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Humanitarian Logistics and Sustainability

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Humanitarian Logistics and Sustainability

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Preface

This book is destined to deliver important information and input regarding the questions arising with *sustainability* in humanitarian logistics from different angles. The individual chapters are therefore sequenced according to three main streams, providing a holistic view regarding the combination of humanitarian aid and sustainability concepts:

Part I outlines *Basic Concepts and Strategies* for sustainable humanitarian logistics, starting with a first introduction chapter by the editors, addressing foremost the question why sustainability aspects are important in humanitarian logistics and how long-term approaches can benefit humanitarian operations. Three further chapters by *Aimen Reminda* regarding systemic approaches in this matter, *Richard Olorunttoba* regarding an empirically based framework as well as *Matthias Klumpp* transferring the topic into a basic definition and questions regarding research into sustainable humanitarian logistics.

Part II describes specific problems and implementation concepts of sustainable management in procurement and preparedness in humanitarian supply chains. First of all, *Jacob Hasselbalch, Nives Costa* and *Alexander Blecken* from UN UNOPS discuss hurdles for sustainable procurement options in the UN organizations. Second, *Bernd Hellingrath, Teo A. Babun, James F. Smith* and *Daniel Link* describe important research results in preparing airports and seaports for disaster reaction in the early stages of humanitarian supply chains. Third, *Chenrong Ni, Robert de Souza, Qing Lu* and *Mark Goh* complement this view towards sustainability and preparedness with system dynamics applications in this field. Finally, an optimization approach with a cooperative warehouse hub concept for humanitarian aid operations from Germany is discussed by *Hella Abidi, Christof Kandel, Solveig Zinnert* and *Matthias Klumpp* in order to increase sustainability in preparedness for humanitarian organizations.

Part III outlines specific experiences and detailed questions of achieving sustainability in humanitarian operations “on the ground”. Therefore, first *Dorit Bölsche* discusses the crucial question and role of dangerous goods in humanitarian logistics; this in itself can be expected to be along-lasting sustainability question within humanitarian operations for many decades. Furthermore, *Alberto Regattieri,*

Giulia Santarelli, Francesco Piana and *Mauro Gamberi* present concepts and experiences regarding waste management in refugee camps, a major part of humanitarian processes, especially regarding sustainability. Again, *Xie Wei, Abbas Al-Refaie, Melissa Robles* and *Bernd Noche* take this perspective a step further by examining ex-post optimization potential for the devastating Wenchuan earthquake with 70,000 casualties in China—highlighting, that a major point in sustainable humanitarian actions may indeed simply be a professional lessons learned approach regarding historic processes with disasters. Taking these experiences a step further, *Julian Harke* and *Sander de Leeuw* are outlining a concept to improve sustainability by enhanced education and learning regarding the case of prepositioned inventory. The final contribution discusses a "closed-loop" sustainability evaluation by the way of discussion of evaluation criteria in performance measurement systems for humanitarian organizations by *Hella Abidi* and *Kirstin Scholten.* This could gladly provide the basic idea of an ongoing management circle also for sustainability in humanitarian logistics as this last evaluation step and concept may again lead to adjustments in sustainability concepts as well as the improvement of individual operations and processes throughout the humanitarian relief supply chain. In this expectation we also share the mission of this book in communicating an elevated understanding for the challenge regarding sustainability—and finally improving efficiency and effectiveness in day-to-day humanitarian logistics in order for as many people as possible to profit from that approach.

Essen, October 2014 — Matthias Klumpp
Amsterdam — Sander de Leeuw
Bologna — Alberto Regattieri
Singapore — Robert de Souza

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Part I
Strategies for Sustainability

Chapter 1
Sustainability in Humanitarian Logistics—Why and How?

Matthias Klumpp, Sander de Leeuw, Alberto Regattieri and Robert de Souza

Abstract Concepts in humanitarian logistics have been a field of increasing interest as well as research and publication activities in the last decade, especially triggered by the response and logistics failures of the 2004 Haiti earthquake. Since then, many things have changed, inside humanitarian organizations (NGOs) with more professional logistics management and preparedness concepts as well as within government organizations, namely the UN organizations with the OCHA coordination effort in order to improve global alignment of humanitarian logistics assets and processes. Also, logistics research has contributed largely to the new professional development of humanitarian logistics, i.e. by transferring and adapting concepts from business logistics to the humanitarian sector or applying many field and case studies in order to understand the specific requirements and conditions in the field better.

The support by *Harold Teng*, *Mark Goh* and *Carmelita Liwag* in preparing the ASEAN statistics and case report are deeply appreciated.

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1.1 Background

Concepts in humanitarian logistics have been a field of increasing interest as well as research and publication activities in the last decade, especially triggered by the response and logistics failures of the 2004 Haiti earthquake. Since then, many things have changed, inside humanitarian organizations (NGOs) with more professional logistics management and preparedness concepts as well as within government organizations, namely the UN organizations with the OCHA coordination effort in order to improve global alignment of humanitarian logistics assets and processes. Also, logistics research has contributed largely to the new professional development of humanitarian logistics, i.e. by transferring and adapting concepts from business logistics to the humanitarian sector or applying many field and case studies in order to understand the specific requirements and conditions in the field better.

This also led to many workshops and fairs as well as conferences where the actors met, among them also the FOM ild International Workshop on Humanitarian Logistics, with the first event taking place in 2011 in Essen, summing up a status quo of the international humanitarian logistics sector. In 2012 the subsequent second workshop dealt with performance measurement and the third workshop in 2013 brought the topic of sustainability in humanitarian logistics into the headlights, building the basis for this book.

Further workshops will be held in Essen/Germany with the support from FOM University of Applied Sciences as well as many partners and the renowned research cluster "EffizienzCluster LogistikRuhr", the largest logistics research cluster in Europe, located in the German Ruhr area. From these research endeavors also stems the cooperation of the *editors* for this book, bringing together logistics researchers from the Netherlands (VU University), Italy (University of Bologna), Singapore (National University of Singapore) and Germany (University of Duisburg-Essen, FOM University of Applied Sciences Essen).

1.2 Why Sustainability?

Sustainability is an old concept but newly rediscovered and named phenomenon in society and research: Whereas from the beginning of mankind human actions and decisions had an impact on the environment and nature, only with the beginning of civilized structures and the connected number of people had these impacts long-term consequences and also negative effects on humans themselves: When the *Romans* in the first millennium B.C. for example used all the available wood in Italy for ship building above the sustainable rate of cutting down forest in the Apennine mountains, they experienced the first—still locally restricted—climate change with more arid and less fertile climate results.

Since then climate and environment impacts and changes have been a normal question of the relationship of mankind with nature, sometimes leading to mass

migration or other results in societies. But since the 18th century a new development took hold with the *industrial revolution*: On the one hand due to unprecedented productivity increases in agriculture as well as in manufacturing, the number of humans was able to grow enormously until the 7 billion people now inhabiting planet earth. On the other hand, the use of carbon-based energy sources to fuel this growth led to one of the first global and probably irreversible impact of human actions to the ecosystem: The experienced and predicted climate change due to the global increase of carbon dioxide levels in the air.

Quite fittingly, the modern understanding of sustainability as a concept was also propagated in the 18th century by *Hans Carl von Carlowitz*, a German agriculture and forest scientist, defining the sustainable concept for wood cutting 1713 for the first time with the words "Wird derhalben die größte Wissenschaft und Einrichtung hiesiger Lande darinnen beruhen, wie eine sothane Conservation und Anbau des Holtzes anzustellen, daß es eine continuierliche beständige und *nachhaltende* ["sustainable"] Nutzung gebe, weiln es eine unentberliche Sache ist ohne welche das Land in seinem Esse nicht bleiben mag" (*Sylvicultura Oeconomica*, p. 105–106).

This first principle was discussed in further research and publications and came to public notice on a global scale for the first time during the 1970s with the 1972 'Club of Rome' report *Limits of Growth* and led to the 1987 UN Brundtland-Report *Our Common Future* with the modern-day definition of sustainability: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (p. 54).

Today this concept is meant to be applied to all areas of society, therefore also to the field of humanitarian logistics—with the special interest of all the humanitarian actors also to mitigate or even to avoid future disasters in the wake of climate change and therefore strive for sustainability on its own account. In this sense, this contributed book was put together in order to provide a first overview of sustainability concepts in all humanitarian logistics processes and areas as well as field for further research and development in the understanding of a guiding light for further research processes.

