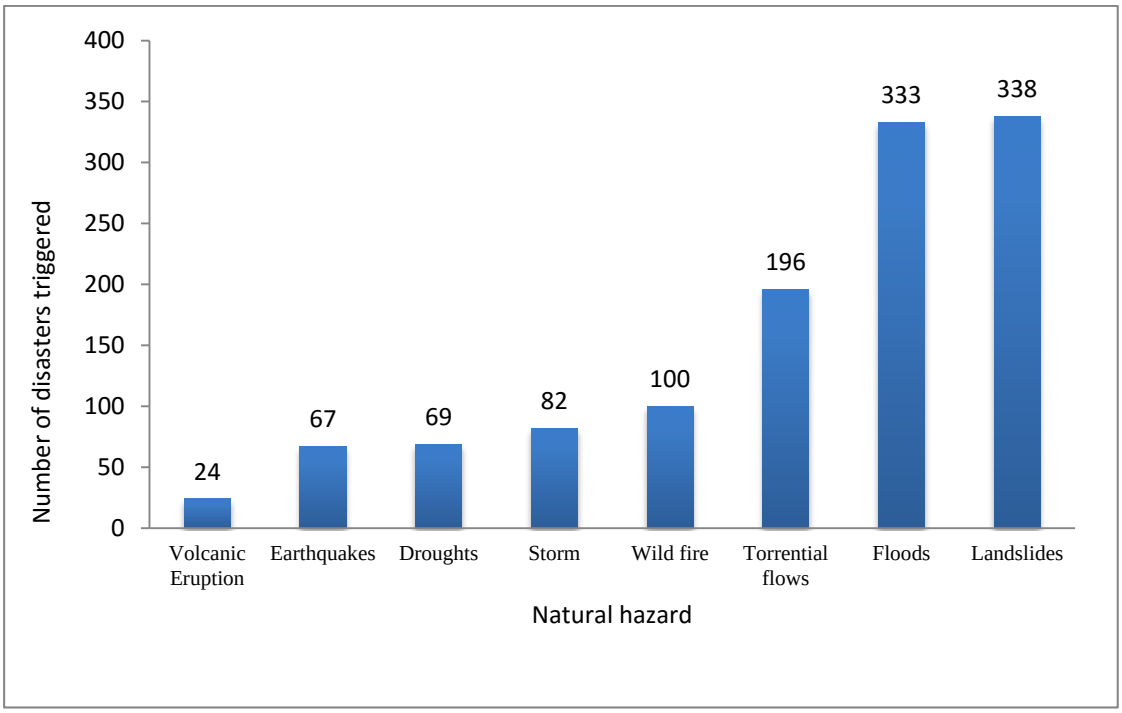

Figure 42 Frequency of disaster events by natural hazard between 1914 and 2013

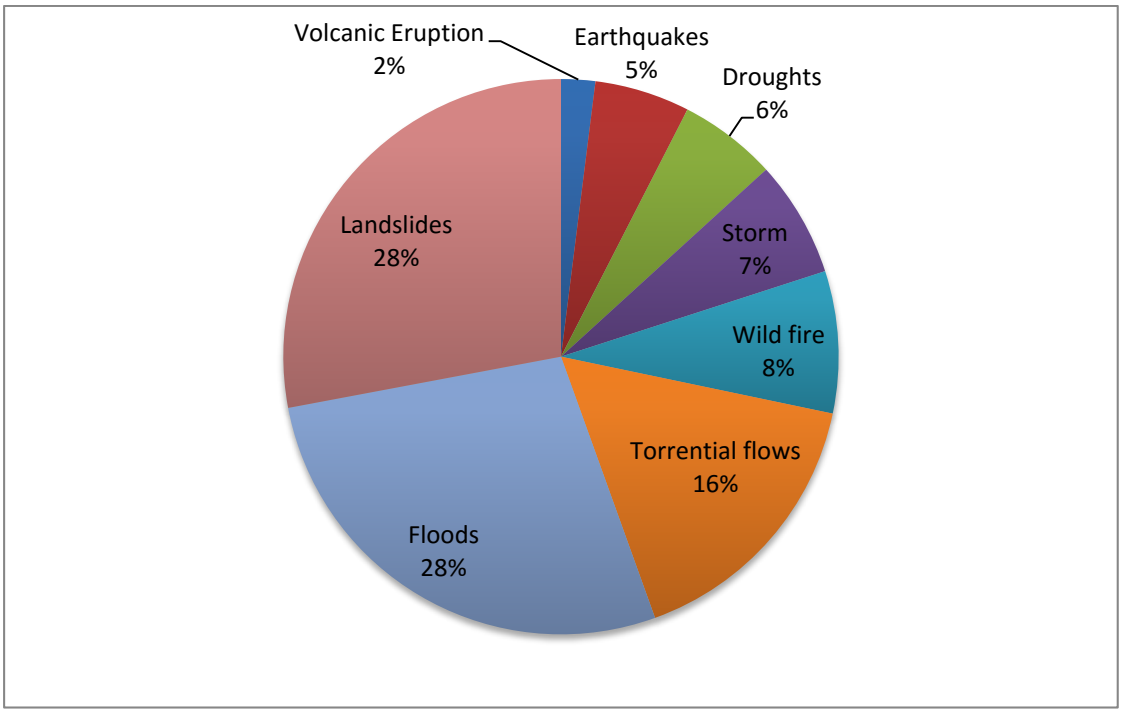

Figure 43 Frequency of disaster events by natural hazard between 1914 and 2013 (percentage)

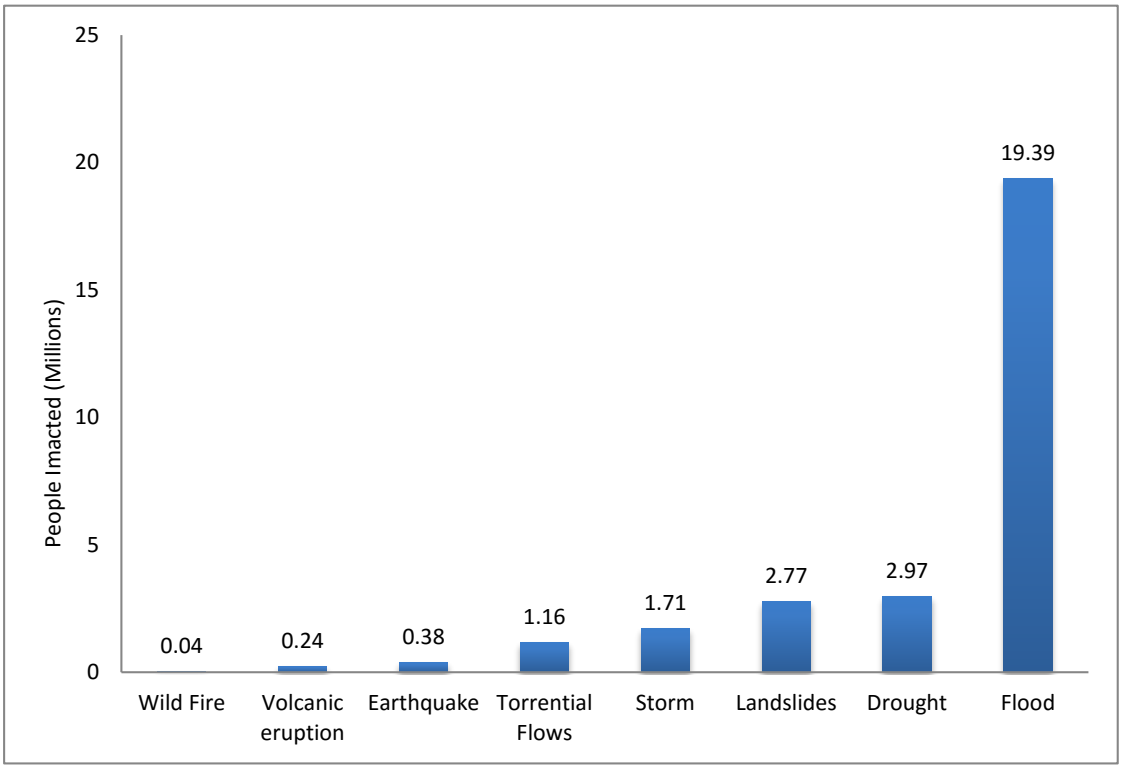

Figure 44 People impacted by natural hazards between 1914 and 2013

8.2.1 Large Scale Disasters Likely to Come from Natural Hazards in Colombia

This subsection draws on technical reports from practitioners that state the significance of natural disaster events in Colombia. The sources have been selected as they present alternative indicators and standard international indexes that help better contextualize the natural disaster frame in Colombia

Table 17 shows the average number of disaster per year by type (UNISDR, 2013). Originally sourced from the same data repository addressed in the introduction of section 8.1, this index has been internationally standardized by the UN. In the case of Colombia, flooding is the natural disaster type to occur most often, according to

historic records. Most likely correlated with floods, wet mass movements are the second more frequent type to occur, followed by earthquakes.

Table 17. Average disaster type per year

Type of Event	**Incidence per year**
Flood	1.71
Mass movement, wet	0.77
Earthquake	0.48
Volcano	0.32
Storm	0.19
Wildfire	0.1
Mass movement, dry	0.1
Epidemic	0.06
Insect infestation	0.03
Drought	0.03

In Colombia, weather-related disasters are strongly correlated with *El Niño* Southern Oscillation (ENSO) episodes (UNISDR, 2013). *La Niña* has hit the country in the past four decades triggering slow on-set floods in 1973-1976, 1988-1989, 1998-2001 and 2010-2011. However, the floods in the latter period ended up causing the greatest losses among *La Niña*-related floods in terms of people impacted and damage to housing.

The United Nations' report also discusses the features of the population typically impacted by disasters regarding the geographic dispersion. Table 18 characterizes the proportion of the population impacted in rural municipalities,

explained by the rural index[4] and the Unsatisfied Basic Needs percentage index[5]. Among the inhabitants whose unsatisfied basic needs index exceeds 56%, rural inhabitants (rural Index between 50 and 75) represent almost twice as urban inhabitants (rural index between 50 and 75) impacted. In other words, the largest population with the highest unsatisfied basic needs happened to be rural prior to the disaster.

Table 18 Disaster-impacted inhabitants (per 10,000 inhabitants) in urban and rural areas with unsatisfied basic needs (expressed by UBN index) during the 2010-2011 floods in Colombia

Unsatisfied Basic Needs (UBN)		**<=27%**	**27< UBN <=41**	**41<UBN<=56**	**>56%**
	Rural Index				
Urban	1-25	144.05	976.17	314.12	0
↕	25-50	607.91	772.63	1,926.43	2,718.05
	50-75	724.18	1,082.98	1,686.34	5,086.53
Rural	75-100	0	150.98	34.73	794.8

(Source: (UNISDR, 2013)

Subsection 8.2 presents the foundations to conclude on the demand characterizations of most common large-scale natural disasters in Colombia from an original content analysis approach. These foundations will draw the feasibility of the hypothetical natural disaster demand scenarios presented in the subsequent sections later in this chapter.

[4] Rural populations are defined here using an Index of Rurality based on population density and the distance between smaller rural and larger urban centers

[5] Common index used to measure poverty in terms of access to clean water, quality of housing, crowding, education level, school attendance, nutrition, and others

8.3 Hypothetical Scenarios

Historically, most humanitarian operations in Colombia have responded to small-scale disasters. In fact, the relief networks (RN) characterized in Chapter 5 are poorly connected to aggregate humanitarian logistics (HL) capabilities responding to large-scale disasters. Hence, this section develops hypothetical disaster scenarios that aim to capture the features of past large-scale disasters in terms of onset, impact and location; that is, although hypothetical, the disaster scenarios that fit, as much as possible, with potential disasters. These disasters are at least as severe as the disasters that have impacted the largest number of people and caused the greatest demand for food aid in Colombian history.

Several observations are taken into consideration:

- The 2010 and 2011 floods have caused the largest impact in terms of people in need of humanitarian aid in relation to national disasters,
- In terms of types of hazards, floods have triggered the most recurrent disasters in Colombian history,
- Both flooding, as a natural disaster, and armed conflict can be represented as a hypothetical disaster scenario with the characteristic of slow onset.

With respect to natural disasters, the hypothetical scenario is drawn from typical floods associated to the *La Niña* phenomenon that impact rural populations located in multiple provinces in the country concurrently. With respect to the armed conflict, the hypothetical scenario is defined as a region where a significant number of IDPs are still being supplied with food aid from different organizations as a humanitarian response. Generically, the hypothetical disaster scenarios also comply

with the following features of the demand for food aid that have been highlighted in the descriptions of past disaster events in previous subsections:

- Most of the impacted population is now located at rural areas, implying that a large number of small and spread-out demand nodes will prevail over a small number of large and condensed demand nodes.
- Flooded areas located in provinces typically described as disaster prone.
- Flooding regularly takes place in areas where there is a significant number of individual displacements due to the armed conflict.
- The estimated impacted population for the natural disaster scenario would be at least as large as the number of people impacted by the 2010-2011 floods.
- The estimated impacted population for the armed conflict scenario would be as large as the estimated IDP population located in the flood disaster areas that are addressed in the natural disaster hypothetical scenario.
- Impacted population in both scenarios is expected to completely lack food supplies right after the disaster hits the area.

Likewise, the humanitarian response structures, defined in Chapter 5 and Chapter 6, face the following challenges when deploying food aid distribution to such hypothetical disaster events:

- Although local food aid distribution to impacted areas may be constrained by disrupted road transportation, this is the only means considered for last mile distribution deployment.
- Given the magnitude of size and number of demand nodes, as well as the fact that among the impacted people there are also IDPs, both humanitarian response

structures may be aggregated in all hypothetical scenarios to create synergistic response capabilities.

- Supply nodes located both outside and inside the disaster area may serve demand nodes within the disaster area.

8.3.1 Armed Conflict Disaster Scenario

In order to keep both hypothetical scenarios aligned, the IDP population taken into consideration is also located in the Caribbean region in Colombia. This region holds about 30% of IDPs officially registered as “victims” from 1985 to 2014. Although it is not known how many of these IDPs still demand humanitarian aid from the humanitarian sector, the humanitarian aid demand in this hypothetical scenario is drawn from the actual dataset displaying the IDPs who did receive humanitarian aid when they registered as “victims” of a displacement event, which was entered in the database from 2004 to 2014. The following are important considerations taken into account when drawing the hypothetical scenario on the real dataset:

- Timing of the events – The hypothetical scenario for a large-scale disaster in the region assumes that the maximum number of IDPs demanding humanitarian aid in any year between 2004 and 2014 in each of the municipalities can occur at the same time. This is equivalent to all displacements registered throughout the year holding the largest total IDPs between 2004 and 2014. This way, it is assumed that the sum of all internal displacement events registered in each particular year and town represent the total population in need of humanitarian aid to be supplied in the hypothetical scenario. The dataset presents municipalities, geo-location and total population taken into account. Assuming all these displacement events happen concurrently in spite of the one year-town

selection, the hypothetical scenario would not only be considered a large-scale one, but also draws on realistic magnitudes derived from aggregation of the worst scenarios drawn from historical data.

- Population impacted – As Figure 45 illustrates, a total of 201,574 people were counted in the 195 demand points of the actual database for the entire region as being IDPs. However, only a subset of 35,732 impacted people spread-out in just 46 demand points in the region was identified as needing humanitarian aid, as Figure 48 illustrates.
- Time frame for the distribution of aid – It is assumed that although the selected population have the right to access food aid continuously until their IDP status is over, only immediate food supply would be provided when running the simulation.

Location of impacted population – The location and magnitude of the humanitarian aid demand nodes can be seen in Figure 45, Figure 46 and Figure 47 below. Figure 45 represents demand spots classified by ranges of people impacted, where the darker the symbol the higher the population. Additionally, Figure 46 represents the point density (percentage of average density), which refers to the concentration of demand spots and their locations in a 10 km radius, as opposed to number of people impacted. Similarly, Figure 47 represents demand by population density, which refers to the concentration of people and their locations in a 10 km radius.