1.3 Sustainable Operations: There is More Than Meets the Eye

In a 2009 Journal of Operations Management paper, Schmenner et al. questioned the extent to which the operations field has been focusing too much on theory and too little on understanding. The field of operations management, of which Humanitarian Logistics may be considered a part, is a broad field in need of a variety of methods. Schmenner et al. amongst others make a good point by arguing to what extent we need more theories; aren't we in need of a better understanding of the world around us?

Literature reviews in our field show a recent surge in papers in the humanitarian logistics domain. Most likely this is an area that academics view as a field with potential. It is a relatively recent field and being in a new field gives authors a better chance to get papers published than a field with ample research coverage. Several of these reviews also show that only few papers are related to the actual practice of humanitarian logistics. Particularly in a field like humanitarian logistics of which we know relatively little compared to the commercial business world this is something to wonder about: how can we publish about a field we know so little of?

At first glance no one will argue about the need for sustainable solutions in humanitarian supply chains. However, what does this concept of sustainability exactly entail? Long ago agencies have started to use bio-degradable plastics in humanitarian relief efforts. In many developing countries there for example is an abundance of plastic bags piled up against fences, contaminating environments. Using bio-degradable plastics would at least ensure that we get rid of this plastic. Tarpaulins—the cover sheets that are often used as emergency shelter—these days are also made of bio-degradable plastic. A visit to the largest refugee camp in the world in Dadaab in Kenya a while ago was very insightful: the plastic shelter sheeting used there indeed degraded in the 40 degrees heat, sun and desert wind—albeit already 6 months after having been installed. Although tarps are used as shelter after an emergency they typically are used beyond the immediate relief period. Several recent disasters have shown us that a year down the line life is not yet back to normal and tarps are still used as shelter material. Even when visiting New Orleans 5 years after Katrina one could see many houses still using plastic sheets to patch up their roofs—the blue plastic was very well visible from out of the landing aircraft. In areas such as Dadaab the quality of shelter material has deteriorated a year down the line—mainly because it does what it should: the plastic has degraded; the climate conditions in this area speeded the process a bit up. The question now is who pays for new shelter material, because the beneficiaries are still in need. One may thus wonder whether this is a sustainable solution to begin within a continent that lives by the constant reuse of material. Sustainability in humanitarian aid is complicated.

This is not the only example where problems at first glance seem easy but turn out to be in a way wicked when studied closely. The role of funding in supply chain management is virtually unexplored, and why has no one ever wondered why humanitarian organizations do not report working capital charges in their annual reports? Why make up problems ourselves or focus on theoretical concepts that are not related to practice if the world is full of interesting and inherently complex problems? Probably this is scary to many: it means that we academics need to spend our time differently. We should spend our time in the field, not behind our desk. That is the only way to understand this area and make progress in the field of humanitarian logistics. There is more than meets the eye in this field and there is a dire need to uncover that.

1.4 The Technical Perspective of Sustainability in Humanitarian Operations

In recent decades, engineers and scientists have been increasingly applying their various skills to the needs of humanitarian logistics, from support to the development of effective and sustainable solutions for helping to provide food, accommodation, and improved medical care. Today a key trend in the humanitarian sector is a shift from developing isolated technical solutions to engaging in much wider system strategies that consider and address the full socio-technical context of humanitarian problems. This trend is related to the shift from direct aid to capacity building, moving the focus from the things people need to the larger contexts in which those things must work in an effective way. When this larger context is not incorporated into technology-based humanitarian projects, the technical solutions are not sustainable in the long term, even if they are able to achieve a short-term, immediate goal.

In this context the technical perspective in humanitarian logistics must be integrated with other aspects of humanitarian help, such as for example the energy (electricity) supply, the Information and Communication Technology (ICT) infrastructure and waste management. Considering this systemic approach new challenging problems involve the technical perspective of humanitarian logistics.

Transport management remains a major concern in humanitarian logistics. Several approaches modeling the use of transport resources in disaster relief are developed, usually deriving them from the military context. The packaging of materials plays a fundamental role in the optimization of transport. But packaging at the end of its main function can represent an important resource in terms of re-utilization of materials to build useful equipment and tools (e.g. household equipment such as cradles, backpacks, stools, etc.).

The use of packaging is closely linked to waste management. Humanitarian crisis can generate large quantities of waste that threaten public health, hinder reconstruction and have an impact on the environment. Disaster waste (DW) can also be generated during the response and recovery phases. Humanitarian actions are typically concentrated in specific locations.

This also means that waste is concentrated in specific areas. Refugees leaving their camps to go back home may leave their tents behind resulting in huge quantities of plastic to be composed off. Properly incinerating may not always be possible, not just because of lack of capacities to do so but also because products are often composed of multiple materials that need to be taken apart (e.g. zippers and metal rings need to be taken out of tents before they can be incinerated). The capacity to take these products apart is often not available in the wake of refugee returns. As a result, unfortunately waste is often left to accumulate and decompose, or is removed and dumped in an uncontrolled manner. DW also presents opportunities: it may contain valuable material such as concrete, steel, and timber as well as organics for composting. This value can be realized as either a source of income or as a reconstruction material, and can reduce burdens on natural resources that might otherwise be harvested for reconstruction.

The United Nations (UN) stated that the lack of electricity during a crisis limits the aid opportunities. Therefore, a reliable, low impact and rapid access to electricity is a key factor in a crisis. The diesel engine electrical generator is the traditional ineffective solution. New technical solutions are needed, including for example low-power stationary facilities, mechanical transducers, passive generation devices (e.g., charge as you walk) and renewable energy hubs.

Information and communication infrastructures support a wide range of humanitarian systems, including logistics, organizational learning, health care and the fundamental initial assessment. The new technological developments in ICT and the new trend in social computing based on many-to-many communication can represent a great opportunity for a quick sharing of informations. Currently, often a one-to-many communication system is applied: people that do not trust the central authority have no way to communicate critical informations.

In conclusion, new technological developments can effectively support the future challenges in humanitarian logistics. But it is important that new generations of engineers and scientists are prepared to take on these complex activities with a systemic approach, considering all the different aspects involved.

1.5 International Sustainability Perspective: The ASEAN Example

In the decade from 2002 to 2012, China, the United States, the Philippines, India, and Indonesia were among the top five countries in the world that experienced the greatest number of natural disasters.[1] Records show that the deadliest natural calamity in recent times in terms of the loss of human lives was the 2004 Boxing Day tsunami in which over 250,000 people died, while the most expensive natural disaster was the 2013 Hurricane Sandy in the United States inflicting some US $50 billion worth of damages. Amongst these five countries, Indonesia and the Philippines are situated right in Southeast Asia.

Southeast Asia is a geographically, ethnically, and culturally diverse region. The ten member states within the Association of Southeast Asian Nations (ASEAN) belong to this region, which has been experiencing numerous natural incidents each year. This is especially true for countries such as Indonesia, Thailand, the Philippines, and Vietnam. These four countries suffer the brunt of most natural (and sometimes man-made) disasters every year within ASEAN.

In both 2013 and 2012, Asia experienced the largest damage on human lives and property, and was frequently impacted by natural disasters, receiving about 40.7 % of the world's total share of reported disasters. Indeed, from 1970 to 2011, Asia witnessed 1.93 million deaths due to disasters, as indicated by Fig. 1.1.

[1] Annual Disaster Statistical Review 2012, Centre for Research on the Epidemiology of Disasters (CRED), Institute of Health and Society, Catholic University de Louvain, Brussels, Belgium.

Fig. 1.1 Deaths due to disasters in Asia (1970–2011)

Collectively, in 2012, the 145 disasters within Asia affected 64.5 % of the global disaster victims or about 80 million people. This number is equivalent to the population of Vietnam. Monetary-wise, the impact is similar: The losses for direct disasters are at least 50 % higher than the internationally reported figures. The total direct losses in the forty low and middle income countries amounted to US $305 billion over the past thirty years. Of these, more than 30 % were not internationally reported.[2] Many of these disaster victims hail from Southeast Asia.

As noted from Fig. 1.1, ASEAN is affected by many of such natural disasters of varying magnitudes each year. Some disasters may affect a small loss in lives but definitely a large amount of damage to infrastructure and the environment. There is an initiative called the ASEAN Coordination Centre for Humanitarian Assistance on Disaster Management (AHA Centre). The AHA Centre is an inter-governmental organisation, based in Jakarta, which aims to facilitate cooperation and coordination among ASEAN members and with the United Nations and international organizations for disaster management and emergency response within ASEAN. Established in 2011, the AHA Centre is governed by the members of the ASEAN Committee on Disaster Management (ACDM), which consists of the Heads of the National Disaster Management Offices.[3] However, the AHA Centre's effectiveness has not been very visible to communities.

As highlighted, the total amount of damages in ASEAN from 2004 to 2013 is about US $50 billion over the ten-year period. This is close to the estimated GDP of Myanmar in 2012 alone or a 0.1 % share of the world's total GDP in PPP terms. From ASEAN's perspective, this represents a loss of 10 % of its membership GDP. The loss of GDP is not ASEAN specific and although the direct impact of disasters on a population can be dreadful the long-term effects may even be worse. We need more research to identify how we can balance short term relief efforts with long-term efforts to stabilize economies and focus on GDP growth.

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[2] See UNISDR, Global Assessment Report on Disaster Risk Reduction (2013).

[3] For more information, see http://www.ahacentre.org.

Chapter 2
A Systemic Approach to Sustainable Humanitarian Logistics

Aimen Remida

Abstract With the purpose of drawing a general outline of a systemic approach, which take into account the ecological, economic and social dimensions of sustainability and simultaneously the increasing complexity of logistics systems within disaster relief operations, the systems thinking paradigm is briefly introduced and presented in a manner that emphasizes its adequateness and applicability in Humanitarian Logistics (HL) research. The context of sustainable development in general and the Triple-Bottom-Line (TBL) perspective in particular are considered as substantial parts of the polycontextual environment of the sustainable HL-systems, which are the objects of inquiry of Sustainable Humanitarian Logistics (SHL) as a specific research field. The main principles of the suggested systemic approach are described within an analysis which includes concrete application possibilities.

2.1 Introduction

Several challenges are urging the scientific community as well as the economic and political players to consider the requirements of sustainable development in their attempts to find appropriate solutions to the natural, social and technical complications observed in the increasingly complex systems of disaster relief operations. Both concepts of "sustainability" and "systems thinking" are subjects to controversial interpretations. Nevertheless sustainability is itself systemic since it primarily aims to ensure the conditions for the continued existence of the modern economic system in which the negative impacts of the contradictions within this system are abolished or compensated (Elling 2010).

In order to increase the ability of practice and research in Humanitarian Logistics (HL) to deal with the complexity of the events and phenomena on the one hand and

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the dynamics of the relationships between the involved stakeholders, who are acting in vulnerable contexts with their corresponding changing requirements on the other hand, a systemic approach is needed to emphasize the coextensive consideration of different dimensions of sustainability in conceiving adequate responses to the complex challenges of HL, so that a specific research field could be recognizable, namely: Sustainable Humanitarian Logistics (SHL).

The systems thinking paradigm is offering the opportunity of taking into account interdependent research questions at once by considering the contingent relationships between the system' elements, which could be various entities, belonging to different ontological levels such as objects, organizations, natural and social multisided constructs etc. This could present a promising starting point for dealing with the raising complexity of today's knowledge management in HL.

In this paper the concept of systems thinking as a scientific paradigm is briefly initiated (Sect. 2.2). This occurs with an emphasis on the adequateness of systemic approaches in managing the complexity of contemporary socio-technical systems in general and HL in particular. The subsequent introduction of the concept of sustainable development (Sect. 2.3), with the field of humanitarian aid as analogously standing in the foreground, contributes deducing the main characteristics of sustainable HL-systems. Finally, with regards to this general analysis of sustainability in HL-systems, whereby interrelated requirements are influencing the efforts in practice, research and education, three basic principles of a systemic approach to SHL are identified (Sect. 2.4).

2.2 The Systems Thinking Paradigm

2.2.1 Historical and Methodological Insights

This section aims at presenting some relevant features of the systems thinking paradigm in order to investigate to what extent it could be considered as an appropriate set of tools in studying HL-systems in the context of sustainable development. The word "paradigm" is used here to stress the epistemological wholeness of the concept "system" beyond any restrictions made by predefined scientific theorization. Indeed scientists can agree in their identification of a paradigm without agreeing on, or even attempting to produce, a full interpretation or rationalization for it (Kuhn 1970).

Systems thinking is deeply rooted in human civilizations: Cultural, intellectual and scientific achievements from early Chinese, Egyptian and Greek polymaths and philosophers (e.g. Imhotep, Confucius, Aristotle) to the contributions of the centuries of Renaissance and Enlightenment (e.g. L. Da Vinci, F. Bacon) are witnessing a systems-oriented cognitive tendency. It culminates in the 20th century with the emergence of the General System Theory (GST) (e.g. L. von Bertalanffy, Boulding, Rapoport) and Cybernetics (e.g. Norbert Wiener, Heinz von Foerster)

which accompanied the advances in several disciplines and allow the establishment of new research fields and scientific paradigms with the related concepts and terminologies [e.g., Systems Engineering (SE), Operation Research (OR)]. The pioneers of these developments were basically scholars with a solid interdisciplinary background: many of them were biologists and natural scientists with knowledge in philosophy, psychology and social sciences. This is essential to grasp the multi-sided perspectives of today's complex systems which involve almost every aspect of the human activities.

Beside the fact that it seems impossible to fix a genuine definition of the word "system", one could assume with the founders of General Systems Theory that "a system can be defined as a set of elements standing in interrelations" (Von Bertalanffy 1968, p. 55). Going one step further, "an open system is defined as a system in exchange of matter with its environment, presenting import and export, building-up and breaking-down of its material components" (Von Bertalanffy 1968, p. 149). It follows that an extension of these definitions could lead to recognize the existence of three concepts which may be found in almost all systems perceptions since they show an unlimited semantic and functional interchangeability:

- **The environment**: is designing the realms outside of the system. The relations of the system with its environment indicate to which extent the system is called an open or a closed system.
- **The subsystem**: is a part of the system which could be considered either as an element (in a bottom-up approach) or as a system itself (in a top-down approach).
- **The element**: is the basic component of a subsystem (or a system).

The interchangeability of these concepts is the cornerstone of the methodology used in this paper. In fact each object of study could be considered either as (1) a system in an environment and thus having its own components (subsystems and elements), or as (2) a subsystem belonging to a system of a higher level, or even as (3) the basic element in a subsystem which is included in a larger system (Fig. 2.1). Some objects of study could also be seen as environments for systems; especially if they are themselves social or cognitive systems.

Within a systemic approach to HL which pursues the objectives of sustainability in the implemented methods of planning, execution and control, the focus will be on various levels and affecting different aspects: the use of environmentally sound equipment, items and transportation and storage systems during the interventions is combined with the planning of social-oriented initiatives and strategies for reconstruction and development assistance which are based on a long term vision of economic prosperity. This requires an enlargement of the current understanding of collaboration between stakeholders and an interdisciplinary orientation in research and practice going far beyond logistics and supply chain management.

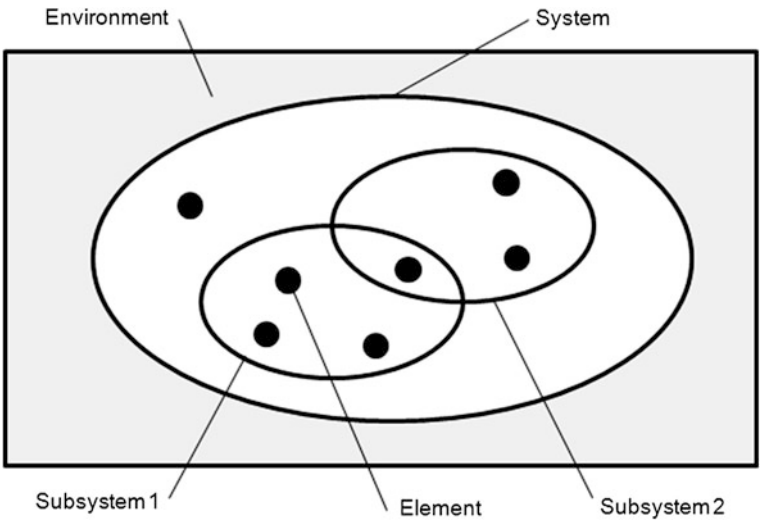

Fig. 2.1 A general system's configuration

2.2.2 Managing Complexity

The systemic approach seeks at a simultaneous consideration of various interconnected sides of complexity: the complexity of the (built and natural) environment which includes the complexity of geopolitical, economic and social contexts with the corresponding phenomena (e.g. urbanization, global, regional and local conjunctures) as well as the complexity of the behavioral issues in relation with decision making and the trade-off strategies between the different, often contrasting, interests of the stakeholders of the HL-systems.