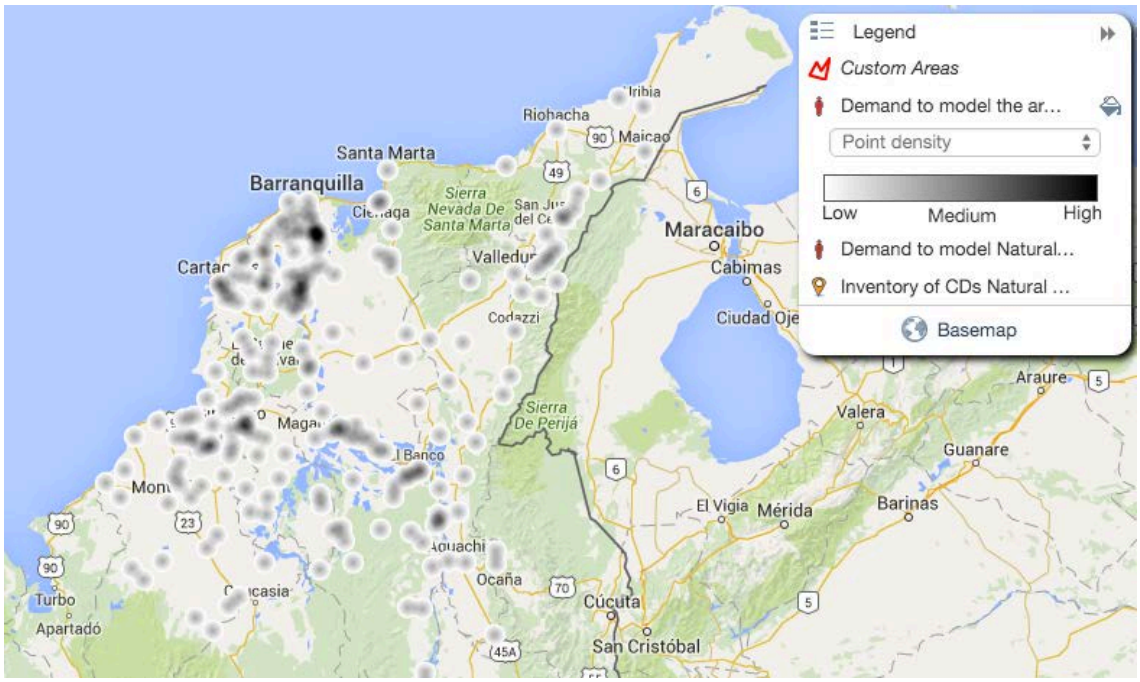

Figure 45. People impacted: Armed conflict hypothetical demand

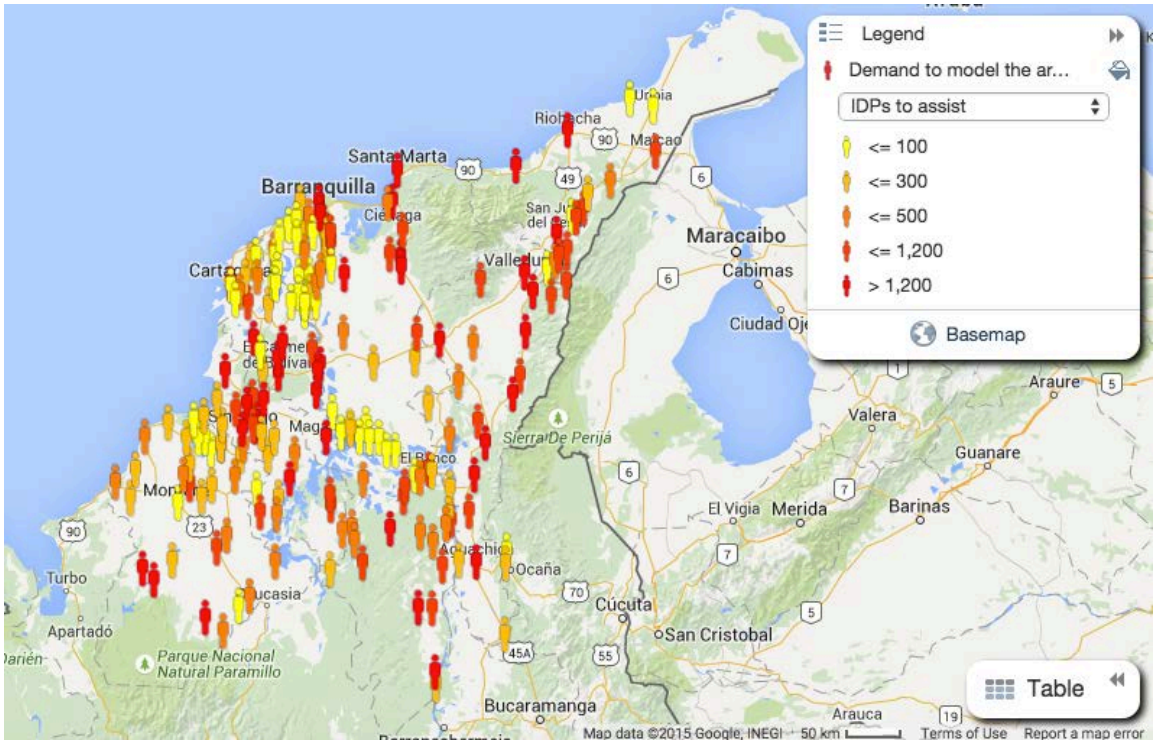

Figure 46. Demand by point density: Armed conflict hypothetical scenario

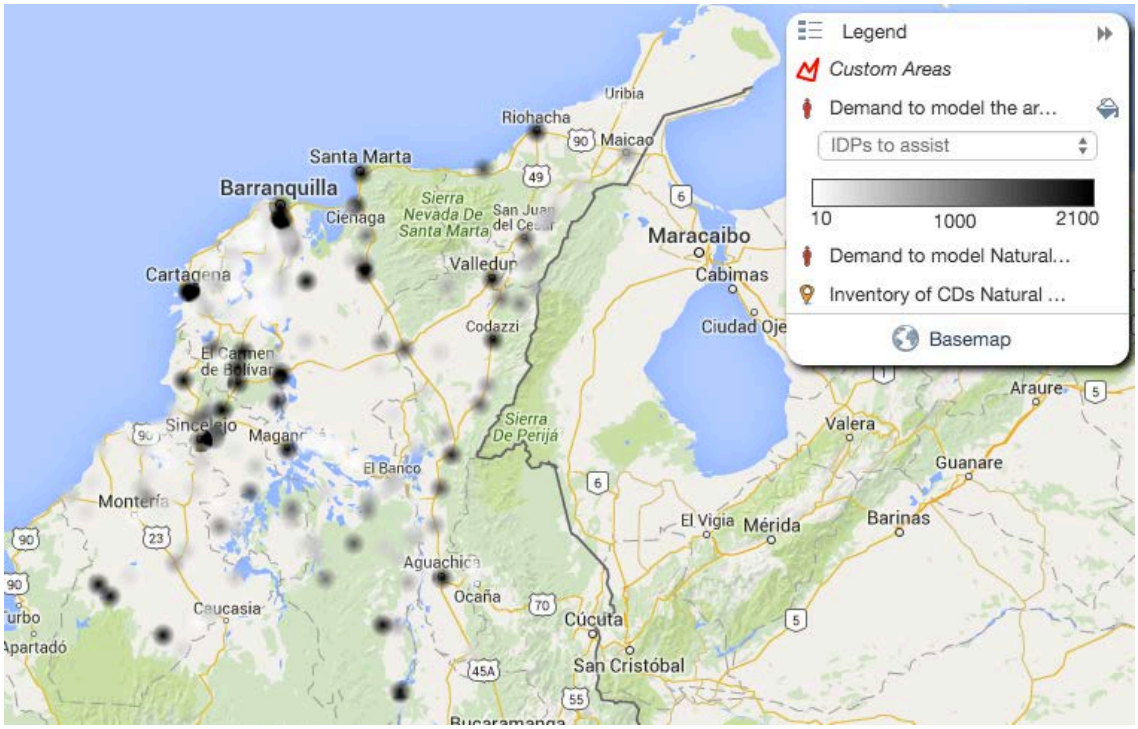

Figure 47. Demand by population density: Armed conflict hypothetical scenario

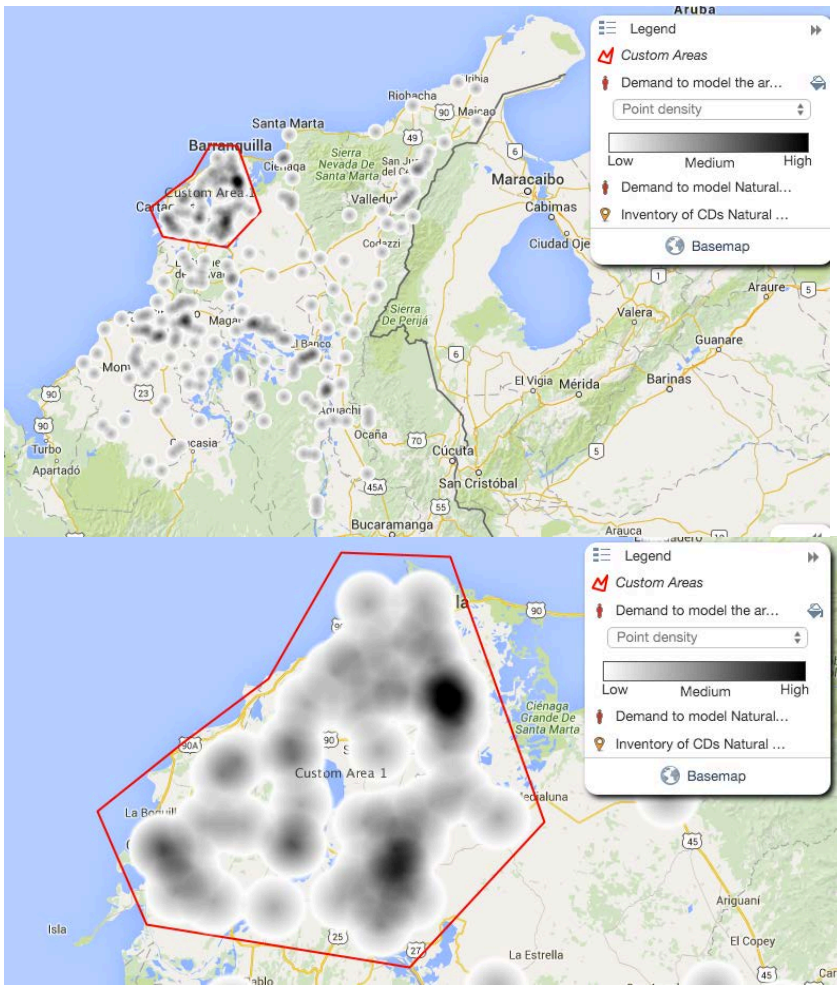

Figure 48. Selected population: Armed conflict hypothetical scenario

8.3.2 Natural Disaster Scenario

Given that the Caribbean region in Colombia is the most vulnerable to floods due the *La Niña* phenomenon, a dataset drawing from the flood events registered in 2010 and 2011 serves as the foundation for building the natural disaster hypothetical scenario. The region is comprised of the provinces of *La Guajira, Cesar, Magdalena, Bolivar, Atlántico, Cesar* and *Córdova*. The following are important considerations taken into account when developing the hypothetical scenario from the real data:

- Timing of the event - The disaster event that impacted the largest population in each municipality is identified and all these events are assumed to occur at the same time. In reality, many of these events may not have occurred at the same time. Also, a particular municipality within these provinces may have had experienced more than one significant flood event throughout 2010 and 2011, but only one event for each municipality is included in the hypothetical scenario.
- Population impacted – A total of 1,406,844 people are impacted based on the database of actual events for the entire region. Of these, a subset of the 313,519 impacted people were purposively and conveniently selected as a manageable size to run the analytical model.
- Geographic location – These 313,519 people were selected based on the concentration in a specific area, where not only the demand point density and large populations impacted were abundant, but also where the mapping with GIS showed close proximity to populations also impacted by the armed conflict.
- Speed of onset – Still, in order to maintain coherence and validity in the dataset, the hypothetical disaster scenario is assumed to be a slow onset event. Rain from the *La Niña* phenomenon is not torrential. Rather, precipitation events are long lasting throughout the day but small in quantity, permitting timely evacuations but creating the need for humanitarian aid for the population impacted.
- Experience with disasters – Much of the population identified from the dataset for inclusion in the hypothetical scenario has been impacted by

flooding due to rain from the *La Niña* phenomenon. Similarly, the humanitarian aid sector in Colombia responded individually to these disasters as specific floods were taking place throughout 2010 and 2011 in the region.

- Distribution of impacted population – The populations impacted are spread out along 1,600 km of shore. The hypothetical scenario also assumes continuous and uniformly distributed precipitation over this region concurrently impacting the population of the Cauca and Magdalena Rivers and their tributaries flood surrounding areas.
- Time frame for the distribution of aid – It is assumed that in a matter of 3 weeks, the humanitarian sector is able to respond to 313,519 people in the need of humanitarian aid.
- Location of impacted population – Specifics on the location of the nodes representing the demand for humanitarian aid where the populations impacted are located can be seen in Figure 49, Figure 50 and Figure 51 below. Figure 49 shows demand spots classified by ranges of people impacted, where the darker the symbol, the higher the population. Additionally, Figure 50 represents the point density (percentage of average density), which refers to the concentration of demand spots and their locations in a 10 km radius, as opposed to number of people impacted. Similarly, Figure 51 represents demand by population density, which refers to the concentration of people and their locations in a 10 km radius

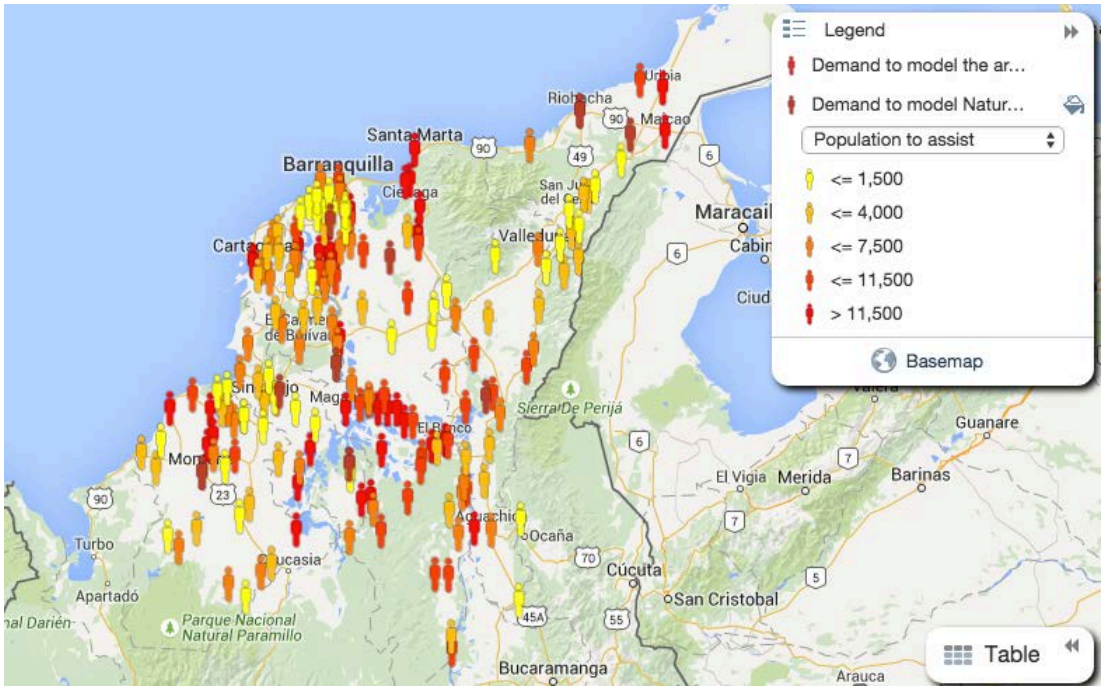

Figure 49. People impacted: Natural disaster hypothetical scenario.

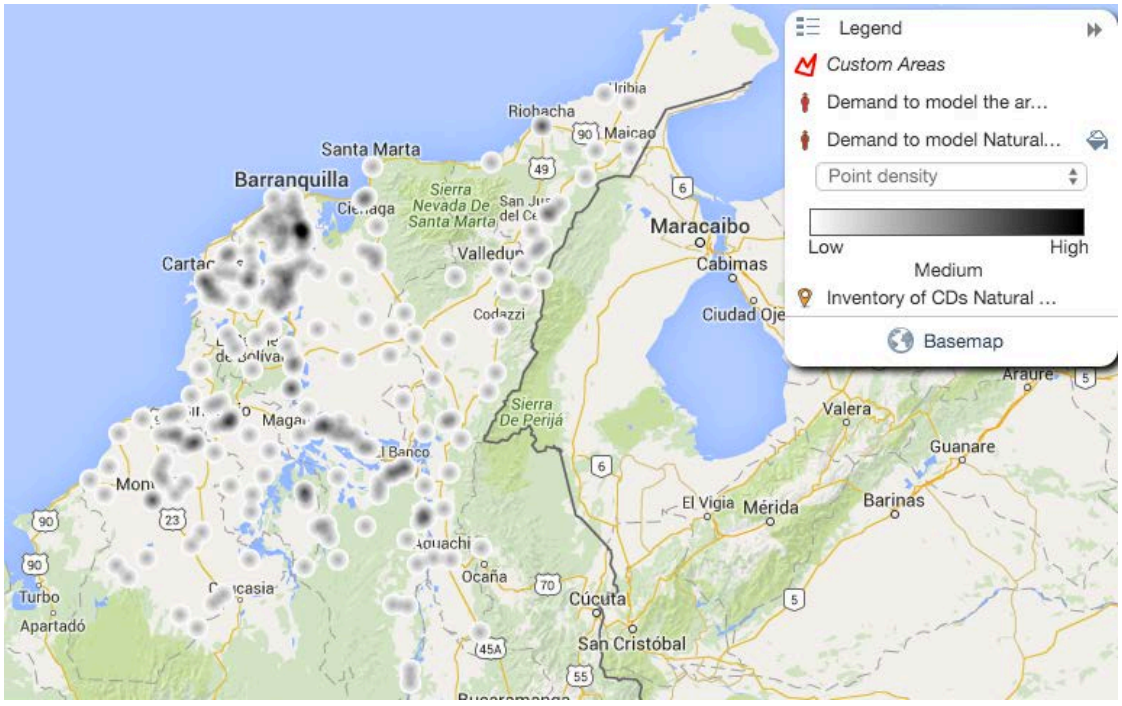

Figure 50. Demand by point density: Natural disaster hypothetical scenario.

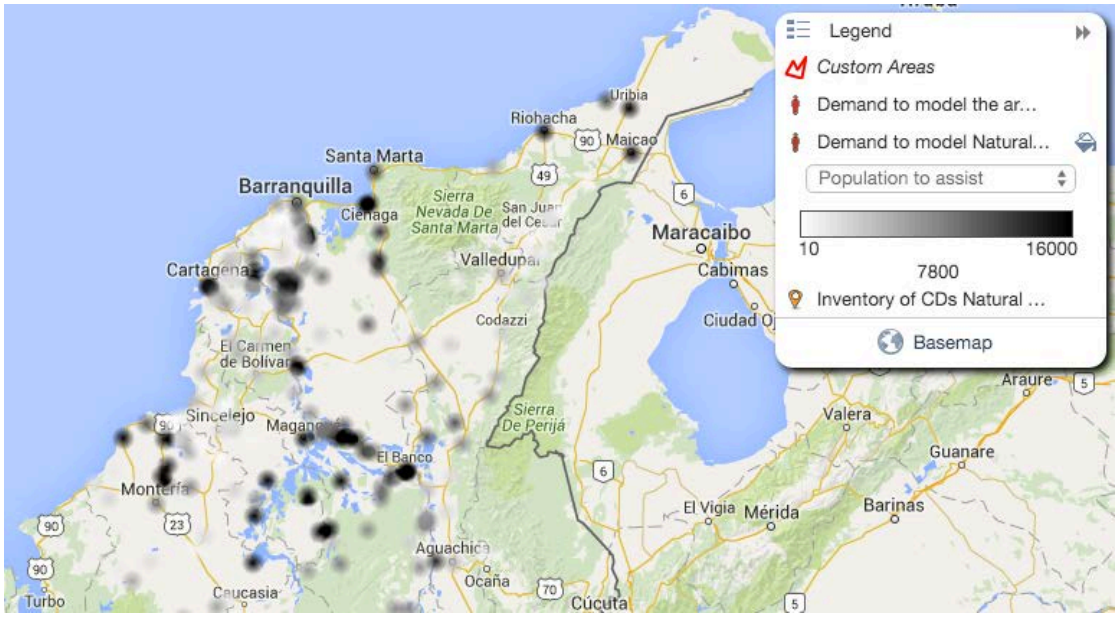

Figure 51. Demand by population density: Natural disaster hypothetical scenario

- Location of the subset of the population impacted for the analytical model – The 313,519 impacted people represented in the analytical model can be seen in Figure 52. These records were purposively selected to match a sub-region that had the following: multiple demand spots, many of which many contained the largest populations, multiple demand spots also corresponding to spots of people impacted by the armed conflict, and, were spread-out in a 10 km radius. In addition, these records were conveniently selected to decrease the scale of analysis from 180 records, representing demand for 1,406,844 people, to only 46 records representing the ultimate 313,510 people selected. This avoided having technical conflicts when coding and running the analytical model in terms of restrictions of the optimization software. Thus, the simulation took place using a single cluster to permit experimentation with the results while

serving as an approach for segmentally targeting the entire region in future research.

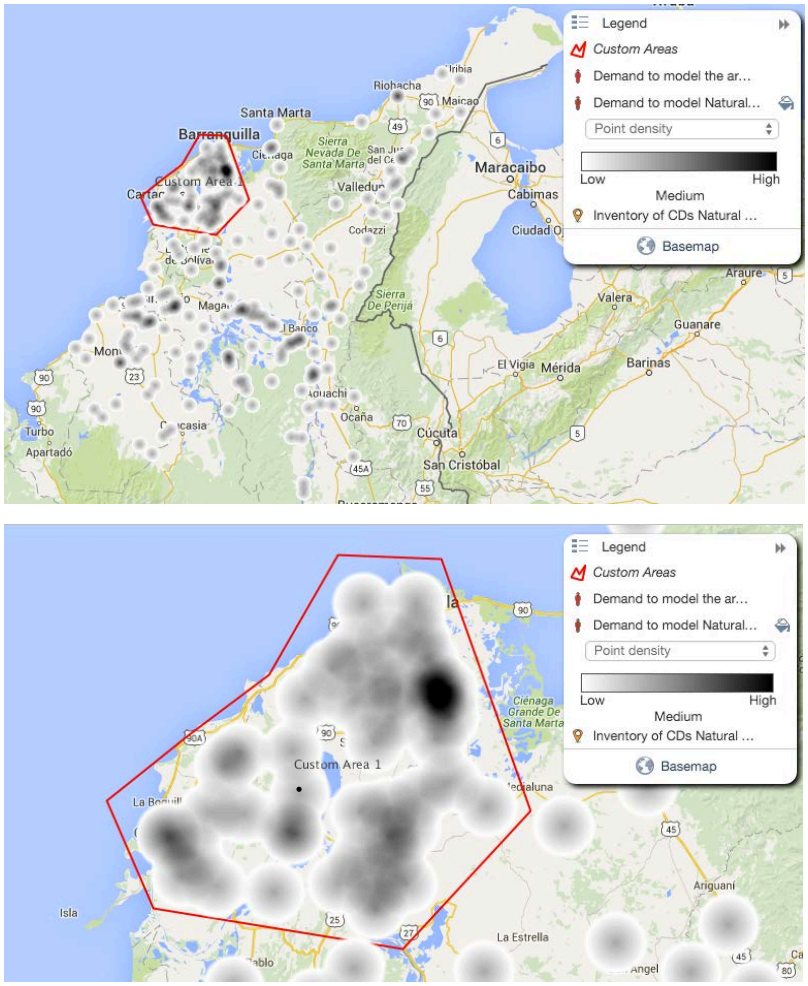

Figure 52. Selected population: Natural disaster hypothetical demand

8.4 Assessment Instrument

In order to quantify potential improvements from the suggested humanitarian logistics structures, an analytical model based on the work of Perez (2011) is implemented to represent humanitarian logistics operations. Specifically, the analytical model is intended to serve as a tool to quantify the impacts of each item in

an inventory of allocation decisions for post-disaster operations where an external (deprivation) cost component is added to conventional logistics operational costs. The model minimizes the total social costs represented by the operational and deprivation cost. The consideration of deprivation costs in the decision-making process for a distribution strategy gives representation to the loss in welfare associated with beneficiaries not having access to critical commodities on a timely basis, which is not normally internalized by the agencies or organizations delivering supplies to the population in need. Following Pérez (2011), this dissertation argues that it is necessary to incorporate deprivation costs in the formulations for humanitarian logistics in order to more realistically capture the social costs and benefits associated to the relief operations.

As documented in Appendix I, the analytical model comprises of a mathematical structure that seeks to optimize (minimize) an objective, which in this case is the total social costs (sum of deprivation costs and delivery costs). When mathematically defining an optimization model, a group of constraints usually represent the commands the modeler wants the analytical model to limit the values that variables can take as a representation of the realistic constraints the actual problem demand. Particularly, Pérez (2011) model defines ten constraint sets, which realistically aim to:

- Capture the minimum value allowed for the deprivation time experienced up to the first delivery to a given demand node or population impacted.

- Capture the minimum value allowed for the subsequent deprivation times experienced after the first delivery to a given demand node or population impacted.
- Total the deprivation costs as a function of a deprivation cost function, the number of deliveries and the population in need.
- Capture a minimum quantity of commodities to ship as a function of the time the delivery aims to serve, the consumption rate and the population in need.
- Capture a maximum quantity of commodities to ship as a function of the maximum vehicle capacity.
- Capture the maximum transportation times as a function of the vehicles needed and the planning time horizon over which the continuous commodities' distribution have to take place.
- Capture the maximum amount of commodities to ship as a function of the total inventory available at the distribution center.
- Ask the model to suggest at least one delivery to each demand node or population in need.
- Ask the model to determine whether the deprivation time after the first delivery is zero (ideal case) or larger, as well as deprivation costs, amount of commodities to ship per delivery to be at least zero.

8.4.1 Limitations and Strengths

The analytical model is developed from the perspective of organizations active in the immediate response to disasters, in which planners usually have to decide the amount and timing of any shipments to the impacted areas. Although the analytical model is actually a tool to make such decisions, certain limitations apply when attempting to assess the performance of the policy recommendations achieved in Chapter 7. First, the convergence of multiple supply chains to a disaster site at a system level involving multiple responders is considered by the model as a chief assumption. In this respect, since the humanitarian logistics structures suggested aim to evaluate a synergistic performance among supply chains from the two response systems, additional assumptions are inherent in the work as a result of the creativity of this research. In fact, according to Holguín-Veras et al (2011), agencies like the Volunteer Organizations Active in Disasters (VOAD) and the United Nations Joint Logistics Center (UNJLC) have emerged to exploit potential synergies and reduce redundancy, affirming that the coordination of multiple supply chains remains a major issue in the response to extreme events. Second, the model focuses on the lower end (downstream) of the humanitarian supply chain, the so-called "last mile" fragment of the distribution subsystem comprising a local distribution center or staging area and the demand points at the disaster area. Third, it is assumed that because of the data collection process from Chapter 5, the following data are available to run the performance assessment:

- Distribution center locations and initial inventory levels.
- Vehicle fleets including number and type of vehicles.

- Transportation networks including connectivity and link attributes (for example, location of demand and supply nodes, length, and travel time).
- Estimates of the number of beneficiaries: i) The amount and type of goods needed (consumption rates) and the resources initially available; ii) Initial deprivation time; iii) Deprivation costs (ideally, an empirically derived deprivation cost function).

On the other hand, as explained at the end of section 2.4, the analytical model developed by Pérez (2011) is a strong candidate over other optimization models also tackling the inventory allocation problem, mainly due to its novel component of deprivation costs in the objective function to minimize.

8.4.2 The Decisions to Be Made

By evaluating multiple demand scenarios linked to representation of different supply structures and allocation strategies suggested in phase IV when running the model, decisions involve the following variables either partially or completely:

- Amount of commodity type shipped by road transportation from the distribution center to a demand point.
- Number of deliveries over the planning horizon to a specific demand node.
- Inventory level, i.e. amount of food aid kits carried over the planning horizon to a specific demand node.
- Deprivation time experienced at a specific node.

- Total deprivation cost.
- Total delivery cost.
- Total social cost.

Scenarios under evaluation are expected to vary according to:

i) Natural disaster and armed conflict demand: the estimated beneficiaries of each disaster type pull the food aid demand disconnectedly.

ii) Multiple supply structures: Different locations of supply nodes and networks configurations serves as another source of sensitivity

8.4.3 Input Parameters and Outputs

Table 19 documents the inputs related to demand and supply parameters that feed the analytical model when performing the simulations with all the supply scenarios considered.

Table 19. Demand and supply input parameters

Parameter	Interpretation
Travel time between demand node and the DC	Time in minutes it takes for vehicles to move between supply and demand points
Initial deprivation time at specific node	Time (hours) beneficiaries hold with no food access until their humanitarian needs are detected.
Initial inventory available at demand node	Number of food aid kits available at demand points right before the very first food aid kit is handed
Initial inventory available at supply node	Number of food aid kits available at supply nodes (warehouses or the like)

Parameter	Interpretation
	right before the next delivering time horizon is planned.
Number of time periods satisfied by a full serving of supplies	Time in days for which a food aid kit is fully consumed
Population at specific node	Number of persons to be supplied at a specific demand node
Travel costs over planning horizon	Cost in Colombian Pesos (COP[6]) for a vehicle to move between supply and demand nodes during the planning horizon
Consumption rate (unit/person/hour)	Theoretical rate at which a food aid kit is consumed by a person/hour
Planning horizon (hours)	Time in hours for which the deliveries are indented to cover beneficiaries at a specific demand node
Maximum vehicle capacity (units)	Maximum number of food aid kits allowed to be loaded in a vehicle
Number of vehicles of the same size-Not limited	Number of vehicles of the same size available in the fleet

Table 20 documents the list of decision variables that shape the performance assessment of each scenario evaluated. Ultimately, such decision variables represent the results derided from running the analytical model. An interpretation of each output is also available on Table 20.

Table 20. Interpretation of outputs.

Output (results)	Interpretation
Deliveries	Number of deliveries derived from the inventory allocation strategy over the planning horizon to a specific demand node
Quantity per delivery	Number of food aid kits to load in each delivery

[6] $1 US = $3,200 COP

Output (results)	Interpretation
Deprivation time experienced	Time in hours it takes for the beneficiary waiting for the first food aid kits to be handed from the very first time the humanitarian needs were detected
Deprivation time experienced	Time in hours beneficiaries wait for the next food aid kit to be handed after the first delivery had taken place.
Deprivation cost for the particular demand node	Representation of the cost derived from beneficiaries not accessing food during deprivation times at a specific demand node
Total inventory at DC	Number of food aid kits needed in the inventory allocation strategy during the time horizon set
Total delivery cost	Logistics (transportation) costs associated to whole allocation strategy
Total deprivation cost	Sum of the representation of the cost derived from beneficiaries not accessing food during deprivation times at all demand nodes
Social Cost	Sum of total delivery cost and total deprivation cost.

8.4.4 Assumptions Made

Running the analytical model using the input parameters derived from the hypothetical scenarios implied some important assumptions despite the fact that these scenarios are drawn on realistic foundations. The following assumptions are attached either by default from the original model or by a particular feature of the scenarios.

- The group of multiple food aid suppliers from the private sector, which are typically contracted by the UNGRD and the UARIV, will be represented as a single supplier when running the analytical model. In other words, given that the analytical model requires a single supply node to provide food aid to multiple demand points, and given the significance distance between *Bogotá*, the city where most of the suppliers are located, and the Caribbean region selected (800 km), all

suppliers together represent a single supplier with unlimited storage and transportation capabilities.

- A similar assumption is made in some particular scenarios when assuming that all private food aid suppliers are located in Barranquilla, the largest city closest to the impacted area (200 km).
- All demand nodes have no food aid inventory available right after the disaster takes place.
- Travel costs are estimated drawing on the official rates of freight transportation in Colombia. Still, it is assumed that travel cost set includes the vehicle's cargo loading and unloading cost as well as an average of waiting for loading and unloading cost.
- Food aid kits are configured to feed a family of five members.
- The number of vehicles available of the same size is large enough to cover all transportation demand. In reality, this assumption is supported as both relief networks and HL structures either rely on private carriers and local community transportation capabilities.
- Initial inventory available at supply node is large enough to cover all beneficiaries at all demand points at all scenarios. Consequently, plenty of food aid is always assumed.
- Although the available trucks and inventory are assumed to be sufficient to fully satisfy all hypothetical demands, sensitivity analysis took place by testing the change in the social costs when changing the number of trucks and inventory of food aid kits at DCs. This way, it was possible to figure out the number of trucks and food aid kits above which the

social costs were no longer impacted. These values then served as inputs to explore final outcomes.

- There is no initial inventory available at demand nodes.
- Travel times implied an average speed of 5 miles/hour, which is consistent with the average speed at which Colombian roads allow freight vehicles to circulate.
- "Making a delivery resets the deprivation costs at the demand node, which will not start increasing again until the units delivered are consumed by the population at the node" (Pérez, 2011).
- Deprivation cost function, which is understood as the author defines it in the original model.
- The deprivation cost function is convex and nonlinear.

8.4.5 The Mathematical Model and Solution Method

The inventory allocation model developed by Pérez (2011) also features routing for last mile distribution. However, as stated in Chapter 3, only the inventory allocation model with point-to-point distribution is considered, as this portion of the model is extracted and implemented as the performance assessment instrument. The following paragraphs elaborate on the model to provide, descriptively and qualitatively, an understanding of the mathematical foundations of the model, whereas the model´s actual mathematical language and formulation is presented in Appendix I.

- A network consisting of a supply node (typically a distribution center) with known initial inventory from which food aid is distributed directly to a single or multiple populations impacted or demand node. Note that

point-to-point distribution implies that deliveries to each demand node can only be carried out from the distribution center in order to satisfy the demand of each impacted area or town. This means that there could be multiple travel times between the distribution center and each of the demand nodes.

- The objective of the decision maker is to determine not only the optimal number of deliveries but also the sizes of each delivery that minimizes total social costs over a planning horizon or the lapse aimed to guarantee the supply.
- The objective function minimizes social costs by considering both the total deprivation costs experienced at each demand node and the operational (delivery) costs of providing the needed food aid to the disaster areas
- Deprivation times are initiated in the model when the first delivery takes place, as well as when the subsequent deliveries do, and the former should be at least equal to the deprivation times initiated by the latter.
- Any delivery to a demand node should be large enough to meet the needs of all its population for at least *3* meals a day.
- The largest size of a delivery cannot exceed the maximum load vehicle capacity.
- The maximum number of vehicles available as well as the maximum inventory at a distribution center must be defined and service levels must be derived from these capacities.
- At least one delivery should take place to each demand node.

By taking the mathematical modeling developed by Pérez, an alternative AMPL (Algebraic Modeling Language for Mathematical Programming) code was developed to run the model as opposed to using the original code developed by Pérez, which essentially aimed to replace such original code not only to reproduce his numerical examples but also to make new runs. Then, by using a free, Internet-based service for solving numerical optimization problems (NEOS Server, 2014), specifically, MINLP (Mixed-Integer Non-linear programming) problems, the hypothetical scenarios were run one by one.

In order to assure validity in the developed code, which can be accessed in Appendix I, the first runs took place using the exact same input parameters and variables from the numerical example that Pérez used to obtain his model results. As expected, the outputs obtained from running the model using these input parameters exactly matched the outputs obtained by Pérez. Consequently, from this point on, the dissertation counted on a complete tool to start running the model using different supply and demand input parameters, representing multiple supply and demand hypothetical scenarios. The next chapter presents all obtained results.