2.2.2.1 The Category of Complex Disasters

The classical distinction between natural and man-made disaster should not hide the existence of specific cases whereby both origins are combined, the so called complex disasters. In addition, it is possible that both sudden-onset and slow-onset disasters strike in the same location at the same time. Kovacs and Spens observe in (2009) that on the African continent some patterns of slow-onset disasters are categorized as complex emergencies as they are the results of armed conflicts. It is for example the case of the population in Darfur, Sudan, which is facing the devastating consequences of repetitive armed attacks while still suffering under drought and famine.

A further recent example of complex disasters is the case of Fukushima, Japan, where on March 11th, 2011 the Tohuko earthquake and Tsunami caused a series of releases of nuclear materials at a nuclear power plant. The effects of the disaster are

still difficult to manage since they are not only concerning the local population and ecosystem but also reaching the entire globe if we take into account the economic and political consequences and in particular the lessons learnt in terms of predictability and prevention.

The interrelated difficulties in dealing with complex disasters emphasize the need for a systemic approach to HL-systems which are already denoted by numerous complexities. These are basically regarding unknown factors (place, severity, etc.), time, trained logisticians, media and funding, equipment and information technology and interference (Overstreet et al. 2011).

2.2.2.2 Reduction Versus Absorption

There is a wide consensus among complexity theorists about considering organizations as complex adaptive systems (e.g. Schneider and Somers 2006). Seen as such, they have two main alternatives to deal with the turbulent and complex environment (Fig. 2.2): complexity reduction and complexity absorption (Boisot and Child 1999). Ashmos et al. argue in (2000) that complexity reduction is based on pursuing simplicity in the internal organizational arrangements while complexity absorption rests on facilitating information exchange and allowing the generation of multiple interpretation of information.

Organizations which pursue a complexity absorption response to complexity are more successful in dealing with complex environments since they pursue multiple and sometimes conflicting goals, a variety of strategic activities and because of the existence of high levels of participation by multiple stakeholder groups in decision making as well as more informal and decentralized structural patterns (Ashmos et al. 2000).

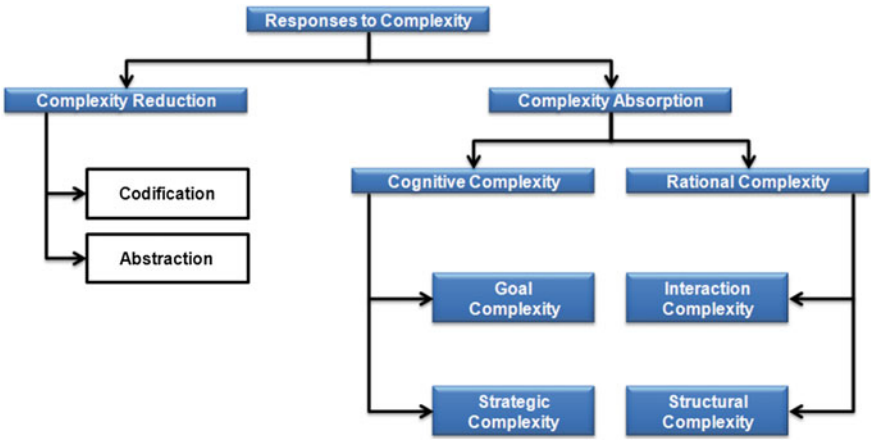

Fig. 2.2 Complexity reduction versus complexity absorption

When transferring these managerial alternatives into the environment of HL-systems, the organizations involved in HL are studied as complex adaptive systems which show different structures, strategies and goals so that sustainable collaboration patterns are often difficult to establish. The first alternative (complexity reduction) could be associated with the use of analytical approaches in order to solve isolated complications while the second (complexity absorption) deals with much more uncertainty and dynamics of the systems' environments and it calls therefore for using a systemic approach.

2.2.3 Analytic Versus Systemic Approaches

Although the two approaches are complementary, the analytic approach has been favored disproportionally in education and research. De Rosnay argued in (1979) that the "classic thought" based on solidity, rigidity, a unique consideration of physical time and reversible phenomena, linear causality as well as further features, as illustrated in Table 2.1, is transformed within the new modes of thought influenced by the systemic approach to emphasize flexibility, adaptability, duration, irreversibility and circular causality. "The dynamics of systems shatters the statistic vision of organizations and structures: by integration time it makes manifest relatedness and development" (De Rosnay 1979).

2.2.4 Applicability to Humanitarian Logistics

Systems thinking could be used for modeling dynamic and complex logistics systems which include several interconnected stakeholders. At a first level, the interrelations between the observed and studied phenomena could be visualized by means of appropriate tools such as Systems Dynamics (SD). Heaslip, Sharif and Althonayan are using in Heaslip et al. (2012) systems analysis and design techniques (SADT) in general and systems archetypes (SA) in particular to draw a detailed causal loop diagram of humanitarian logistics in a conflict-based context.

It should be mentioned that in recent years, several efforts are trying to investigate the application possibilities of Systems Dynamics in various HL-systems (e.g. Besiou et al. 2011; Gonçalves 2011).

Furthermore the systems paradigm includes the usage of Multi-Agent Systems (MAS) to model the behavior of the stakeholders. Within the framework of HL, the existing complex relationships between the donators, the beneficiaries, the international organizations and the logistics providers are investigated and modeled to allow constructing agile and real time-based logistics systems. This could affect the tracking of items, communication tools for the practice side as well as optimization and simulation methods as far as research and education are concerned. Thus this

Table 2.1 Analytic versus systemic approaches based on (De Rosnay 1979)

	Analytic approach		Systemic approach	
	Features	Examples of applications	Features	Examples of applications
1	Isolates, then concentrates on the elements	Detection of machine failure	Unifies, then concentrates on the interactions between elements	Chess play
2	Studies the nature of interactions	Linear correlation	Studies the effects of interactions	Macroeconomic analysis
3	Emphasize the precision of details	Industrial design	Emphasize global perception	Policy making
4	Modifies one variable at a time	Simple regression	Modifies group of variables simultaneously	Multiple regression
5	Remains independent of duration of time; the phenomena considered are reversible	Newtonian mechanics	Integrates duration of time and irreversibility	Processes in thermodynamics
6	Validates facts by means of experimental proof within the body of a theory	Chemistry experiments	Validates facts through comparison of the behavior of the model with reality	Simulation models
7	Uses precise and detailed models which are less useful in actual operation	Econometric models	Uses models which are insufficiently rigorous to be used as bases of knowledge but are useful in decision and action	models of the club of Rome (limits of growth)
8	Has an efficient approach when interactions are linear and weak	Elementary mathematics	Has an efficient approach when interactions are nonlinear and strong	System dynamics
9	Leads to discipline-oriented (juxtadisciplinary) education	One area of expertise in an applied science	Leads to multidisciplinary education	Combining natural sciences and humanities
10	Leads to action programmed in details	Automated systems	Leads to action through objectives	Reduction of GHG-emissions
11	Possesses knowledge of details, poorly defined goals	Division of labor	Possesses knowledge of goals, fuzzy details	Strategy development

(continued)

Table 2.1 (continued)

	Analytic approach		Systemic approach	
	Features	Examples of applications	Features	Examples of applications
12	Static vision (simple systems)		Dynamic vision (complex systems)	
	Solid			Fluid
	Force			Flow
	Closed system			Open system
	Linear causality			Circular causality
	Force equilibrium			Flow equilibrium

kind of applications could contribute bridging the gaps detected in HL practice, research and education, as well as between these (Kovacs and Spens 2011).

Since systemic approaches are resting upon a holistic understanding and a high adaptiveness to use various kinds of data and techniques, they could be considered as knowledge-based methodologies. Within the field of logistics activities, there is a need of Knowledge-Based Systems (KBS) that can collect, transform and store the organizational knowledge to support the stage of formulating logistics strategy in a systematic way (Chowa et al. 2005). Although this may emphasize a specific adequateness of systems-oriented approaches during the phases of disaster management cycle which require a high level of strategic logistics planning, the complexity of tactical and operational planning as well as the interdependencies of the geopolitical and economic realities make the systemic approach suitable in all phases of prevention, mitigation, preparedness, response and recovery. In fact the success of every disaster management system is highly dependent on the characteristics of the region affected by a disaster in addition to the characteristics and intensity of each particular disaster (Nikbakhsh and Farahani 2011).