Chapter 9

RESULTS OF PERFORMANCE ASSESSMENT AND DISCUSSION

In this chapter, sections 9.1, and 9.2 explore the performance of three supply structures (RN, and HL with two different distribution policies) using the hypothetical demand scenarios described in section 8.3. These two sections present results for the armed conflict response system (as described in section 5.1), the natural disaster response system (as described in section 5.2).

In particular, the RN-ACHD scenario is evaluated by considering just one delivery (d=1) to satisfy the needs of the population impacted, which is the distribution policy currently taken place by relief networks in Colombia. Whereas the HL-ACHD scenario, which suggests an alternative supply structure, evaluates two distribution policies – d=4 and d≥1 – with former implies that a family representative receives the food aid kit split into four rations. By splitting the food aid kit, we seek more manageability of the weight to be carried and better administration of the supplies over the period of distribution. The latter allows the analytical model to choose as many deliveries as the needed to minimize both deprivation cost and delivery costs together (social costs). Similarly, the RN-NDHD scenario is evaluated by setting just one delivery (d=1) while the HL-NDHD scenario evaluates two distribution policies, these are d=3 and d≥1. Again, the former is set according to the food aid kit configuration and the latter allows the number of deliveries to be set to minimize the social costs in the analytical model. Finally, section 9.3 revisits the logistics performance by comparing the results obtained from running the simulations

for both scenarios and all distribution policies in terms of the performance of the humanitarian logistics operations.

The rationale for the performance assessment draws on the fact that the relief networks (RN) are actual existing supply structures applied to the hypothetical scenarios for natural disasters and the armed conflict, and humanitarian logistics (HL) structures are hypothetical integrated supply structures, also applied to the hypothetical scenarios.

9.1 RN Structures Approach

9.1.1 Performance Assessment: Relief Networks Responding to the Armed Conflict Hypothetical Demand (RN-ACHD) Scenario.

This section presents the outputs derived from running the analytical model, using a representation of conventional relief network (RN) structures to respond to the armed conflict hypothetical demand. Once again, only one representation of the relief network structure is used.

As stated in Chapter 5, the UARIV is a relief network that mostly relies on private food aid suppliers basically acting as food aid retailers in the private market. When demand exceeds supply capacity from local food retailers, local governments request back up from the central government, which usually purchase the food aid from food providers located in *Bogotá*. Since that situation currently exists, it is used here to represent a supply structure from the UARIV relief network (armed conflict response system). However, this relief network is represented here by using a supply structure which bases its supply from a food retailer cluster located 800 km from the impacted area. As justified in the assumptions list above, the sum of storing and

transportation capabilities, which is determined by treating all food suppliers as they were one large entity, is used as inputs needed to assess the performance when responding to the hypothetical demand scenario.

Table 21 documents the inputs related to both supply and demand parameters that feed the analytical model when doing the simulations for the relief networks responding to the armed conflict hypothetical demand. Full details are included in Appendix J.

Table 21. Demand and supply input parameters: RN-ACHD scenario

Parameter	**Actual value**
Travel time (includes loading and unloading) between demand nodes and the DC	Given that the multiple food aid suppliers are located in *Bogotá*, an average travel time of 39 hours was determined
Initial deprivation time at demand node	An average of 48 hours.
Initial inventory available at demand node	0 at all demand nodes
Initial inventory available at supply node	A function of the consumption rate (kg/family/hours) times the population at node times the planning horizon (hours).
Number of time periods satisfied by a full serving of supplies	1 time period of 1,080 hours (45 days)
Population at node	Values may vary dramatically. A maximum of 205 families (4 persons) in a single demand spot to a minimum of 3 families.
Travel costs over planning horizon	2,562,562 COP divided by the travel time
Consumption rate (kg/person/hour)	0.07592 Computed as 82 kg of food being consumed in 1080 hours by a family
Planning horizon (hours)	1080
Maximum vehicle capacity (kg)	17000

Table 22 below presents performance results. Full details are included in Appendix J.

Table 22. Performance results: RN-ACHD scenario

Average deprivation time (hours) experienced up to the first delivery (S1)	87
Average deprivation time experienced after first delivery (Sx)	0
Delivery Cost (Millions of COP)	$261
Deprivation Cost (Millions of COP)	$4,202
Social Cost (Millions of COP)	$4,700
Kg of food received by family per delivery	82
Deliveries (d)	1
Time covered (T in hours)	1,080
Kg of food received by family during T days for zero deprivation	82
Actual kg of food received by family during T days	82
Average number of persons in line in each delivery	69
Average number of lines to serve per vehicle	1
Number of lines to serve per town (mode)	1
Number of persons to serve in each line	58
Average manpower serving each line	3
Total manpower needed (workers)	186
Number of vehicles needed	356
Average quantity per delivery (q)	5,643
Number of kits to ship per delivery	87
Maximum vehicle capacity needed (kg)	17,000

9.1.2 Performance Assessment: Relief Networks Responding to the Natural Hazards Hypothetical Demand (RN-NDHD) Scenario

This section presents the outputs derived from running the analytical model using a representation of conventional relief networks to respond to the hypothetical scenario for natural disasters. Although there are multiple supply chains that can be derived from the relief networks characterized in Figure 34, which shows the information available from the surveys specifically tailored to run the analytical model where in only one single representation of these relief networks is used to assess its performance when responding to the natural disaster hypothetical demand.

As stated in Chapter 5, the UNGRD is a relief network that mostly relies on private food aid suppliers essentially acting as food aid retailers in the private market. This food retailer's cluster is currently chosen based on a criterion other than the proximity to the impacted area despite the fact that there are other food retailers clusters located all around the country and, thus, much closer to potential impacted areas. However, this relief network is represented here by using a supply structure that bases its supply from a food retailer cluster located 800 km from the impacted area, which occurred when the UNGRD responded to small-scale disasters in 2013 and 2014. As justified in the assumptions list above, the capability to store and transport food aid resulting from treating all food suppliers as if they were singular is used as input to assess the performance when responding to the hypothetical demand scenario.

Table 23 documents the inputs related to both supply and demand parameters that feed the analytical model when performing the simulations for the relief networks responding to natural disaster hypothetical demand. Full details are included in Appendix J.

Table 23. Demand and supply input parameters: RN-NDHD scenario.

Parameter	Actual value
Travel time between demand nodes and DC	Given that the multiple food aid suppliers are located in *Bogotá*, an average travel time of 39 hours was determined
Initial deprivation time at demand node	An average of 48 hours.
Initial inventory available at demand node	0 at all demand nodes
Initial inventory available at supply node	A function of the consumption rate (kg/family/hours) times the population at node times the planning horizon (hours).
Number of time periods satisfied by a full serving of supplies	1 time period of 720 hours (30 days)

Parameter	Actual value
Population at node	Values may vary dramatically. A maximum of 209 families (4 persons) in a single demand spot to a minimum of 6.
Travel costs over planning horizon T	2,562,562 COP divided by the travel time
Consumption rate (unit/person/hour)	0.05 Computed as 36 kg of food aid being consumed in 720 hours by 1 family
Planning horizon (hours)	30 days (720 hours)
Maximum vehicle capacity (units)	240

Table 24 presents performance results. Details are presented in Appendix J. Analysis of these results is presented in section 9.3.

Table 24. Performance results: RN-NDHD scenario.

Average deprivation time (hours) experienced up to the first delivery (S1)	87
Average deprivation time experienced after first delivery (Sx)	0
Delivery Cost (Millions of COP)	$1,007
Deprivation Cost (Millions of COP)	$37,441
Social Cost (Millions of COP)	$41,408
Kg of food received by family per delivery	36
Deliveries (d)	1
Time covered (T in hours)	720
Kg of food received by family during T days for zero deprivation	36
Actual kg of food received by family during T days	36
Average number of persons in line in each delivery	200
Average number of lines to serve per vehicle	2
Number of lines to serve per town (mode)	2
Number of persons to serve in each line	80
Average manpower serving each line	4
Total manpower needed (workers)	3,899
Number of vehicles needed	393
Average quantity per delivery (q)	7,186
Number of kits to ship per delivery	87
Maximum vehicle capacity needed (kg)	8,000

9.2 HL Structures Approach

This section presents performance assessment results for humanitarian logistics (HL) structures. These results are in contrast to the performance assessments of the supply structures offered by current relief networks (RN). In order to achieve so, and as an example to evaluate the pertinence of the policy implications presented in chapter 7, two representations of the HL structures as identified in chapter 7 are used as supply structures responding to the respective hypothetical demand scenarios.

9.2.1 Performance Assessment: Humanitarian Logistics Responding to the Armed Conflict Hypothetical Demand (HL-ACHD) Scenario.

This section presents the outputs derived from running the analytical model using a representation of HL structures to respond to the armed conflict hypothetical demand.

As stated in Chapter 5, the Full Outsourcing Networks (FONs), such as the UARIV, are HL structures that mostly rely on private food aid suppliers basically acting as food aid retailers in the private market. As opposed to the structure representation shown in section 8.5, here the selected structure representation takes the most from the flexibility that FONs structures have when choosing the location of food supplier's cluster. Consequently, the group of food aid suppliers contracted by the UARIV, as discussed, is considered as a single supplier for modeling purposes, located in Barranquilla given that is the fourth largest city in the country and it is closely located to the impacted area. It is worth clarifying that although this is technically possible, such a decision hasn't been realistically adopted by FONs in

Colombia as the UARIV typically prefer to guarantee local food aid by contracting food suppliers located in *Bogotá*. The reason why the approach of selecting food providers close to the impacted area has not been adopted in practice is outside the scope of this dissertation. As justified in the assumptions list above, the sum of storing and transportation capabilities resulting from treating all food suppliers as they were singular is used as inputs needed to assess the performance when responding to the armed conflict hypothetical demand scenario.

Table 25 documents the inputs related to both supply and demand parameters that feed the analytical model when performing the simulations for the HL structures responding to the natural disaster hypothetical demand. Table 26 and Table 27 present performance results. Details are in Appendix J. Analysis of these results is presented in section 9.3.

Table 25. Demand and supply input parameters: HL-ACHD scenario

Parameter	**Actual value**
Travel time (includes loading and unloading) between demand nodes and the DC	Given that the multiple food aid suppliers are located in *Bogotá*, an average travel time of 10 hours was determined
Initial deprivation time at demand node	An average of 48 hours.
Initial inventory available at demand node	0 at all demand nodes
Initial inventory available at supply node	A function of the consumption rate (kg/family/hours) times the population at node times the planning horizon (hours).
Number of time periods satisfied by a full serving of supplies	1 time period of 1,080 hours (45 days)
Population at node	Values may vary dramatically. A maximum of 205 families (4 persons) in a single demand spot to a minimum of 3 families.
Travel costs over planning horizon	2,562,562 COP divided by the travel time
Consumption rate (kg/person/hour)	0.07592 Computed as 82 kg of food being consumed in 1080 hours by a family
Planning horizon (hours)	1080

Table 26. Performance results: HL-ACHD, d=4

Average deprivation time (hours) experienced up to the first delivery (S1)	58
Average deprivation time experienced after first delivery (Sx)	0
Delivery Cost (Millions of COP)	$103
Deprivation Cost (Millions of COP)	$144
Social Cost (Millions of COP)	$247
Kg of food received by family per delivery	21
Deliveries (d)	4
Time covered (T in hours)	1,080
Kg of food received by family during T days for zero deprivation	82
Actual kg of food received by family during T days	82
Average number of persons in line in each delivery	34
Average number of lines to serve per vehicle	1
Number of lines to serve per town (mode)	4
Number of persons to serve in each line	34
Average manpower serving each line	2
Total manpower needed (workers)	114
Number of vehicles needed	300
Average quantity per delivery (q)	2,728
Number of kits to ship per delivery	33
Maximum vehicle capacity needed (kg)	4,500

Table 27. Performance results: HL-ACHD, d≥1.

Average deprivation time (hours) experienced up to the first delivery (S1)	58
Average deprivation time experienced after first delivery (Sx)	0
Delivery Cost (Millions of COP)	$28
Deprivation Cost (Millions of COP)	$144
Social Cost (Millions of COP)	$172
Kg of food received by family per delivery	82
Deliveries (d)	1
Time covered (T in hours)	1,080
Kg of food received by family during T days for zero deprivation	82
Actual kg of food received by family during T days	82
Average number of persons in line in each delivery	109
Average number of lines to serve per vehicle	2
Number of lines to serve per town (mode)	1
Number of persons to serve in each line	60
Average manpower serving each line	3
Total manpower needed (workers)	410
Number of vehicles needed	115
Average quantity per delivery (q)	8,877
Number of kits to ship per delivery	109
Maximum vehicle capacity needed (kg)	17,000

9.2.2 Performance Assessment: Humanitarian Logistics Responding to the Natural Hazard Hypothetical Demand (HL-NDHD) Scenario.

This section presents the outputs derived from running the analytical model using a representation of HL structures to respond to the natural disaster hypothetical demand. As usual, only one single feature of these HL structures is used to represent this supply structure when aiming to assess its performance on responding to the natural disaster hypothetical demand.

As stated in Chapter 5, the Full Outsourcing Networks (FONs), such as the UNGRD, are HL structures that mostly rely on private food aid suppliers basically acting as food aid retailers in the private market. As opposed to the structure representation showed in section 8.5, here the selected structure representation takes the most from the flexibility that FON structures have when choosing the location of a food supplier cluster. Consequently, the group of food aid suppliers contacted by the UNGRD, which is considered as a single supplier for modeling purposes, is located in Barranquilla given that is the fourth largest city in the country and it is closely located to the impacted area. It is worth clarifying that although this is technically possible, FONs in Colombia haven't realistically adopted such a decision. As justified in the assumptions list above, the sum of storing and transportation capabilities resulting from treating all food suppliers, as they were singular is used as input needed to assess the performance when responding to the hypothetical demand scenario.

Table 28 documents the inputs related to both supply and demand parameters that feed the analytical model when doing the simulations for the HL structures responding to the natural disaster hypothetical demand. Details are included in Appendix J.

Table 28. Demand and supply input parameters: HL-NDHD scenario

Parameter	**Actual value**
Travel time between demand node and DC	Given that the multiple food aid suppliers are located in Barranquilla, an average travel time of 10 hours was determined
Initial deprivation time at demand node	48 hours.
Initial inventory available at demand node	0 at all demand nodes
Initial inventory available at supply node	A function of the consumption rate (unit/family/hours) times the population at node times the planning horizon (hours).
Number of time periods satisfied by a full serving of supplies	1 (720 hours)
Population at node	Values may vary dramatically. A maximum of 209 families (4 persons) in a single demand spot to a minimum of 6.
Travel costs over planning horizon	338,438 COP divided by the travel time
Consumption rate (unit/person/hour)	0.05. Computed as 36 kg of food aid being consumed by 1 family in 720 hours
Planning horizon (hours)	30 days (720 hours)
Maximum vehicle capacity (units)	3000

Table 29 and Table 30 present performance results. Details are included in Appendix J. Analysis of these results is presented in section 8.8.

Table 29. Performance results: HL-NDHD, d=3

Average deprivation time (hours) experienced up to the first delivery (S1)	58
Average deprivation time experienced after first delivery (Sx)	0
Delivery Cost (Millions of COP)	$399
Deprivation Cost (Millions of COP)	$1,332
Social Cost (Millions of COP)	$2,457
Kg of food received by family per delivery	12
Deliveries (d)	3
Time covered (T in hours)	720
Kg of food received by family during T days for zero deprivation	36
Actual kg of food received by family during T days	36
Average number of persons in line in each delivery	67
Average number of lines to serve per vehicle	1
Number of lines to serve per town (mode)	3
Number of persons to serve in each line	67
Average manpower serving each line	3
Total manpower needed (workers)	1,306
Number of vehicles needed	1,113
Average quantity per delivery (q)	2,396
Number of kits to ship per delivery	67
Maximum vehicle capacity needed (kg)	3,000

Table 30. Performance results: HL-NDHD, d≥1.

Average deprivation time (hours) experienced up to the first delivery (S1)	58
Average deprivation time experienced after first delivery (Sx)	0
Delivery Cost (Millions of COP)	$133
Deprivation Cost (Millions of COP)	$1,252
Social Cost (Millions of COP)	$1,390
Kg of food received by family per delivery	36
Deliveries (d)	1
Time covered (T in hours)	720
Kg of food received by family during T days for zero deprivation	36
Actual kg of food received by family during T days	36
Average number of persons in line in each delivery	200
Average number of lines to serve per vehicle	2
Number of lines to serve per town (mode)	2
Number of persons to serve in each line	80
Average manpower serving each line	4
Total manpower needed **(workers)**	3,899
Number of vehicles needed	371
Average quantity per delivery (q)	7,186
Number of kits to ship per delivery	58
Maximum vehicle capacity needed (kg)	8,000

9.3 Performance Analysis

This section analyzes the results obtained from running the analytical model. Each of the hypothetical demand scenarios defined in section 8.5 are run using data configured to represent two different supply structures: the existing relief network (RN) most relevant to the demand scenario and a humanitarian logistic (HL) structure representing a hypothetical structure. In order to identify which outputs drive better decisions, only the outputs related to the costs of running the inventory allocation strategy are considered in the comparative analysis. These are total delivery cost and

total deprivation cost, which together these make up the social cost. The analysis is presented by grouping the results of the armed conflict hypothetical demand (ACHD) scenarios and natural disaster hypothetical demand (NDHD) scenarios.

Drawing on Table 22, Table 26 and Table 27, Figure 53 summarizes all results obtained from the armed conflict hypothetical scenarios also featuring two delivery policies. Similarly, drawing on Table 24, Table 29 and Table 30, Figure 54 summarizes all results obtained from the natural disaster hypothetical scenarios also featuring two delivery policies. This way, six scenarios are considered, these are 1) "RN-NDHD", 2) "HL-NDHD d=3", 3) "HL-NDHD d ≥1", 4) "RN- ACHD", 5) "HL-ACHD d=4" and 6) "HL-ACHD d≥1".

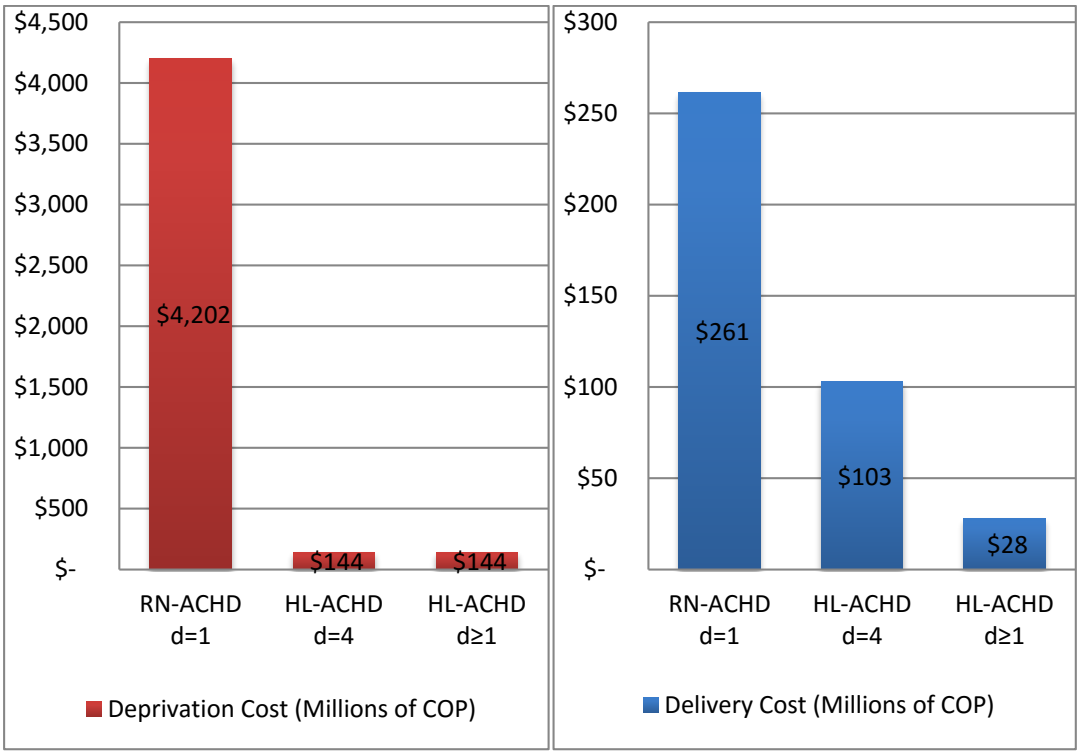

Figure 53. Total costs (millions of COP, $3,300 COP = $1 USD): ACHD scenarios

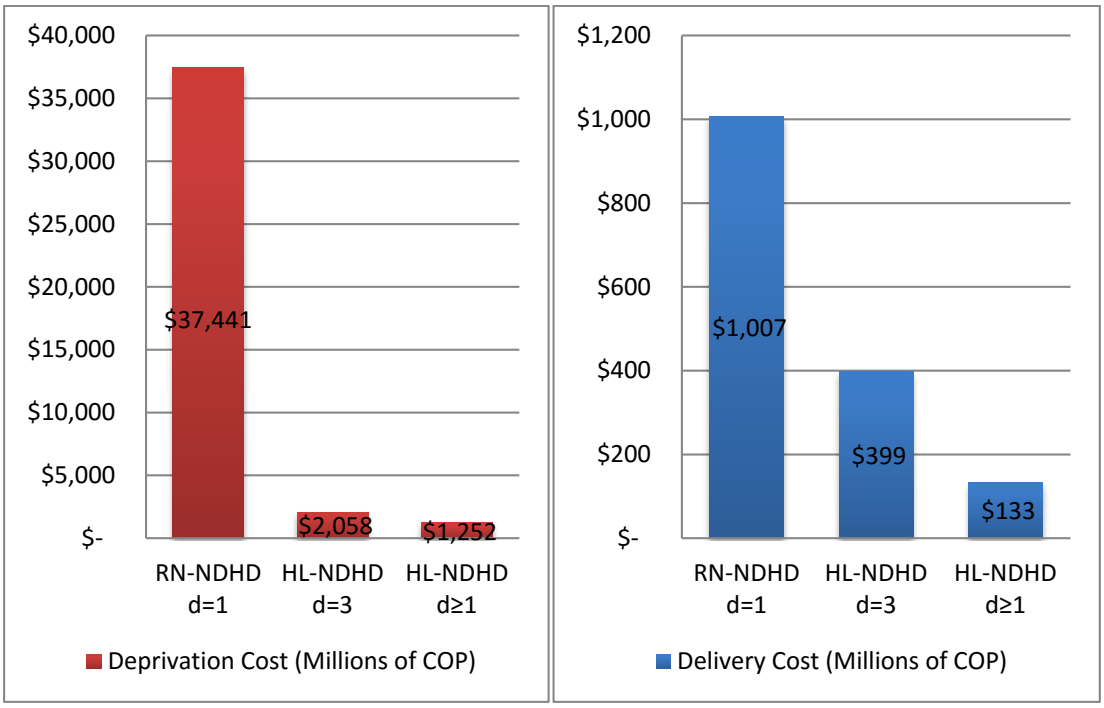

Figure 54. Total costs (millions of COP, $3,300 COP = $1 USD): NDHD scenarios.

In order to illustrate how policy recommendations associated with either RN or HL relief structures may make the most from the analytical model in future analyses, the results are used as inputs for a decision-making process approach presented in Table 31. Based on the outputs obtained, the approach ranks each hypothetical demand scenario and type of cost from one to four, one being lowest type of cost and therefore the best performance. The rankings are provided for delivery costs, deprivation costs and social costs within the natural hazard or armed conflict scenario. For example, for the natural hazards hypothetical demand scenario, the HL structure (HL-NDHD) is ranked number one for delivery costs because it has the lowest delivery cost. However, the RN structure is ranked number four because it presented the largest delivery cost when minimizing deprivation costs only.

Table 31. Decision making approach based on performance

Scenario	Delivery costs	Deprivation costs	Social costs
RN – ACHD d=1	3	2	3
HL – ACHD d=4	2	1	2
HL – ACHD d≥1	1	1	1
RN – NDHD d=1	3	3	3
HL – NDHD d=3	2	2	2
HL – NDHD d≥1	1	1	1

The following observations with respect to performance are based on the results from the simulations using the analytical model irrespective of the hypothetical supply scenario (RN or HL) responding either to the ACHD or the NDHD scenario. Such observations are drawn from the performance results previously introduced (Table 22, Table 24, Table 26, Table 27, Table 29 and Table 30):

- Trade-offs between delivery costs and deprivation costs – When it comes to all distribution policies in both scenarios, deprivation costs are significantly higher than delivery costs, which is mainly explained by the long transportation times derived from distributing from a city located at hundreds of kilometers away from the impacted area. Such long transportation times especially increase the deprivation time before the first and only delivery of the one delivery distribution policy (d=1), which ultimately increase deprivation costs largely for both scenarios. In addition, as expected, delivery costs dramatically decrease when switching from RN in both scenarios ACHD and NDHD, to the distribution policies d=4 (HL-ACHD), d=3 (HL-NDHD) and d≥1 in both scenarios, due to the proximity of the distribution center from the impacted area, which is a supply approach supported by the humanitarian logistics (HL)

structure suggested in this dissertation. Similarly, the gap between deprivation and delivery costs dramatically decreases as distribution policies allowing more than one delivery take place (d=4, d=3 andd≥1). Indeed, by allowing the analytical model to decide the number of deliveries that optimizes deprivation and delivery costs (d ≥1), the lowest social cost is achieved in both scenarios (deprivation costs plus delivery costs).

- Supply resources needed –Naturally, vehicles needed to satisfy the same beneficiaries in the three distribution policies of both scenarios vary according to the number of deliveries and the maximum vehicle's load capacity. For example, by setting loading capacities up to 17 tons in the ACHD, which realistically is a vehicle size that still manages to transit in the limited-quality roads in the region, again, by using a distribution policy of d≥1, the least number of vehicles needed is achieved. Of course, this latter distribution policy brings along the largest number of kits to ship per delivery.
- Impact of unlimited resources – Outputs demonstrate that even when using unlimited transportation resources and unlimited inventory levels, deprivation cost does not decrease to zero at any logistics cost, despite the fact that deprivation times after the first delivery is zero to all distribution policies and scenarios. Evidently, although initial deprivation time counts when totaling deprivation costs, relief networks have the chance to understand the implications on reducing the human suffering to its greatest extent by offering the most of its resources. Evidently, HL structures operationalize the trade-offs involved in decreasing deprivation cost while still decreasing logistics costs.

- Connecting the results to practice – Realistically speaking, the approach adopted by the UARIV may be easily aligned with using unlimited resources and minimizing deprivations costs, only given the flexibility of contacting multiple food aid suppliers who have independent and large transportation capabilities from private carriers. In addition, although the UARIV does not typically rely on generous budgets, which could translate into limited service levels, the results obtained in this simulation do give estimates of what the services levels have to be in order to minimize deprivation costs. However, the approach adopted by the UNGRD may be easily aligned with using unlimited resources given the flexibility of contacting multiple food aid suppliers who have independent and large transportation capabilities from private carriers. In addition, it is typical that the UNGRD relies on generous budgets, which could translate into willingness to respond with unlimited services levels. Nevertheless, even when this is not always the case, the results obtained in this simulation do give estimates of what the service levels have to be in order to minimize deprivation costs.

- Locating food aid suppliers - Logistically speaking, placing a cluster of food aid suppliers close to the impacted area may be quite obvious beforehand if minimizing logistics costs is the goal. However, in both hypothetical scenarios, the simulations also demonstrated that having the supply node(s) close to the impacted area results in the smallest deprivation costs. In other words, although responders usually make this kind of decision based on minimizing logistics costs, they may not be aware that the proximity to the impacted area may be

directly proportional to minimizing the human suffering, due to the reduction in travel times

- Impacts of supply location and alternative objective function - Since realistically speaking food suppliers (food retailers) are located in all major cities and given the UNGRD and UARIV freedom to choose them, last mile delivery cost are smaller hence deprivation times are shorter too. Ultimately, no extra cost is expected by switching to this configuration because local food aid clusters wouldn't charge an extra cost for eventually ending up being located close to the impacted area.

As the hypothetical scenarios could have been set up using input parameters that represented supply and demand with different scales, location and speed of onset, this chapter presented a way, among many available, to assess the performance of such scenarios while serving as a model tool for pre-disaster planning. By considering two different supply structures (RN and HL) and three different distribution policies for both the armed conflict and natural disaster hypothetical demand scenario, this chapter presents the results from minimizing social costs and deprivations costs as a decision making tool to assess the impact of policy recommendations. Ultimately, the approach suggests taking the most from the HL structures identified over the already existing RN structures, especially when it can be assumed that unlimited logistics resources (transportation, storing and inventory) are available.

Chapter 10

FINAL CONSIDERATIONS

This chapter completes the dissertation by reiterating the most significant attributes and findings that shape the state of the art of food aid distribution to natural disasters and armed conflict beneficiaries in Colombia, which are presented as conclusions in section 10.1. In section 10.2, the major contributions to the fields of disaster science, humanitarian logistics and the operations research are presented. Finally, areas for future research are suggested in section 10.3 as potential research efforts that are directly derived from the results and contributions in a straightforward manner.

10.1 Conclusions

Food aid distribution to those impacted by natural disasters and the armed conflict in Colombia is deployed by multiple organizations that are affiliated with the private sector, national and local governments, local and international NGOs, communities, as well as neutral relief organizations, recognized both nationally and internationally. These organizations typically respond through regular humanitarian logistics operations as most frequent natural and manmade disasters in Colombia are small-scale and predictable. On the other hand, these relief organizations also respond through post-disaster logistics operations, as they are also responsible for deploying food aid to those large-scale and random disasters. Content analysis and fieldwork conducted for this dissertation presented evidence that the World Food Program and

UARIV are major established relief organizations deploying food aid to those impacted by the armed conflict. These organizations mainly comprise the humanitarian response system assisting IDPs and other beneficiaries. Similarly, Colombian Red Cross, the Civil Defense and the UNGRD were found to be major established relief organizations deploying food aid to those impacted by natural disasters. These organizations mainly comprise the humanitarian response system assisting these beneficiaries.

When orchestrating food aid distribution, these two response systems, which operate independently, comprise relief networks through the above-mentioned organizations. Such relief organizations deploy food aid throughout the national territory supported by their supply chain network architecture. On characterizing these supply chain networks, a mapping tool portrayed each architecture, illustrating the location of supply facilities, the linkages between them, and the nature of the commodities flowing from upstream to downstream in the supply chains. The flow represented either procured or donated food aid kits, or single commodities. Organizations such as the Colombian Red Cross and the Civil Defense prioritize the flow from material convergence commodities whereas UARIV, UNGRD and the WFP procure commodities. The only organization found to start the supply chain upstream from international locations is the WFP, but this also was the only organization procuring in bulk as opposed to food aid kits like the remaining organizations.

The study of the selected relief networks revealed that, when not supported by in-house actors, the supply chain architecture is supported by a set of partners, which are involved in the network as outsourcing or subcontracting third parties. Third parties ranged from organizations without humanitarian aid experience, such as real

estate, private road carriers, food suppliers (retailers), 3PL (third party logistics) and locals, to governmental and humanitarian organizations like NGOs, the Police Department and military forces. Consequently, understanding the supply chain characterization of these relief networks implied understanding the heterogeneity of the third parties involved in transporting, storing and distributing food aid to beneficiaries.

By analyzing the extent to which relief networks outsource third parties to carry on any logistics operation, three typologies of humanitarian logistics structures were identified:

- Full Outsourcing Networks (FONs) – FONs, such as UARIV and UNGRD, literally outsource or subcontract all the logistics involving food aid distribution from upstream to downstream the supply chain.
- Strong Supportive Networks (SSNs) – SSNs, such as the Colombian Red Cross and the Civil Defense, are distinguished from FONs because of their exclusive characteristic to own a great percentage of in-house logistics providers.
- Hybrid Approach Networks (HANs) – HANs, like the World Food Program, use both third parties and in-house logistics providers from upstream to downstream in the supply chain.

This dissertation suggests strategies for improving the performance of supply chains for deploying food aid by tackling two fronts: collaboration among relief networks belonging to the same response system and collaboration among relief networks belonging to the same typology of HL structure. Policy implications were analyzed to demonstrate the performance improvement by distinguishing courses of action applied to supply chain segments and by linking other principles from

commercial supply chain management to the characterization of response systems (RNs and HL structures). The development of these policy implications draws on either replicating principles of commercial supply chain management already identified in the characterization, or novel principles worth replicating. Postponement, partnerships, collaboration and convenient outsourcing were principles used as the cornerstones for these courses of action.

Lastly, by implementing an analytical model of inventory allocation as a performance assessment tool, this dissertation demonstrated that some tangible representations of the courses of action derived from the policy implications could bring along improvements in the overall performance of supply versus demand within hypothetical scenarios. Repositories of data regarding historic disaster records were used to build these hypothetical scenarios from the demand side, whereas a representation of the supply structure derived from some of the policy implications shaped the supply side. Ultimately, performance assessment results indicate that courses of action derived from the policy implications, such as the reallocation of supply clusters, do contribute to improving overall supply chain performance in larger-scale disaster scenarios.

10.2 Contributions

The contributions and results in this dissertation partially answer the call from researchers and practitioners to explore collaborative approaches in relief supply chains. Such collaborative efforts to improve performance of food and delivery are impeded as practitioners experience political and organizational constraints to improve performance of food aid delivery, and the sociological and behavioral perspectives of impacted populations are not yet fully understood when aiming to satisfy their needs

as a population suffering under the extremely complex situation encompassed in a disaster.

The contributions from this dissertation serve humanitarian relief organizations in making better decisions and determining policies regarding aid distribution in disaster scenarios. Moreover, the fact that there is no literature available in any discipline regarding considering the systematic performance of the relief supply chains that serve both Internally Displaced People derived from an armed conflict and population impacted by natural disasters, increases humanistic knowledge to international scenarios other than Colombia, where manmade and natural disasters coexist but parallel humanitarian systems support people who might be impacted by both situations.