2.3 Sustainable Humanitarian Logistics Systems

2.3.1 Modeling the Systemic Approach

One could argue that, broadly speaking, every HL-system is somehow a sustainable HL-system since it contributes in saving lives and improving the life conditions of the population. However this argument could be rejected by stressing the fact that sustainable HL-systems are conditioned by much more directness and effectiveness in pursuing sustainability objectives while HL-systems in general are adapting in-between-targets of the stakeholders which may indirectly serve the purposes of sustainable development.

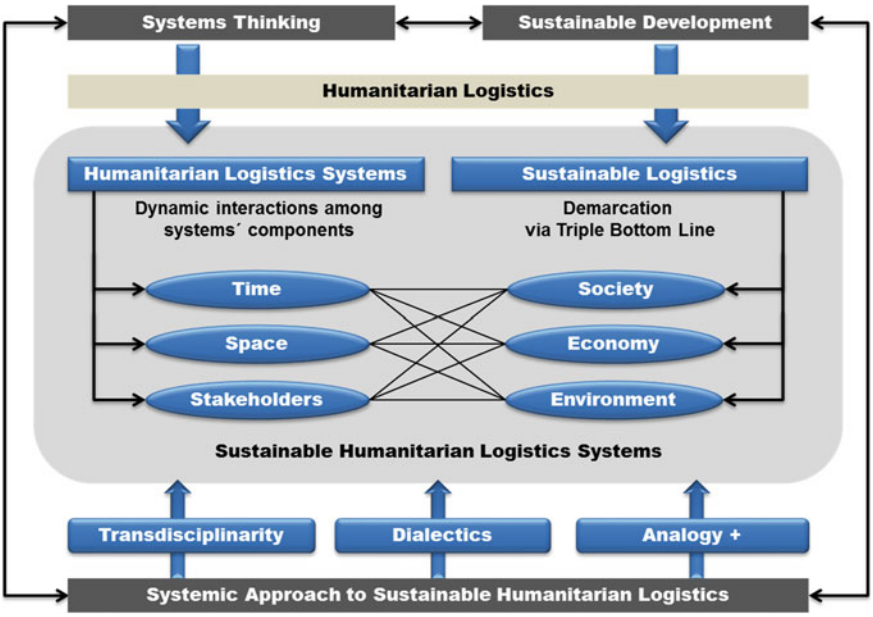

Fig. 2.3 Illustrative model of the systemic approach to SHL

The proposed systemic approach is basically considering HL-systems from the perspective of sustainable development. It combines theoretical starting points with methodological principals to focus on the potentialities to make logistics systems in the research and practice areas of humanitarian aid and disaster management. Figure 2.3 is showing the unifying model of the systemic approach, by highlighting the interrelationships between the elements of various subsystems. These elements could manifest emergent patterns if combined and perceived as components of sustainable humanitarian logistics systems.

2.3.2 A Polycontextual Environment

Interpretations of sustainability and sustainable development: Sustainable development is defined by the Brundtland report of the United Nations World Commission on Environment and Development as being the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987). This definition has been a substantial part of a fuzzy discourse and a vague understanding of sustainable development in politics and economy during the last decades. The used formulations contain significant weaknesses which include an incomplete perception of the problems of poverty and environmental degradation, and confusion about the role of economic growth and about the concepts of sustainability and participation (Sharachchandra 1991).

Since the concept of sustainability lays a strong emphasis on ethics (Elling 2010), the critical viewpoints are questioning not only the terminological usage but also the very essence of the notions surrounding sustainability; these critical voices are varying from "green washing" reproaches against organizations claiming the pursuit of sustainability goals to the radical denial of any link between climate change and human activity. In scientific and academic circles as well as in mainstream debates, the issues regarding sustainability are often reduced to the point of environment protection.

Technological advances in logistics: The crucial role of different logistics systems in disaster relief and humanitarian supply chain management is discussed in numerous contributions in HL research from an operative but not enough utilitarian perspective. Recent advances in Information and Communication Technologies (ICT), increasing automation, computational systems, and handling equipment and transportation engines are offering unprecedented opportunities towards sustainable logistics systems and hence creating a suitable environment for research, development and implementation.

Economic and geopolitical conjunctures: the so called mega-trends in our globalized world present general contexts for social and economic developments: the increasing urbanization, the demographic challenges, and the infinite prospects offered by internet tools, especially the social media, are among the major elements which shape the present and the future. Nevertheless they are at the same time powerful factors within recurring cyclical crisis and conflicts leading to armed interventions with catastrophic consequences.

2.3.3 The Triple Bottom Line as a Demarcation Framework

In the philosophy of science, the problem of finding a criterion which could distinguish between empirical sciences on the one hand and mathematics, logic and "metaphysical" systems on the other hand is called the problem of demarcation (Popper 2002). Apart from the different philosophical responses to the problem, the use of the idea of demarcation is here restricted to the attempt of determining a goal-oriented framework for a systemic approach which seeks at going beyond the differentiation induction/deduction.

In order to cope with the fuzziness of the concept of sustainable development and to integrate the variables of advanced technical logistics systems, business and managerial models as well as the phenomena surrounding social and physical transformations, a demarcation of the areas of investigation could be helpful while conceptualizing methodological approaches since it contributes in distinguishing between science and pseudoscience.

The trade-offs between the objectives of sustainable development were summarized in an illustrative figure (Manusinghe 1992) which was later further developed and called the sustainable development triangle (Manusinghe 2009). The consideration of the interconnections among the economic, social and ecological

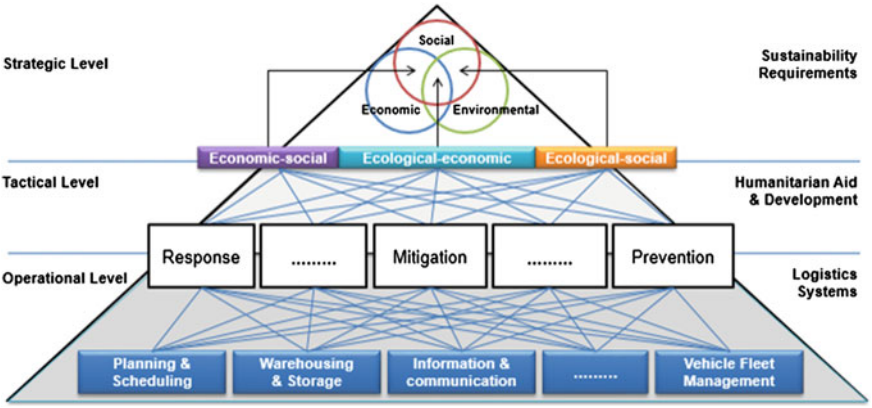

Fig. 2.4 Levels and interconnections among sustainable humanitarian logistics systems

dimensions of sustainability is also known as the Triple Bottom Line (TBL) (Elkington 1998). The three pillars are also referred to as "People, Planet and Profit". This perception of the balanced treatment of the different dimensions is allowing the detection of common areas, which could assist the emergence of new research questions. It was also the basis of particular methodologies and neologisms, such as "sustainomics" which is described as "a transdisciplinary, integrative, comprehensive, balanced, heuristic and practical framework for making development more sustainable" (Manusinghe 2009, p. 32).

According to the considered sustainable HL-systems, the elements, subsystems and interconnections among them, as well as the surrounding environment are undergoing a demarcation process which takes into account the capability of reaching three levels of goals as illustrated in Fig. 2.4: (a) Strategic: sustainability in its three dimensions, (b) Tactical: humanitarian relief as aiming at helping the concerned beneficiaries, and (c) Operational: logistics functionalities (e.g. supply chain, information systems).

2.3.4 Some Characteristics of Sustainable Humanitarian Logistics Systems

2.3.4.1 Enlargement of the Spatio-Temporal Horizon

The systemic reflections about sustainable concepts in HL request an expanding of the potentialities of opportunities in a way that ensure considering the interests of all actual and future stakeholders (next generations). At the same time no area on the globe should be left behind. Integrating different types of participants within an enlarged spatio-temporal perspective with a consideration of sustainability' dimensions is illustrated in Fig. 2.5.