This dissertation contributes to the humanitarian sector in Colombia and the scientific community in disaster science as the strengths and weaknesses for operationalizing food aid distribution for each actor involved, identified throughout the distinct supply chain segments through the following concepts:

- Integration of insights, concepts, and models from Operations Research, Industrial Engineering and the Social Sciences, as well as research tools, to leverage knowledge in disaster science and management. In this dissertation, principles from Operations Research and Industrial Engineering addressed both the performance objectives of current and hypothetical supply and demand scenarios for food aid distribution, and the realistic resource constraints of humanitarian organizations toward establishing policies that are beneficial to those impacted by natural disasters and the armed conflict as a whole. Specifically, on one hand, industrial engineering

insights contributed to the characterization of humanitarian supply chain networks, its potential improvement and suggestions for integrated response systems. On the other hand, content analysis of the results obtained from the survey approach, conceived as a research strategy, permitted qualitative methods contributed to identifying the Humanitarian Logistics structures. Ultimately, disaster science and management benefited from the multidisciplinary research approach carried out in this dissertation.

- Characterizations of humanitarian supply chains based on a freeware supply chain visibility solution-mapping tool, typically used for commercial supply chains. The tool enhanced the visualization of the end-to-end supply chain data, which turned descriptive and qualitative data into graphic information. Flows of food aid commodities and food aid kits were depicted from upstream to downstream in the supply chain. The mapping tool allowed this dissertation to identify the Regular Humanitarian Logistics (R-HL) features, where rules of thumb have been shaping commercial logistics structures instead. In addition, because this characterization examines, in detail, the architecture of the largest established relief organizations in Colombia in terms of nodes and linkages, it also contributes the foundations needed for practitioners and researchers to explore complementary policies and their implications.
- Contextualization and mapping of demand points within the context of hypothetical disaster scenarios communicate the spatial relationships between potential beneficiaries, the demand points, and demand densities, all of which were drawn from historic records of disasters in Colombia. This mapping was achieved using the freeware geographic information system-mapping tool.

- Identification of Humanitarian Logistics structures based on the extent to which outsourcing takes place. A complementary approach to the one developed by Holguín-Veras et al (2012a) was used. The approach broadened the spectrum of relief organizations and networks classified due to the heterogeneity of the supply chains orchestrating food aid distribution, using supply chain segment analysis, typically carried out in commercial supply chains.
- Development of policies drawn from commercial logistics practices carried out by humanitarian relief networks when orchestrating Regular and Post-Disaster humanitarian logistics operations. These policies include postponement strategies, international procurement and bulk transportation. Additional policy implications were explored based on the adaptation of other logistics strategies, also typically carried out on commercial logistics, such as the development of collaborative logistics networks among humanitarian organizations comprising relief networks and response systems.
- Approach for developing multiple hypothetical scenarios capturing realistic features of demand and supply conditions likely to occur in future large-scale disaster events. This dissertation relied on repositories of historic data for disaster events in Colombia to estimate aggregate demand and simulate large-scale disaster scenarios to evaluate the performance of both existing and suggested supply structures.
- Approach for modeling the implications of alternative policies and strategies by choosing an existing analytical model for measuring the impact of the policies and strategies developed. One final contribution this dissertation makes is the use of an inventory allocation strategy that is able to measure the performance impact of a

selected group of supply chains across a broad spectrum of structures characterized to respond to the hypothetical demand scenarios.

10.3 Future Research

Opportunities for future research are presented in terms of potential contributions practitioners and scholars can make to improve the delivery of humanitarian aid to those in need following natural disasters and the armed conflict. This includes better handling of demand and supply uncertainty prior to a large-scale disaster. Also, this dissertation calls for future research to characterize the perspective of disasters as internal to the system, particularly in the context of natural disasters occurring in areas influenced by armed conflicts. This dissertation also recommends future research regarding the characterization of supply chains from emergent organizations and identification of the HL structures associated with them, as well as the characterization of supply chains from established relief organizations in Colombia that have yet to be characterized. Next, alternative configurations of the hypothetical demand approach developed in this dissertation are suggested as future research. Future research is suggested as well regarding the search, selection and implementation of further analytical tools to assess performance of other representations of new policies, the definition of hypothetical scenarios that represent demand and input parameters of areas with "*Doble afectación*" and the development of further case studies that bring to light evidence linking the existing social fabrics and established relief organizations. Other areas for future research include the exploration of alternative inputs to the analysis derived from using the inventory allocation model developed by Pérez (2011), as well as a deeper state of the art of food security in post-disaster scenarios. Finally, assembling a panel of experts to further

critique and evaluate the policy recommendations developed in this dissertation is strongly recommended. These concepts for further research are elaborated on below.

i) Demand uncertainty. Although the historic databases analyzed to build hypothetical scenarios in this dissertation may be used to develop other hypothetical demand scenarios as a way to tackle uncertainty, it is strongly recommended that practitioners also explore other methods to estimate future demand, such as forecasting models. In addition, multiple demand dimensions should be considered prior to tackling supply uncertainty. For example, the demand estimates should go beyond simply estimating the number of beneficiaries and their exact locations and recognize demographics (gender, age, ethnics). A deeper demand characterization would better bridge the configuration of food aid kits to meet the needs derived from the diversity of beneficiaries, which would imply deploying multi-commodity shipments from points of distribution.

Another challenge derived from sources of uncertainty, which was reported by practitioners, is the random addition of new beneficiaries to demand at locations at which food aid supply has been already deployed, especially when responding to the armed conflict. This fact reinforces the recommended approach also used in this dissertation. It suggests magnifying potential demand beneficiaries by assuming a correlation to historic natural disasters records, or alternatively, to other variables such as the ones available in demographic datasets and vulnerability indexes such as the unsatisfied basic needs (UBN) and others directly related to risk-exposure.

ii) Supply uncertainty – The supply side possesses different sources of uncertainty, which can also challenge the food aid deployment process. For instance, the configuration of dynamic or not fixed points of distribution downstream in the

supply chain brings along a set of challenges to which the solutions are usually improvised by practitioners, such as defining facilities (number and locations), responsible parties to run them, manpower and last mile transportation resources. In order to avoid undervaluing improvisation, future research should be oriented to handling this uncertainty by strategically tackling the above-mentioned implications beforehand.

Another situation recognized in this dissertation regarding supply uncertainty is linked to upstream in the supply chains. Although this dissertation assumed that because food retailers also exist in midsize cities, hypothetical scenarios could set up a supply structure with food suppliers located much closer to the impacted area. Given the current policy of Full Outsourcing Networks (FONs) responding to both natural disasters and armed conflict beneficiaries from food suppliers located in remote areas from the actual impacted area, future research should be oriented to developing a partnership and logistics collaboration strategies with potential food retailers, so that a mere act of subcontracting switches to an actual outsourcing process, where the role of an additional actor in the chain prevails over a single food retailer figure.

iii) Perspective of disasters as internal to the system – Future work is strongly encouraged to enhance the characterization of the aspects attached to the social structure that are governed by a particular political ecology or political economy in the armed conflict context. This future work would potentially evidence the political variables immersed in the Colombian social structure, which in the event of a natural or manmade disaster, the imminent social disruption could be remedied through social structural manipulations itself.

iv) Characterization of supply chains and identification of HL structures from emergent organizations – This dissertation strictly focused on understanding the supply chain architecture of established organizations distributing food aid to those impacted by natural disasters and the armed conflict in Colombia. However, studying the emergent counterparts to existing organizations would not only help understand how emergent organizations link between the supply chains of the established organizations, but also help identify their capabilities to distribute, independently, food aid to those impacted by natural disasters in areas that might be also impacted by an armed conflict. Similarly, characterizing supply chains from established relief organizations in Colombia that has not been characterized yet, constitutes another future research initiative as this dissertation did not characterized 100% of this type of relief organizations. For instance, the role of other NGOs involved in either directly deploying food aid or collaborating with others actors, which was not deeply analyzed in this dissertation, may enrich the understanding of the architecture of other HL structures.

v) Alternative configurations of the hypothetical demand approach – This dissertation developed an approach for defining hypothetical demand scenarios based on historic disaster records of a specific region and configuring a specific disaster scale at a particular time frame. However, not only should alternative data repositories be considered in futures research, but also alternative regions, demand magnitudes and the rate of onset of the disaster should be explored as well.

vi) Search, selection and implementation of further analytical tools to assess performance of other representations of new policies – This dissertation also calls for future research that considers other analytical tools to evaluate other performance

measures that assess the impact of alternative representations of policy implications, such as analytical models focused on routing and facility allocations, while also using realistic input parameters able to create outputs worth considering to practitioners.

vii) Define hypothetical scenarios that represent demand and input parameters of areas with “Doble afectación” – This dissertation examined in detail data repositories of historic disasters events in Colombia for each response system independently. However, because a single region was chosen to draw the hypothetical demand scenarios, which conveniently represented a high density of people impacted by both natural disasters and the armed conflict, there is an open door to define hypothetical scenarios for both demand and supply that reflect the actual population facing the “Doble afectación”. This dissertation only developed hypothetical demand and supply scenarios for each group of impacted people separately because it is evident that the needs of people being concurrently impacted by both sources should not only be assessed differently, but the response would have to be different as well.

viii) Development of further case studies that show evidence of the linkage between social fabrics and established relief organizations – This dissertation provided at least one case study, which presented evidence of how practitioners can overcome the uncertainty associated with setting up points of distribution in a specific region in Colombia where they were not established. The case study presented unique features that assured accessibility to beneficiaries by overcoming technical constraints regarding security, political, legal, topographic, and transportation issues. Hence, this dissertation suggests extending future research efforts to better characterize disaster prone areas, so that resources coming from established or emergent parties can add complementary value by previously identifying the impact they may have when

working synergistically in response to disaster events likely to occur. In identifying such impact, the distinction between what the social fabrics can and cannot contribute to the capabilities of established organizations becomes crucial. The focus should be on how these complementary resources best confront the difficulties imposed by potential armed conflicts, the political organization of the population and communities impacted, legal frameworks, harsh terrain conditions, and potential third parties, to supplement eventual massive or larger than expected transportation and warehousing needs in the region.

ix) Recognition of different truck loading configurations when using the inventory allocation model to explore other performance improvements – When implementing Pérez's model in this dissertation, it was assumed that all trucks had the same loading capacity as originally assumed by Pérez when doing numerical experiments. However, this approach may be counterproductive to the performance assessment since the findings achieved here show that there is a wide spectrum of trucks of varying sizes, load capacities and adaptability to terrain and local road conditions. The vehicles come from private carriers mostly, hence future research should be oriented not only to modifying the original mathematical model and coding to a set of trucks varying in loading capacities to explore potential delivery cost savings, but also to doing further sensitivity analysis by exploring the impact of alternative input parameters.

x) Digging deeper into the state of the art of food security in post-disaster scenarios would help balancing the links between humanitarian logistics and all other conceptual frameworks introduced in this dissertation. As food security offers such a wide spectrum of options regarding the nutritional aspects alone, identifying with the

intersection between food security and the disaster response contexts would strongly contribute to assuring that the needs of the impacted are appropriately satisfied when modeling new food distributions policies.

xi) In order to double check that policy recommendations developed in this dissertation were technically realistic for practitioners, it was originally planned to assemble a panel of experts for such a purpose. Hence, future research is suggested so that a panel of experts of selected representatives is assembled from all the actors and parties identified in Phase I and II to consider these issues. The aim of the panel would be to disseminate the policy recommendations that match the typologies identified in Phase III. This way, policy recommendations would present to the experts for critique and evaluation purposes.

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Appendix A

INSTUTUTIONAL REVIEW BOARD APPROVAL LETER

RESEARCH OFFICE

210 Hullihen Hall
University of Delaware
Newark, Delaware 19716-1551
Ph: 302/831-2136
Fax: 302/831-2828

DATE:	November 13, 2013
TO:	Juan Camilo Sanchez Gil
FROM:	University of Delaware IRB
STUDY TITLE:	[531674-1] Food aid distribution during disaster response and short-term recovery: enhancing performance of heterogeneous humanitarian logistics structures
SUBMISSION TYPE:	New Project
ACTION:	APPROVED
APPROVAL DATE:	November 13, 2013
EXPIRATION DATE:	November 12, 2014
REVIEW TYPE:	Expedited Review
REVIEW CATEGORY:	Expedited review category # 7

Thank you for your submission of New Project materials for this research study. The University of Delaware IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a study design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the study and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All SERIOUS and UNEXPECTED adverse events must be reported to this office. Please use the appropriate adverse event forms for this procedure. All sponsor reporting requirements should also be followed.

Please report all NON-COMPLIANCE issues or COMPLAINTS regarding this study to this office.

Please note that all research records must be retained for a minimum of three years.

Appendix B

HUMAN SUBJECTS PROTOCOL

Protocol Title: Food aid distribution during disaster response and short-term recovery: enhancing performance of heterogeneous humanitarian logistics structures.

Principal Investigator
Name: Juan Camilo Sánchez Gil
Department/Center: Disaster Research Center
Contact Phone Number: +1302-7227197 or +573005104765
Email Address: jcsanche@udel.edu

Advisor (if student PI):
Name: Sue McNeil
Contact Phone Number: 302-831-6578
Email Address: smcneil@udel.edu

Other Investigators: None.

Investigator Assurance:

By submitting this protocol, I acknowledge that this project will be conducted in strict accordance with the procedures described. I will not make any modifications to this protocol without prior approval by the IRB. Should any unanticipated problems involving risk to subjects occur during this project, including breaches of guaranteed confidentiality or departures from any procedures specified in approved study documents, I will report such events to the Chair, Institutional Review Board immediately.

1. Is this project externally funded? □ YES X NO

If so, please list the funding source: None.

2. Research Site(s)

University of Delaware
X Other (please list external study sites)
Data collection methods take place in four phases. Phase I, II and IV will be held at the Office for the Coordination of Humanitarian Affairs (OCHA) facilities, Food and Aid Organization (FAO) facilities, International Committee of Red Cross facilities, Colombian Red Cross facilities, Governmental Organizations facilities for natural disasters response, Governmental Organizations facilities for Internal Displacement Crisis response, and Non-Governmental Organization facilities directly involved in food aid distribution during disasters. All of these abovementioned facilities are located either at *Medellín* or *Bogotá*, Colombia. Direct observation intended in Phase III will be held at either a rural or urban area of the national Colombian territory subject to a disaster occurrence and technical feasibility.

Is UD the study lead? X YES □ NO (If no, list the institution that is serving as the study lead)

3. Project Staff
Please list all personnel, including students, who will be working with human subjects on this protocol (insert additional rows as needed):

NAME	ROLE	HS TRAINING COMPLETE?
Juan Camilo Sánchez Gil	Data Collection and Analysis	Yes
Sue McNeil	Data Analysis	Yes

4. Special Populations
Does this project involve any of the following:

Research on Children? No.

Research with Prisoners? No.

If yes, complete the Prisoners in Research Form and upload to IRBNet as supporting documentation

Research with Pregnant Women? No.

Research with any other vulnerable population (e.g. cognitively impaired, economically disadvantaged, etc.)? No.

5. RESEARCH ABSTRACT Please provide a brief description in LAY language (understandable to an 8th grade student) of the aims of this project.

The purpose of this study is to characterize and analyze humanitarian logistics structures that support the distribution of food aid during disasters in Columbia. There are four phases.

Phase I. Group interviews and qualitative analysis. This phase consist of qualitative analysis for the identification of actors involved in food aid distribution for both those impacted by natural disasters and the armed conflict.
Phase II. Semi-structured in-person interviews. This phase consist of qualitative analysis for the identification of carriers, forwarders and composition of supply chains involved in food aid distribution for both those impacted by natural disasters and the armed conflict.

Phase III. Structured Interviews (surveys) and direct observation. This phase will define typologies of the humanitarian logistics structures whose composition may come from either response system (those impacted by natural disasters and the armed conflict). Both qualitative and quantitative data collected regards logistics capabilities and features.

Phase IV. Content analysis and panel of experts. This phase defines policy recommendations for the supply chain typologies defined in Phase III. Expert´s opinions will be gathered drawing from their judgment on the policy recommendations.

All materials will be translated to Spanish. All interviews will be conducted in Spanish. Spanish is the native language of the PI. Furthermore, he will be working with professionals in organizations responsible for humanitarian aid in Colombia rather than directly with those impacted by disasters (either natural hazards or the internal conflict). His experience as a researcher and educator focusing on logistics in Colombia means that he is familiar with the cultural norms and expectations within these organizations. The PI is on leave from Universidad de Antioquia in *Medellín*, Colombia. While individual universities in Colombia have procedures for the review of projects involving

human subjects, this project is not affiliated with the University and does not require review. There are no government requirements for review.

6. PROCEDURES Describe all procedures involving human subjects for this protocol. Include copies of all surveys and research measures.

Phase I. At least two group interview sessions will be held. One group session will be held with organizations from the natural disaster response system while organizations from the internally displacement crisis will attend the other one. See the Phase I interview guide attached.

Phase II. Semi-structured in-person interviews will be conducted to enrich the supply chains' characterization. The number of interviews may vary depending on the number of actors identified in Phase I. See the Phase II interview guides attached. Some interviews may take place either via skype or by telephone.

Phase III. More than one subject per actor (organization) may be of interest to survey. Consequently, the number of surveys will depend on the number of parties and staff representing the whole food distribution process executed. See the Phase III survey model attached.

Phase IV. At least one panel of experts is planned. Participants may be the same as those attending the group interview in Phase I.

NOTE: A project modification will be submitted before Phase II commences, which will include the revised interview protocols and informed consent forms reflecting the findings in Phase I. Furthermore modifications will also be required before Phase III and possibly Phase IV.

7. STUDY POPULATION AND RECRUITMENT
Describe who and how many subjects will be invited to participate. Include age, gender and other pertinent information.