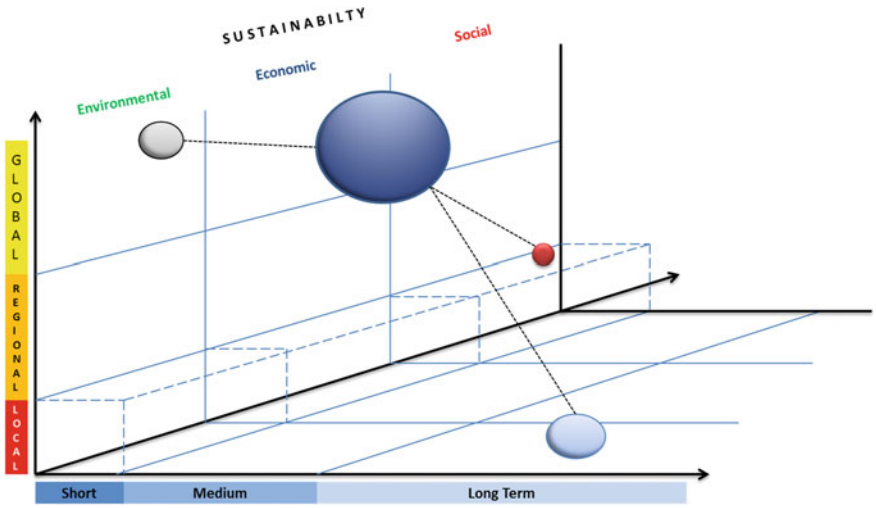

Fig. 2.5 Spatio-temporal horizon and the dimensions of sustainability

Temporal scope: The factor of time is considered in disaster relief management operations as being the crucial criterion in defining the phases of intervention and for assessment and evaluation issues. Broadly speaking one could identify three temporal levels of disaster relief operations, namely the short, medium and long term. These are related to the distinction between the successive phases of the disaster management cycle, i.e. response, recovery, mitigation and preparedness etc. An emphasis on the sustainable development prospects may broaden the long term to forthcoming centuries (Manusinghe 2009).

Spatial scope: a disaster could concern various scales of geographical areas; it could affect merely a local community or an entire region or it could have a global impact. From a systemic perspective the spatial scope is not only the place where a disaster may occur; it is about all spatial considerations along the planning works and all the operative interventions from the collections of donations to the delivery of the required items.

2.3.4.2 Integration of an Expanded Perception of Stakeholders

Traditionally the actors in HL are classified according to their contributions and roles; one could identify four basic categories of stakeholders: donors, beneficiaries, humanitarian agencies and logistics service providers. The suggested systemic approach deals with stakeholders as elements and subsystems of sustainable HL-systems, i.e. as parts of a set of organizations in permanent interactions with other homologous consortia and at the same time with the corresponding complex

environments. The most sustainable forms of these interactions are to be found in cooperation and coordination patterns, the lack of which could be coped with by means of systemic tools such as cluster thinking. In fact the cluster concept includes both horizontal (functional) and vertical (supply chain) coordination between stakeholders. However inter-cluster coordination is still considered as a challenge (Jahre and Leif-Magnus 2009). A potential starting point for an appropriate reply to this challenge could be the systemic investigation of new types of clusters and the integration of advanced information and communication systems. This may occur through methodological and conceptual alternatives such as: (1) considering stakeholders as complex adaptive systems (CAS) since they are organizations with adaptable structures, goals and strategies and flexible learning capabilities, and (2) considering sustainable HL-systems with different types of stakeholders as MAS, whereby computational methods are relevant in planning, modeling and controlling collaboration schemes.

2.4 Basic Principals of the Systemic Approach

2.4.1 Transdisciplinarity

In explaining the main features of sustainomics as a framework, Manusinghe distinguishes in (Manusinghe 2009) between multidisciplinarity, interdisciplinarity and transdisciplinarity in order to highlight the faculty of his approach to integrate knowledge from the sustainability and the development domains. Multidisciplinary teams includes efforts of researchers and practitioners from different disciplines, which is required to cope with the multitude and complexity of issues in making HL-systems more sustainable, while interdisciplinarity goes a step further with attempts to bridge the gaps between the various disciplines. The needed level is however transdisciplinarity, which means the creation of holistic scientific knowledge able to achieve innovative concepts and methods.

A transdisciplinary approach should enable the participants in HL in general and logisticians in particular to have an overview, as complete as possible, on various interdependent subsystems of humanitarian relief operations. In fact many organizations have pieces of information, the role of the logistics manager is to put them together by blending first- and third-world logistics and private and public-sector outlooks (Wood et al. 1995).

In the case of a holistic approach to sustainable HL-systems, the desired knowledge is a synthesis made of logistics methods, functions and processes in humanitarian relief, sustainability science, human development to name the main three groups under which several disciplines could be involved from economics and management to engineering and computer science.

2.4.2 The Dialectical View

The suggested systemic approach rests on a predefined understanding of the specificity of sustainable HL-systems; the subsystems in this kind of systems are denoted by several pairs of features, which may appear as controversial but should be considered within a dialectical thinking as two faces of the same coin:

2.4.2.1 Immediateness of Reaction Versus Durability of Effect

Kovacs and Spens identify in Kovacs and Spens (2009) three types of challenges in HL, namely (a) challenges related to different types of disasters, (b) challenges related to different types of humanitarian organizations and (c) challenges related to disaster relief phases. As far as the third type is concerned, the contradiction between the need for immediate reactions in the response phase and the ability to establish efficient structures according to a post-disaster needs assessment, which take into account the medium and the long term, in the mitigation, reconstruction and recovery phases, is impeding the achievements of sustainable systems. The systemic approach could indicate some theoretical paths towards solving this problem by rethinking the range and the characteristics of "preparedness" and "participation" and thus developing advanced planning mechanisms supporting sustainable development. In fact, in order to avoid redundancy and to gain precious time, especially in the prevention planning phase and during the implementation of concrete preparedness measures, learning from previous experiences could assist the work of creating the required conditions for sustainable development.

2.4.2.2 Private Versus Public Spheres

There is a set of conflicting perspectives within private and nonprofit stakeholders of disaster relief operations which is closely related to the differences between the commercial and the humanitarian supply chains. The balance between cost and speed regards both phases of response and preparedness and the efforts towards its achievement require collaboration between the private sector, the humanitarian agencies and the local communities, which help not only reducing costs and increasing speed but also creating learning and business development opportunities as well as contributing enhancing the local capacities of the communities (Tomasini and Van Wassenhove 2009). Numerous examples of general controversial aspects of HL operations are related to the motivation, scope and results of interventions. In their identification of three dimensions as a basis for theoretical development in HL, Jahre, Leif-Magnus and Listou present in Jahre et al. (2009) some starting points which may refer to the discussed dialectical perspective such as permanent versus temporary networks, vertical versus horizontal coordination and centralized versus de-centralized structures.

2.4.3 Transcending the Analogy

This principle is about using a transdisciplinary approach while learning from analogous structures and schemes among diverse complex logistics systems. It rests upon a mixture of rationality (logical comparison), criticism (seeking optimization) and creativity (inspiration-based design) as within the science of bionics (learning from nature), whereby the focus could be on how instinct based reactions are functioning while facing emergency situations.

2.4.3.1 The Supply Chain

Commercial logistics operations at their international dimension are offering case studies and best practices in terms of the general configurations and internal structural aspects of the supply chain. One could begin with highlighting the different functional systems of the science of logistics (Fig. 2.4) and attempt to establish a concrete road map for the conception of sustainable HL-systems using analogy in learning from the similarities among supply chain applications in international logistics and transferring the obtained knowledge from the exclusive commercial level to the sphere of HL (Table 2.2).

The identification of such components and the analysis of potential similarities should occur within a predefined perception of the sustainable supply chain in humanitarian relief. The setting by the systemic approach of strategic goals for the supply chain design in HL could rests on three main pillars: globalism, agility and greenness.