Phase I. Representatives from organizations based in *Medellín* or *Bogotá*, Colombia and directly involved in food aid distribution during disasters in Columbia will be invited to participate. These organizations include the Office for the Coordination of Humanitarian Affairs (OCHA), Food and Aid Organization (FAO), International Committee of Red Cross, Colombian Red Cross, Governmental Organizations involved

in natural disasters response, Governmental Organizations involved in Internal Displacement Crisis response, and Non-Governmental Organizations.). Participants are expected to be individuals knowledgeable in the overall composition of the humanitarian actions that assist each response system and can be described as executives in the organizations. Between 6 and 15 participants are expected. The participants are identified as representatives from member organizations of the Equipo Humanitario Pais-Colombia, an interagency standing committee of the United Nations. The link between the PI and this organization is based on the collaboration existing between the Humanitarian Studies Institute, another organization affiliated to United Nations, and the home University of the PI, Universidad de Antioquia.

Phase II. As opposed to Phase I, participants will be representatives from each organization confirmed as an integral actor of the food aid supply chain. These participants are expected to be individuals knowledgeable in the detailed operation of food aid distribution who are able to characterize the food aid distribution process and can be described as operations or logistics experts. Between 10 and 20 participants are expected. The participants in Phase I will help to identify the participants in Phase II.

Phase III. Individuals knowledgeable in the specific logistics features run by the respective organization involved in food aid distribution during disasters will be surveyed. Surveys will only include people who are 18 years of age or older. Between 15 and 30 surveys will be distributed via email. The participants in Phase II will help to identify the participants in Phase III.

Phase IV. Attendees to the panel of experts must be individuals knowledgeable enough to evaluate the potential changes in the current policies that govern food aid distribution to natural disasters and internally displaced persons in Colombia. We expect the participants in Phase IV to be similar to the participants in Phase I. Panels will include people who are 18 years of age or older.

Attach all recruitment fliers, letters, or other recruitment materials to be used. If verbal recruitment will be used, please attach a script.

The PI and his dissertation committee may be involved in identifying subjects to participate in the expert panels and other data collection sessions, which may be conducted via email or verbally.

Describe what exclusionary criteria, if any will be applied.

No one under the age of 18 will be interviewed.

Describe what (if any) conditions will result in PI termination of subject participation.

Subject participation will be terminated if a subject declines to participate in or asks to be excused from the research.

8. RISKS AND BENEFITS

List all potential physical, psychological, social, financial or legal risks to subjects (risks listed here should be included on the consent form).

None of these risks are applicable to this project.

In your opinion, are risks listed above minimal* or more than minimal? If more than minimal, please justify why risks are reasonable in relation to anticipated direct or future benefits.

The risks are minimal. No personally identifying information will be included in the analysis.

(*Minimal risk means the probability and magnitude of harm or discomfort anticipated in the research are not greater than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests)

What steps will be taken to minimize risks?

Individually identifiable information will not be included in the analysis or resulting documents.

Describe any potential direct benefits to participants.

There are no direct benefits to the participants.

Describe any potential future benefits to this class of participants, others, or society.

Phase I and II. A greater and holistic understanding of the actors involved in food aid distribution provides an opportunity for potential reconfigurations towards enhancements in the humanitarian logistics structures. The participants will see ways to directly apply the observations to their organizations.

Phase III. Defining typologies of the humanitarian logistics structures may lead to closing the gaps in the performance of the currently disconnected supply chains present in food aid distribution.

Phase IV. Designing policy recommendations and assessing the performance for the enhancement of the humanitarian logistics structures that distribute food aid translates into reducing the human suffering derived from disasters.

If there is a Data Monitoring Committee (DMC) in place for this project, please describe when and how often it meets.

There is no Data Monitoring Committee in place.

9. COMPENSATION
Will participants be compensated for participation?

No.

If so, please include details.

10. DATA
Will subjects be anonymous to the researcher?

Not always. In some cases, the transcripts and questionnaires contain personally identifiable information. However, names will not be reported in the analysis or resulting documentation. I will be coordinating the identification of respondents with personnel from the UN and governmental agencies and the University of Delaware. I expect to have contact with some or all of the respondents before conducting the data collection sessions.

If subjects are identifiable, will their identities be kept confidential? (If yes, please specify how)

Owing to the public nature of the events and the organizations involved, we are not promising confidentiality. However, names of subjects will not be reported in the

analysis or in any reports or publications. Organization names may be reported. However, classes or organizations (NGO, Government, etc.) will be addressed.

How will data be stored and kept secure (specify data storage plans for both paper and electronic files. For guidance see http://www.udel.edu/research/preparing/datastorage.html)

Paper files will be maintained in a locked room at the Disaster Research Center. Electronic files from the analysis will be encrypted using Axantum AxCrypt and stored on the PI's computer and a University of Delaware owned server with regular back-up.

How long will data be stored?

Data generated for this project will be stored indefinitely during the life the research.

Will data be destroyed? □ YES X NO (if yes, please specify how the data will be destroyed)

Will the data be shared with anyone outside of the research team? □ YES X NO (if yes, please list the person(s), organization(s) and/or institution(s) and specify plans for secure data transfer)

No.

How will data be analyzed and reported?

The data will be analyzed by the PI. Pseudonyms will be used in reports and presentations. Some data will be reported in aggregate.

11. CONFIDENTIALITY
Will participants be audiotaped, photographed or videotaped during this study?

Group interviews, and semi structured interviews will be audiotaped and transcribed.

How will subject identity be protected?

Personally identifiable information will not be reported in the analysis or resulting documentation.

Is there a Certificate of Confidentiality in place for this project? (If so, please provide a copy).

No.

12. CONFLICT OF INTEREST
(For information on disclosure reporting see: http://www.udel.edu/research/preparing/conflict.html)

Do you have a current conflict of interest disclosure form on file through UD Web forms?

No.

Does this project involve a potential conflict of interest*?
* As defined in the University of Delaware's Policies and Procedures ,a potential conflict of interest (COI) occurs when there is a divergence between an individual's private interests and his or her professional obligations, such that an independent observer might reasonably question whether the individual's professional judgment, commitment, actions, or decisions could be influenced by considerations of personal gain, financial or otherwise.

No.

If yes, please describe the nature of the interest:

13. CONSENT and ASSENT

X Consent forms will be used and are attached for review (see Consent Template under Forms and Templates in IRBNet)
NOTE: Project modifications will be submitted before each of the subsequent phases (Phase II, III and IV) commence. Each modification will include the informed consent forms.

____ Additionally, child assent forms will be used and are attached.

____ Waiver of Documentation of Consent (attach a consent script/information sheet with the signature block removed).

Waiver of Consent (Justify request for waiver)

14. Other IRB Approval
Has this protocol been submitted to any other IRBs?

No.

If so, please list along with protocol title, number, and expiration date.

15. Supporting Documentation
Please list all additional documents uploaded to IRBNet in support of this application.

PhD Proposal
Recruitment letter
Informed consent
Protocol Phase I
Protocol Phase II
Protocol Phase III
Protocol Phase IV

Appendix C

RECRUITMENT LETTER

DATE

NAME
ADDRESS
CITY, ST ZIP CODE

Dear XXXXX:

Note: <[…] or […] > Indicates where the letter will be tailored to the specific data collection effort. The options are shown between [..].

I am a doctoral candidate in the interdisciplinary Disaster Science and Management program at the University of Delaware. I am seeking your participation in <[an interview session] or [survey]> to characterize the humanitarian logistics structures and design of policy recommendations that enhance food aid distribution during disasters.

The interview session will consist of <[an in-person interview] or [a group interview] or [a panel of experts] or [a survey]>. Each participant is encouraged to respond to the questions based on their own expertise and point of view. <Consensus is not necessary in group sessions, but I expect the dialogue to add richness to the data.> < [Group interviews] or [Expert panels] will take place at an agreed on location in Bogotá or Medellín city. > <In-person interviews may take place in your organization´s facilities or via streaming or telephone.>

Both qualitative and quantitative data collected through the multi-method approach of this research is intended to inform the design of policy recommendations to enhance the performance of food aid distribution during disasters. In addition, a humanitarian logistics analytical model will be run as a validation approach to test the scope of such policy recommendations.

< [I anticipate group interviews will take up to four hours.] or [I anticipate in-person interviews will take up to two hours.] or [I anticipate surveys will take up to two hours. Surveys will be conducted via email with telephone communication for clarification purposes.] or [I anticipate expert panels will take up to four hours.] > Your participation

in this research is completely voluntary, and you can choose to terminate your participation at any time without fear of retribution or negative consequences.

The enclosure with this letter describes the overall multi-method approach of this research for a holistic understanding.

Thank you for your consideration. Questions regarding the research project and data collection methods as well as your confirmation whether positive or negative to participate in this research can be directed to the undersigned at +573005104765 or jcsanche@udel.edu.

Sincerely,

Juan Camilo Sánchez Gil
Doctoral Candidate Disaster Science and Management

Appendix D

INFORMED CONSENT FORM

Title of Project: Food aid distribution during disaster response and short-term recovery: enhancing performance of heterogeneous humanitarian logistics structures.

Principal Investigator (s): Juan Camilo Sánchez Gil

Other Investigators: Sue McNeil

You are being asked to participate in a research study. This form tells you about the study including its purpose, what you will do if you decide to participate, and any risks and benefits of being in the study. Please read the information below and ask the research team questions about anything we have not made clear before you decide whether to participate. Your participation is voluntary and you can refuse to participate or withdraw at anytime without penalty or loss of benefits to which you are otherwise entitled. If you decide to participate, you will be asked to sign this form and a copy will be given to you to keep for your reference.

WHAT IS THE PURPOSE OF THIS STUDY?

The purpose of this study is to characterize and analyze humanitarian logistics structures that support the distribution of food aid during disasters. The results of the study will be used to design policy recommendations to enhance the performance of food aid distribution during disasters. The research will draw on information from knowledgeable personnel from multiple and diverse organizations involved in humanitarian actions in Colombia. This study is part of a doctoral dissertation. You are being asked to take part in this study because of your unique expertise in strategic, managerial or operational activities regarding distribution of food aid during disasters in Colombia. Volunteers lacking professional experience working in disaster response and short-term recovery operations may be excluded from this study if. In-person and group interviews, surveys and expert panels will be held. Your potential participation in at least one of these data collection activities is requested.

WHAT WILL YOU BE ASKED TO DO?

You are being asked to participate in at least one of the data collection methods abovementioned depending on your expertise and position within the organization. In-person and group interviews intend to facilitate the appropriate selection of actors directly involved in distributing food aid for both those impacted by natural disasters and the armed conflict. Surveys aim to collect both qualitative and quantitative data that serve as inputs to performance analysis and policy recommendations while expert panels will be held to evaluate the pertinence of such policy recommendations. In-person interviews and surveys are expected to last no more than two hours while group interviews and expert panels may last up to four hours.

WHAT ARE THE POSSIBLE RISKS AND DISCOMFORTS?

Participating in this study will expose you to minimal risks consistent with those faced in daily life. While confidentiality is not guaranteed, personally identifiable information will not be reported in the analysis or resulting documentation.

WHAT ARE THE POTENTIAL BENEFITS?

You will not benefit directly from taking part in this research. However, the knowledge gained from this study may contribute to our understanding of food aid distribution during disasters and lead to improved humanitarian logistics structures able to effectively reduce the human suffering.

HOW WILL CONFIDENTIALITY BE MAINTAINED?

We will make every effort to keep all research records that identify you confidential to the extent permitted by law. Publications and presentations resulting from the research will not share personally identifiable information.
Your research records may be viewed by the University of Delaware Institutional Review Board, but the confidentiality of your records will be protected to the extent permitted by law.

WILL THERE BE ANY COSTS RELATED TO THE RESEARCH?

There are no costs associated with participating in this study.

WILL THERE BE ANY COMPENSATION FOR PARTICIPATION?

There is no compensation association with participating in this study.

DO YOU HAVE TO TAKE PART IN THIS STUDY?
Taking part in this research study is entirely voluntary. You do not have to participate in this research. If you choose to take part, you have the right to stop at any time. If you

decide not to participate or if you decide to stop taking part in the research at a later date, there will be no penalty or loss of benefits to which you are otherwise entitled. Your refusal will not influence current or future relationships with the University of Delaware.

WHO SHOULD YOU CALL IF YOU HAVE QUESTIONS OR CONCERNS?

If you have any questions about this study, please contact the Principal Investigator, Juan Camilo Sánchez Gil at +573005104765 or jcsanche@udel.edu.

If you have any questions or concerns about your rights as a research participant, you may contact the University of Delaware Institutional Review Board at +1-302-831-2137.

Your signature below indicates that you are agreeing to take part in this research study. You have been informed about the study's purpose, procedures, possible risks and benefits. You have been given the opportunity to ask questions about the research and those questions have been answered. You will be given a copy of this consent form to keep.

By signing this consent form, you indicate that you voluntarily agree to participate in this study.

_____ _____

Signature of Participant Date

_____

Printed Name of Participant

Appendix E

GROUP INTERVIEW PROTOCOL (PHASE I) FOR THE PRELIMINARY IDENTIFICATION OF ACTORS INVOLVED IN FOOD AID DISTRIBUTION IN COLOMBIA

A Study Conducted by the University of Delaware

To improve the distribution of food aid to those impacted by natural disasters and the armed conflict Colombia, we plan to characterize and model the logistics structures. The purpose of this group interview is to make sure that all agencies and structured organizations participating in humanitarian action in Colombia involving food aid distribution to those impacted by natural disasters and the armed conflict are identified and their perspectives taken into consideration when characterizing the humanitarian logistics structures that orchestrate the humanitarian operations. We wish to identify each actor involved in food aid distribution during disasters in Colombia regardless of its organizational structure (private, non-governmental or governmental) and irrespective of the response system they belong to (those impacted by natural disasters and the armed conflict).

Given the fact all participants in this group interview are representatives from member agencies of the *Equipo Humanitario Pais-Colombia* (Interagency Standing Committee - a party composed of different agencies and organizations to orchestrate, develop policies and make decisions regarding humanitarian action), a draft characterization of the supply chains in charge of food aid distribution during disasters for each response system built from secondary information is presented. After the presentation, relevant questions will be asked to evaluate the completeness, pertinence and relevance of such characterization.

We will start by asking you to briefly introduce yourself - in one minute or less - by telling the group:

1. Your name
2. Your position

3. Your organization
4. An experience you had with orchestrating food aid distribution during disasters.

We will address the following list of questions and issues during the next two hours. We are not looking for consensus. Every opinion is valuable, and we welcome different points of view on these issues.

- Regarding the humanitarian actions that respond to those impacted by natural disasters:

1. Does the presented sketch fully illustrate all the organizations involved in food aid distribution during the response and short-term recovery phases of disasters in Colombia?

2. What actors or organizations should be added or deleted and why?

3. What would be an alternative classification/characterization of actors/organizations other than its private, non-governmental and governmental affiliation?

4. How can these actors/organizations be characterized by the disaster phase (response and short-term recovery) in which they execute their food aid distribution operations?

5. How can these actors/organizations be characterized by the kind of natural disaster they are good at responding to in regard with food aid distribution?

6. How can these actors be characterized by the geographical location (rural, urban, regional, etc.) where food aid is usually distributed to those impacted by natural disasters.

7. How can these actors be characterized by the commodity they usually ship to those impacted by natural disasters?

- Regarding the humanitarian actions that respond to internally displaced persons in Colombia:

1. Does the presented sketch fully illustrate all the organizations involved in food aid distribution during the response and short-term recovery phases of disasters in Colombia?

2. What actors or organizations should be added or deleted and why?

3. What would be an alternative classification/characterization of actors/organizations other than its private, non-governmental and governmental affiliation?

4. How can these actors/organizations be characterized by the disaster phase (response and short-term recovery) in which they execute their food aid distribution operations?

5. How can these actors/organizations be characterized by the kind of natural disaster they are good at responding to in regard with food aid distribution?

6. How can these actors be characterized by the geographical location (rural, urban, regional, etc.) where food aid is usually distributed those impacted by natural disasters.

7. How can these actors be characterized by the commodity they usually ship to those impacted by natural disasters?

- Regarding the identification of participants for in-depth interviews to characterize the logistics operations for food aid:

1. Can you identify organizations?
2. How would you characterize these organizations?
3. Can you identify roles or individuals within these organizations?
4. Can you provide contact information of potential participants?

- Other information

1. Do you have other information you would like to add to better characterizing food aid supply chains in Colombia?
2. Are there documents, reports etc. that are relevant to outlining food aid supply chains for those impacted by disasters in Colombia?

Appendix F

IN-PERSON INTERVIEW (PHASE II) PROTOCOL FOR THE PRELIMINARY IDENTIFICATION OF SUPPLY CHAINS INVOLVED IN FOOD AID DISTRIBUTION IN COLOMBIA

A Study Conducted by the University of Delaware

To improve the distribution of food aid to those impacted by natural disasters and the armed conflict in Colombia, we plan to characterize and model the logistics structures. The purpose of this group interview is to make sure that each organization identified in Phase I (Group Interview) is disaggregated into carriers or forwarders with the respective nodes or facilities (e.g. civil infrastructures such as points of distributions, warehouses, etc.) and transportation infrastructure through which food aid distribution operations for those impacted by natural disasters and the armed conflict take place. Thus, a richer characterization of the actor in question can better illustrate the breadth and depth of its participation in the overall process.

Given your expertise and knowledge on the specifics about the humanitarian operations performed, we would appreciate as much detail as possible to help us depict the resources and processes the organization you represent is presently using to orchestrate food aid distribution during disasters.