Globalism: The analogy with the global supply chain has been used to develop hub and spoke networks in HL and to design several architectures of distribution and supply, e.g.: the regional logistics concept of international Federation of red Cross and Red Crescent Societies (IFRC) and the United Nations Joint Logistics Centre (UNJLC). Nevertheless global, regional and supranational structures in

Table 2.2 Examples of systems and subsystems in humanitarian logistics

HL-systems	Functions	Eventual related subsystems
Transport logistics	Freight and *passenger* transportation	Intermodal supply chains
Distribution logistics	*Last mile* logistics operations	Permanent hub and spoke networks
Procurement logistics	Availability and management of physical donations	Recycling of urban waste
Information logistics	Transparency, accessibility and circulation of data	Tracking and tracing tools, cloud computing
Warehousing	Storage of relief items	Inventory management ergonomic handling equipment

supply chain management require adequate methods able to deal with complexity and vulnerability. The usage of OR to adapt supply chain best practices to HL may lead to significant improvements (Van Vassenhove and Pedraza Martinez 2010). On extended geographical scales, data analysis and statistics are critical factors for intervention planning: Wood et al. argue in (Wood et al. 1995) that forecasts as parts of information management systems allow regions at risk to prepare themselves and relief agencies to anticipate their arrangements.

Agility: Agility is defined twice by Christopher in (2000): firstly as being a business-wide capability that embraces organizational structures, information systems, logistics processes and, in particular, mindsets. After this "systemic" definition he argues that agility is needed in less predictable environments where demand is volatile and the requirement for variety is high, to formulate the second definition of agility as being the ability of an organization to respond rapidly to changes in demand both in terms of volume and variety. Within a systemic perspective the analogy between agile systems is bidirectional. Since the environment of HL-systems is just as characterized by uncertainty as the business environment, experiences from the humanitarian context could be helpful for the commercial supply chain in terms of learning how to improve the supply chain agility (Charles et al. 2010). An extension of this may involve several issues related to risk management and the resilience of complex systems.

Greenness: A green supply chain is often associated with the reduction of GHG-emissions in transportation and warehousing activities. In addition the usage of environmentally friendly items and equipment is seen as an attribute of sustainable logistics systems. A further aspect is the multimodality. The decision about the usage of different transportation modes is depending on several factors: delivery (transportation) time, load capacity, type of freight which has to be adapted to the requirements of humanitarian aid context. Several theoretical and practical efforts could be registered in transferring logistics knowledge to the research fields of HL by investigating general problems under specific assumptions related to HL like combining facility location and stock pre-positioning decisions responding to quick-onset disasters (Balcik and Beamon 2008) or studying Field Vehicle Fleet Management (Field VFM) of large International Humanitarian Organizations (IHO) (Pedraza Martinez et al. 2011). These efforts could be developed onwards by including green logistics concepts related to renewable energy systems and biotechnology-based innovations and hence transferred to the realm of sustainable HL.

2.4.3.2 Military Logistics Operations

Policymakers around the world are recognizing that the ability to achieve sustainable development can be increased by reducing the impacts of natural disasters (Clarke and Manusinghe 1995). To that one could argue that regarding the statistics of refugees and wars casualties, man-made disasters have to be integrated in a holistic approach towards sustainable HL-systems. Military forces are able to perform complex logistics operations since they have the necessary resources and

the required know how. Bayman, Lesser, Pirnie, Bernard, and Waxman present in Bayman et al. (2000) several contributions in studying the role of American military forces as partner of Non-Governmental Organizations (NGO) and European allies in disaster relief operations and notice important potential transatlantic synergies in humanitarian contingencies. This illustrates an application of a systemic integration of stakeholders in a broad spatial perspective. A further extension could involve other regional authorities and even multinational corporations. As a form of advanced Public Private Partnership (PPP) the possibility of enlarging the coordination consortium to involve various governmental and private organizations increases the potentialities of reaching sustainable solutions when dealing with complex disasters.

A systemic approach is promoting the efforts of innovative collaboration concepts by emphasizing the pragmatic consequences of analogy detection. Tatham et al. notice in (2012) the numerous similarities in the challenges facing military forces in complex emergencies and humanitarian agencies in natural disasters and build upon them to conceptualize an analysis and planning tool which is inspired from the Defence Lines of Development (DLOD) framework. The collaborative use of existing military devices and infrastructure (e.g. military bases) in disaster relief operations could occur within the framework of Civil Military Co-ordination (CIMIC). Although this particular context suggests the seamless division of labor between aid workers and international military forces (Heaslip et al. 2012), the mutual operational exercise may establish a concrete basis for sustainable initiatives, i.e. with long term effects. As far as the army is concerned these initiatives could incorporate some recommendations made by Bayman et al. (2000) such as systematically and routinely briefing agencies on military capabilities, appointing permanent "humanitarian advisors" and sponsoring partnerships with Center of Excellence as well as conferences and seminars.

2.5 Conclusion

Skyttner identifies in (2005) a set of general principals which characterize the systems thinking approach: Holism, regulation, hierarchy, differentiation, entropy, equifinality and multifinality are among the most relevant. The consideration of such principals while attempting to make logistics systems in general and HL-systems in particular more sustainable is the core of systems-oriented methodologies not only in research and education but also in any practical implementation.

A systemic approach to sustainable humanitarian logistics rests on the continuous awareness that the objectives of sustainable development could not be achieved unless ecological, social and economic goals are reached within a holistic perspective. This awareness leads to considering humanitarian logistics systems in their complex environments on the one hand and to focus on the complex interrelations between the components of the systems (elements and subsystems) on the other hand. The implementation of the systemic approach refers to a multisided dynamic

process including an enlargement of the spatio-temporal context of humanitarian relief operations together with an involvement of various types of stakeholders and hence the consideration of their different goals, strategies and methodologies in both practice and research. This could occur by means of multi-criteria analyses able to transcend the observable analogies in supply chain management and military logistics operations. Because of the heterogeneous contents of the involved fields as well as the controversial targets and interests of different agents and organizations, a dialectical view is needed for more consensus and trade-offs.

Ringers and White point out in Mingers and White (2010) that the number of applications of systems ideas is tremendous and they are making contributions to several domains, particularly health, production and sustainability. They argue that "there are also potentially new opportunities, given the context of a global economic downturn and global climate change, for systems approaches which may bring fresh thinking to existing problems and to a future uncertain world". Correspondingly the emphasis on transdisciplinary efforts within the suggested systemic approach aims at contributing making the responses to HL-challenges more sustainable and thus creating the required conditions for a generalized sustainable development of not only the concerned areas and populations when disasters strike but also of the interdependent rest of the planet as well as the world of the forthcoming generations.

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Chapter 3
A Planning and Decision-Making Framework for Sustainable Humanitarian Logistics in Disaster Response

Richard Oloruntoba

Abstract While the term sustainability has been used in a broad range of literatures, disciplines and contexts; sustainability in the context of humanitarian logistics (HL) has been given less attention and integration (Halldorsson and Kovacs 2010). Sustainable humanitarian logistics (SHL) planning and decision-making in response to natural disasters implies innovative, socially responsible, and proactive decision-making by logisticians that minimizes negative impacts, and enables long-term maintenance of community wellbeing, while maintaining a balance between social, environmental, and economic goals. This chapter outlines important assumptions from the existing literature on HL about its nature, processes and activities; and discusses unaddressed issues of environmental responsibility, community participation in disaster response and sustainability that are not currently addressed by the HL literature. Using case examples of natural disaster response and recovery, and associated logistical response in Australia as examples, the chapter illustrates the range and types of response and recovery-related logistical activities that contribute to sustainability in the field of HL, and from which a SHL planning and decision-making framework is proposed.

3.1 Introduction

The terms 'humanitarian logistics operations' (HLO) and 'sustainability' seem incompatible and unrelated. Both seem to be at opposite ends of the logistics, distribution and transportation continuum (Frota et al. 2008; Halldorsson and Kovacs 2010; Lee et al. 2010). The perception of extreme bi-polarity seems to originate from some of the earliest and most common references to humanitarian logistics (HL) activities. References of this nature often implicitly assume that features of

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sustainability, such as the protection of ecological systems and community participation, are of secondary importance in the emergency delivery of urgent life-saving disaster relief (e.g. Long and Wood 1995). Hence, it is not surprising that sustainability is an often overlooked concept in humanitarian logistics literature.

Yet, sustainability in both research and practice is rapidly gaining ground as a viable area of research (e.g. Baumgartner et al. 2008; Golini et al. 2014; Hirsch et al. 2006; Mont et al. 2014; Sharma and Ruud 2003). Sustainability is also an ideology in economic, technological, political and academic circles—in spite of the fact that academic research has only just begun to understand the concept theoretically, empirically and strategically (Bansal and Roth 2000; Kilbourne et al. 2002; Sharma et al. 2010).