I will start by asking you to briefly introduce yourself - in one minute or less - by telling me:

5. Your name
6. Your position
7. Your organization
    a. The geographical area your organization covers.
    b. Focus – Disasters or IDPs?
    c. Affiliation (Governmental, NGO, etc.)
8. An experience you had with orchestrating food aid distribution during disasters.

The following is a list of questions and issues I will address during the next two hours.

- Regarding the food aid distribution operations to those impacted by natural disasters:

1. How many fixed points of distribution are set up? Where are they located? Who are they supplied from? Where are they supplied from? Where are the target beneficiaries located? What are the commodities operated?

2. How many warehouses are set up? Where are they located? Who are they supplied from? Where are they supplied from? Who are they shipping to? Where are they shipping to? What are the commodities operated?

3. What are other facilities that represent additional nodes in the supply chain of food aid? What is their purpose? Where are they located? Who are they supplied from? Where are they supplied from? Who are they shipping to? Where are they shipping to? What are the commodities operated?

- Regarding the food aid distribution operations to internally displaced persons in Colombia:

1. How many fixed points of distribution are set up? Where are they located? Who are they supplied from? Where are they supplied from? Where are the target beneficiaries located? What are the commodities operated?

2. How many warehouses are set up? Where are they located? Who are they supplied from? Where are they supplied from? Who are they shipping to? Where are they shipping to? What are the commodities operated?

3. What are other facilities that represent additional nodes in the supply chain of food aid? What is their purpose? Where are they located? Who are they supplied from? Where are they supplied from? Who are they shipping to? Where are they shipping to? What are the commodities operated?

Appendix G

SURVEYS (PHASE III) PROTOCOL FOR THE IDENTIFICATION OF TYPOLOGIES OF HUMANITARIAN LOGISTICS STRUCTURES FOR FOOD AID DISTRIBUTINO IN COLOMBIA

A Study Conducted by the University of Delaware

To improve the distribution of food aid to those impacted by natural disasters and the armed conflict in Colombia, we plan to characterize and model the logistics structures. The purpose of this survey (Phase III) is to take a snapshot not only of the current material convergence of food aid during the response and short-term recovery phases when the agency in question is assisting natural disasters and internal displacement crisis, but also of the performance it is achieving in relieving the human suffering and contributing to reducing food insecurity of those impacted by disasters.

Aside from providing basic personal information and the expertise you have in orchestrating food aid distribution during disasters from the organization you represent, you are expected to be precise in providing information regarding the following performing factors:

1. Attributes about commodities: coded by dry and wet rations, specific beneficiaries targeted, specific disaster-oriented, initial level of inventories by node in the supply chain in a time period, shipping frequency to beneficiaries, size of shipments, transportation mode, lead times to beneficiaries, storing costs per unit time, packaging, life cycle, quantification of non-priority goods, high priority goods and low priority goods.

2. Attributes about assessing population in need: methods to assessing consumption rates by commodity, methods to estimating number of impacted people, methods to characterizing those impacted in the light of food security needs.

3. Attributes about capabilities: characterization of fleets in terms of number of vehicles per type, cargo capacities, loading and unloading technologies, loading and unloading times, maximal travel times.

4. Attributes about historic disaster response operations: number and types of events assisted with food aid distribution, number of beneficiaries assisted by disaster event, distribution policies

conducted in terms of frequency, quantity and size of shipment in a time period for each commodity.

Specific survey questions will be developed based on the results of Phase II and a revised protocol submitted for review. Survey questions will also be elaborated based on humanitarian logistics features and performance literature review,

Survey is originally intended to take place via email. However, telephone communication may also be needed for clarification purposes from the surveyed to the surveyors and vice versa.

Appendix H

LOGISTICS CAPABILITIES SURVEYED

The following tables document the data obtained by the surveys. Table 32 shows the food aid delivered by the Colombian Red Cross in the province of Antioquia in 2013.

Table 32. Food aid delivered by the Colombian Red Cross in the province of Antioquia, 2013

Municipality	**Tons of food aid**	**Beneficiaries**
Turbo	4.96	122
Antioquia	0.82	100
Apartadó	3.83	86
Itagui	0.8	78
Santa Rosa	1.36	64
Necoclí	2.12	50
Chigorodó	1.88	50
Cisneros	0.1	32
Don Matías	0.17	30
Sonsón	0.04	25
Andes	0.16	24
Ituango	0.02	20
Bello	0.13	15
Puerto Berrío	0.26	14
La Ceja	0.02	10
Funaciones	6.78	813
TOTAL	23.4	1.533

Table 33show the travel times in minutes for the Colombian Red Cross between strategic warehouses and points of distribution.

Table 34 through Table 42 show the distribution times and costs from warehouse 1 through warehouse 9 to the PODs for the WFP.

Table 33. CRC travel times (minutes) between strategic warehouses and points of distribution

PODs location	**Riohacha**	**Magangué**	**Medellín**	**Bogotá**	**Montenegro**	**Cartago**	**Neiva**	**Mocoa**
Riohacha	720 a 1440	X	X	X	X	X	X	X
Valledupar	721-1440	X	X	X	X	X	X	X
Santa Marta	722-1440	X	X	X	X	X	X	X
Cartagena	723-1440	723-1440	1440	X	X	X	X	X
Barranquilla	724-1440	X		X	X	X	X	X
Montería	X	X	360-1440	X	X	X	X	X
Sincelejo	X	X	360-1440	X	X	X	X	X
Cúcuta	724-1440	X	X	X	X	X	X	X
Bucaramanga	X	1440	724-1440	X	X	X	X	X
Medellín	X	X	360-724	X	X	X	X	X
Tunja	X	X	X	360-1440	X	X	X	X
Manizales	X	X	X	X	360-1440	X	X	X
Armenia	X	X	X	X	360- 440	X	X	X
Pereira	X	X	X	X	360-1440	X	X	X
Quibdó	X	X	360-1440	X	X	X	X	X
Bogotá	X	X	360-724	X	X	X	X	X
Cali	X	X	X	X	X	360-724	X	X
Popayán	X	X	X	X	X	724-1440	X	X
Ibagué	X	X	X	X	724-1440		X	X
Pasto	X	X	X	X	X	724-1440	X	X
Villavicencio	X	X	X	360-1440	X	X	X	X
Yopal	X	X	X	360-1440	X	X	X	X
Mocoa	X	X	X	X	X	X	724 -1440	X
Arauca	X	X	X	724-1440	X	X	X	X
Puerto Carreño	X	X	X	724 -1440	X	X	X	X
Puerto Inírida	X	X	X	10080	X	X	X	X
San José	X	X	X	724 a 1440	X	X	X	X
Florencia	X	X	X	724 -1440	X	X	X	360-1440
Leticia	X	X	X	10080	X	X	X	X
Mitú	X	X	X	10080	X	X	X	X

Table 34. WFP last mile distribution from warehouse 1

		Location	Benef-iciaries	Warehouse 1	
				Jamundi	
				Travel times in minutes	Travel Costs (COP)
Demand nodes	POD 1	Villa Colombia	301	60	65,000
	POD 2	San Antonio	385	60	65,000
	POD 3	Poteriro	720	30	30,000
	POD 4	Timba-Valle	393	60	65,000
	POD 5	Robles	501	50	65,000
	POD 6	Quinamayo	316	50	65,000
	POD 7	Villa Paz	590	50	65,000
	POD 8	Gaitán	220	20	12,000
	POD 9	Bocas del Palo	85	40	65,000
	POD 10	Guachinte	166	40	50,000
	POD 11	Paso de la bolsa	212	20	30,000
	POD 12	La ventura	54	50	65,000

Table 35. WFP last mile distribution for warehouse 2

		Location	Population	Warehouse 2	
				Buenos Aires, Cauca	
				Travel times in minutes	Travel costs (COP)
Demand Nodes	POD 13	Timba-Cauca	436	50	130000
	POD 14	La portada	101	50	130,000
	POD 15	La balsa	166	50	130,000
	POD 16	San Miguel	66	60	130,000
	POD 17	Palo Blanco	93	80	130,000
	POD 18	Mandules	24	111	1,500000
	POD 19	Las villas	62	70	130,000
	POD 20	San Francisco	212	70	130,000
	POD 21	Bello Horizonte	54	90	150,000

Table 36. WFP last mile distribution for warehouse 3

		Location	Population	Warehouse 3	
				Palmira	
				Travel times in minutes	Travel costs (COP)
Demand Nodes	POD 22	Rozo	1217	70	150,000
	POD 23	Boyaca	289	50	150,000
	POD 24	Cabecera	597	50	150,000
	POD 25	La Pampa	262	30	150,000

Table 37. WFP last mile distribution for warehouse 4

		Location	Population	Warehouse 4	
				Tulua	
				Travel times in minutes	Travel costs (COP)
Demand Nodes	POD 26	Cienegueta	181	20	250,000
	POD 27	La balastrera	170	15	250,000
	POD 28	La rayadora	1679	15	250000
	POD 29	La cruz	374	20	250,000
	POD 30	Aguaclara	975	40	250,000
	POD 31	Mateguadua	47	40	250,000

Table 38. WFP last mile distribution for warehouse 5

		Location	Population	Warehouse 5	
				Buga	
				Travel times in minutes	Travel costs (COP)
Demand	POD 32	Presidente	624	20	200,000
	POD 33	Chambimbal	293	25	200,000
	POD 34	Manantial	139	30	200,000
	POD 35	Altobonito	601	15	200,000
	POD 36	Balboa	1206	0	200,000

Table 39. WFP last mile distribution for warehouse 6

		Location	Population	Warehouse 6	
				Candelaria	
				Travel times in minutes	Travel costs (COP)
Demand Nodes	POD 37	Urbano	416	30	130,000
	POD 38	Arenal	51	25	130,000
	POD 39	Buchilo	12	30	130,000
	POD 40	cabuyal	251	25	130,000
	POD 41	Carmelo	613	25	130,000
	POD 42	Caucaseco	447	40	130,000
	POD 43	Juanchito	120	45	130,000
	POD 44	Regina	93	30	130,000
	POD 45	San Joaquin	43	30	130,000
	POD 46	Carmelo	613	45	130,000

Table 40. WFP last mile distribution for warehouse 7

		Location	Population	Warehouse 7	
				Notiva	
				Travel times in minutes	Travel costs (COP)
Demand Nodes	POD 47	Multiple urban areas	2705	0	0
	POD 48	Tambito	254	120	100,000
	POD 49	La puente	123	120	100,000
	POD 50	Sed de Cristo	72	120	100,000
	POD 51	Quebrada larga	163	90	90,000
	POD 52	Tigre	192	80	75,000
	POD 53	Afua Clara	183	60	70,000
	POD 54	Sesego	139	45	65,000
	POD 55	Agua sucia	90	75	90,000
	POD 56	Pindaza	339	70	70,000
	POD 57	Santa Rosa	267	60	70,000
	POD 58	San Lorenzo	189	45	70,000

Table 41. WFP last mile distribution for warehouse 8

		Location	Population	Warehouse 8	
				Quibdo	
				Travel times in minutes	Travel costs (COP)
Demand Nodes	POD 59	Fuego verde	2468	45	2,000,000
	POD 60	Paraiso	3147	45	2,000,000
	POD 61	Caraño	571	40	2,000,000

Table 42. WFP last mile distribution for warehouse 9

		Location	Population	Warehouse 9	
				Tumaco	
				Travel times in minutes	Travel costs (COP)
Demand Nodes	POD 62	Comuna 4	1232	30	60,000
	POD 63	Tangareal	505	60	120,000
	POD 64	Km 35,36,37	443	60	120,000
	POD 65	Iberia	520	30	60,000
	POD 66	Porvenir	628	30	60,000
	POD 67	Otros barrios colindales	347	30	60,000

Appendix I

MATHEMATICAL MODEL AND CODE

Parameters

T: planning horizon

τ_i: $travel\ time\ between\ node\ i\ \in DN\ and\ the\ distribution\ center$

δ_i^0: $initial\ deprivation\ time\ at\ node\ i\ \in DN$

I_n^o: $initial\ inventory\ available\ at\ node\ n \in N$

u: $consumption\ rate$

h: $number\ of\ time\ periods\ satisfied\ by\ a\ full\ serving\ of\ supplies$

P_i: $population\ at\ node\ i \in DN$

K: $number\ of\ identical\ vehicles\ available$

Q: $Vehicle\ capacity$

Variables

d_i: $number\ of\ deliveries\ to\ node\ i\ \in DN$

q_i: $shipment\ size\ (number\ of\ commodities) to\ demand\ node\ i\ \in DN$

δ_i^1: $deprivation\ time\ experienced\ at\ node\ i$

$\in DN\ during\ the\ first\ deprivation\ period$

δ_i^*: $deprivation\ times\ experienced\ at\ node\ i$

$\in DN\ during\ deprivation\ time\ 2..d_i + 1$

γ_i: $total\ deprivation\ cost\ at\ node\ i\ \in DN$

Objective function

$$Minimize \sum_{i \in DN} \gamma_i + \sum_{i \in DN} (2\tau_i C^T)_i$$

Subject to

$$\delta_i^1 \geq \delta_i^0 + \tau_i - \frac{I_i^0}{uP_i} \quad \forall i \in DN$$

$$\delta_i^* \geq \frac{1}{d_i}\left(T + \delta_i^0 - \delta_i^1 - \frac{q_i d_i + I_i^0}{uP_i}\right) \quad \forall i \in DN$$

$$\delta_i^1 \geq \frac{1}{d_i + 1}\left(T + \delta_i^0 - \frac{q_i d_i + I_i^0}{uP_i}\right) \quad \forall i \in DN$$

$$\gamma_i \geq P_i\left(\Gamma(\delta_i^1) + d_i \Gamma(\delta_i^*)\right) \quad \forall i \in DN$$

$$q_i \geq huP_i \quad \forall i \in DN$$

$$q_i \leq Q \quad \forall i \in DN$$

$$\sum_{i \in DN} d_i \tau_i \leq TK \quad \forall i \in DN$$

$$\sum_{i \in DN} q_i d_i \leq I_j^0$$

$$d_i \geq 1 \quad \forall i \in DN$$

$$\delta_i^* \geq 0, \ \gamma_i \geq 0, \ q_i \geq 0, \ d_i \geq 0, integer$$

AMPL Code

```
# MODELO: Perezmodel.MOD

#Allocation model one commodity

#Sets declared

set Nodes;

# Parameters

param t{Nodes}>=0; # ! (1)Travel time between demand node i E DÅ∏ and the DC

param s{Nodes}>=0;   #  ! (2)Initial deprivation time at node i E D

param I{Nodes}>=0;   #  ! (3)Initial inventory available at demand node i

param w>=0; # ! (4)Initial inventory available at supply node k

param h>=0;  # ! (5)Number of time periods satisfied by a full serving of supplies

param p{Nodes}>=0;  # ! (6)Population at node i E D

param c>=0; # ! (7) Travel costs over planning horizon T

param u>=0; # ! (8) Consumption rate

param T>=0; # ! (9) Planing horizon

param Q>=0; # ! (10)Maximun vehicle capacity

param K>=0;  # ! (11)Number of vehicles of the same size-Not limited ...or set of vehicles type?

#Decision variables

var d {i in Nodes}>=0 integer;  #(1)Number of deliveries to node i E D

var q {i in Nodes}>=0 integer;   #(2)Shipment size (number of commodities) to demand node

var s1 {i in Nodes}>=0;          #!(3)Initial deprivation time, experienced at node DiÅ∏during the first deprivation period
```

```
var sx {i in Nodes}>=0 ;    #!(4)Regular deprivation times, experienced at node DiÅ∏during deprivation periods 2...di+

var F {i in Nodes}>=0 ;      # !(5)Total deprivation cost at node i E D

# Objective Function

minimize TC:sum{i in Nodes}  F[i]+ sum{i in Nodes} 2*t[i] * c  *d[i];

#!(1) deprivation times at the first and subsequent deprivation periods contraint


subject to  Constraint1 {i in Nodes}:

s1[i]>=s[i]+t[i]-(I[i]/(u*p[i]));

subject to Constraint2 {i in Nodes}:

sx[i]*d[i]>=(T+s[i]-s1[i]-(q[i]*d[i]+I[i])/(u*p[i]));

subject to Constraint3  {i in Nodes}:

s1[i]*(d[i]+1)>=(T+s[i]-(q[i]*d[i]+I[i])/(u*p[i]));

#!(2)Total deprivation costs at the demand nodes constraint

 subject to Constraint4 {i in Nodes}:

F[i]>=p[i]*(exp(1.5031+0.1172*s1[i])

-exp(1.5031)+d[i]*(exp(1.5031+0.1172*sx[i])-exp(1.5031)));

#!(3)Prevention of partial deliveries from creating a time-expanded network

subject to Constraint5 {i in Nodes}:

q[i]>=h*u*p[i];

#!(4)maximum vehicle capacity constraint

subject to Constraint6 {i in Nodes}:

q[i]<=Q;

#!(5)Total vehicle travel time constraint

subject to Constraint7 :
```

```
sum {i in Nodes} d[i]*t[i]<=T*K;
#!(6)Supply inventory restrictions constraint
subject to Constraint8 :
sum {i in Nodes}  q[i]*d[i]<=w;
subject to Constraint9 {i in Nodes}:
 d[i]>=1;
# Data entry
```

Appendix J

HYPOTHETICAL SCENARIOS INPUT PARAMETERS AND OUTPUTS

See excel file attached.