Nonetheless, understanding the importance of sustainability in HL activities, its strategic nature, and how it influences the development of HL theory and practice seem to be urgent tasks (Halldorsson and Kovacs 2010; Sharma et al. 2007; Starik and Marcus 2000; Varey 2011). So far, efforts to introduce sustainable HL solutions in theory and practice implicitly have assumed that HL practitioners and employees of humanitarian and disaster relief organizations are aware of the goals of sustainable humanitarian logistics operations, and related policies and procedures. However, such an assumption may be inaccurate as HL practitioners and employees may be unaware of sustainability issues, especially pertaining to HL activities in the context of natural disaster response and management (Lozano and Lozano 2014). Even when they are aware of the issues, the term 'sustainability' has been used so generally in a broad range of literatures, scientific disciplines, and contexts that the term probably means different things to different people (Borland 2009a, b; Lindahl et al. 2014).

As a result of complexities arising from differing usages of the term, each 'context' must define what sustainability means to it (Borland 2009a, b; Lindahl et al. 2014). However, it is impractical to have a different approach to each similar event. A part of this challenge is that sustainability as a concept has its roots in a range of scientific disciplines and, therefore, does not belong to any one body of knowledge (Borland 2009a, b). The concept of sustainability is interdisciplinary, and scientific papers published about the concept often use a range of laws and theories as a lens for analysis. For example, ecological systems theories, systems theory, the laws of thermodynamics and Gaia theory have often been used (Borland 2009a, b). Overall, it seems that the overarching theme of these varied approaches to the concept of sustainability is to try to explain the behavior, homeostatic balance and maintenance of life on earth (Lovelock 2000).

In the specific context of HLO for natural disaster management, sustainable humanitarian logistics (SHL) implies innovative, socially responsible and proactive decision-making by responders and logisticians, as well as host governments. Such decision-making must: minimize negative impacts; enable long-term maintenance of community wellbeing; and maintain a balance between life-saving, social, ethical, environmental and economic goals. Also, SHL implies a systematic longer term view and a focus on life-saving ethics, as well as social, environmental and economic goals.

As previously highlighted, in spite of the importance of SHL, sustainability in the field of HLO and HL research has had relatively little attention and integration (Halldorsson and Kovacs 2010). As a result, reference to SHL often results in one's mind almost always wandering to issues of: transport energy efficiency (Halldorsson and Kovacs 2010); reduced transport emissions and carbon-footprints in transport, as well as the delivery and distribution of recyclable disaster relief such as tents and cooking utensils. However, sustainability is broader in scope than these narrow issues. Thus, the HL literature is in urgent need of research that addresses issues of sustainability in HL planning and decision-making which incorporates, for example, considerations of: environmental conservation, community participation, social responsibility, equity and ethics. This chapter fills this gap by:

1. Drawing out key assumptions about current approaches to the nature, process and activities of HL, and how these might have become barriers to SHL planning and decision-making;
2. Advocating for sustainable humanitarian logistics (SHL) planning and decision-making in response to, and management of, natural disasters with a focus on environmental conservation, community participation, social responsibility, equity, and ethics;
3. Outlining a simple framework from case examples for SHL planning and decision-making in humanitarian assistance and disaster recovery.

The rest of the chapter is structured as follows: Sect. 3.2 traces the historical origins of important features and characteristics of HL and the key assumptions that underpin current approaches and perspectives on the nature, processes and activities of HL; and how these might have become barriers to the incorporation of sustainability into HL planning and decision-making. Section 3.3 argues the case for incorporating elements of sustainability into humanitarian logistics (SHL) planning and decision-making in response to, and management of, natural disasters. Section 3.4 outlines from case examples a framework for sustainable HL planning and decision-making in disaster relief, thus explicating the range of disaster response and recovery-related logistical activities that contribute to sustainability in the field of HL. Section 3.5 concludes the chapter.

3.2 Origins, Features and Assumptions of HL Underpinning Current Approaches

There are several historical features and assumptions of HL that underpin current approaches and perspectives in the HL literature. These features and assumptions may be summarized into four broad categories: (a) response speed, (b) inconsistent use of terms, (c) the anthropocentric nature of HL and (d) miscellaneous issues in HL.

(a) Response speed: a barrier to sustainable HLO?

Early references to HL activities may be traced to Henry Dunant, Guillaume-Henri Dufour, Gustave Moynier, Louis Appia and Théodore Maunoir who rapidly organized and delivered relief to wounded soldiers, and later founded the first National Society for Relief in the state of Württemberg in Germany in 1863, which later became the Red Cross Society (Arizzabalaja 2014). Later, in 1917, Samuel Prince undertook a sociological study of the aftermath of the Halifax ship explosion in 1917 and associated disaster relief response (Prince 1920). More recently, Long and Wood (1995) in their seminal article referred to the term 'disaster relief' in the context of urgent famine relief rather than HL. However, Thomas (2003, p. 3) seems to be the first to use the term 'HL' directly in the context of 'the processes and systems involved in mobilizing people, resources, skills and knowledge to help vulnerable people affected by natural disasters and complex emergencies.'

These examples imply an urgency to provide relief to needy and vulnerable people affected by disasters in order to save lives and reduce suffering. Therefore, the focus of HL seems to be on the speedy delivery of relief goods and services, leaving very little time to plan for other important considerations that have little to do with a speedy response, at least in the emergency relief phase (Thomas 2003). Long and Wood (1995) described the features of such logistical activities quite well: "…a model for famine relief would emphasize quick reaction capabilities…," (p. 215), and with a requirement for agility, flexibility and speed in the distribution of relief. Such a focus on speed may leave little room to think more systematically and comprehensively. Such antecedents seem to be a hallmark of HL activity according to the academic literature. A second feature is the inconsistent use of terms and terminology.

(b) Inconsistent use of terms and terminology in HL

A second issue is that, as commonly found in emerging areas of research and emerging disciplines, and, in spite of its generally acknowledged importance in our disaster-prone world, there remains no consensus on what the term HL actually means. There is no agreement on how the term relates to other concepts and processes in procuring, delivering and distributing relief to needy people in the aftermath of a disaster (compare, for example, the definitions of Holguín-Veras et al. 2012; Kovacs and Spens 2007 and Oloruntoba and Gray 2006). Kovacs and Spens (2007) in their literature review indicate that HL encompasses a range of operations at different times and can be a response to various catastrophes with the goal to "aid people in their survival", and this includes "assisting the development of a region…," "… and the running of refugee camps" (p. 101). Presumably "different times" refer to the notion that there are three phases of disaster management and, as such, HL involves the range of activities that are performed *before*, *during* and *after* a disaster. Implicit in such a phased conceptualization of how disasters unfold is that HL activities ensure that planning, mitigation and preventive measures are undertaken before a disaster strikes (Van Wassenhove and Pedraza-Martinez 2014).

Subsequently HL activities ensure that prompt and appropriate assistance is given to victims of disasters when they occur, as well as in the longer term aftermath during recovery, rehabilitation, rebuilding and resettlement of affected communities (Kapucu 2007, 2008). In reality, mitigation and preparedness activities such as: the training of disaster and emergency personnel; the setting up and activating of disaster early warning and communication systems; and the undertaking of the hazard, risk and vulnerability analyses of the population may not strictly be categorized as logistics or HL activities, and so are the continuous surveillance and monitoring activities undertaken before a disaster (Overstreet et al. 2011). Hence, it seems that, strictly speaking, many HL activities are often not undertaken before a disaster occurs, given Thomas' (2003) view of HL as being "… processes and systems involved in mobilizing people, resources, skills and knowledge to help vulnerable people affected by natural disasters and complex emergencies…" (p. 3). Thomas (2003) seems to assume that a disaster needs to strike first before HL can be triggered.

Furthermore, Long and Wood (1995) argue that: "Relief is foreign intervention into a society with the intention of helping local citizens" (p. 213), such as in the "logistics of famine relief" and other operations that often occur in less developed regions, which usually have inadequate infrastructures and are away from major traffic lanes (e.g. Pedraza Martinez et al. 2011; Long and Wood 1995; Thomas 2003). Hence, HL in this definition seems to be perceived as being international—concerned with some far flung corner of the world, the proverbial 'Timbuktu,' where people cannot take care of themselves and require overseas assistance from outsiders. The Japanese tsunami of 2011, Cyclone Larry of 2006, the Victorian bushfires of 2009 and Hurricane Katrina of 2005 demonstrate that HL activity can be local, domestic, national, regional or international.

Disaster impacted places in the developing world are often characterized in the literature as not having infrastructure, having devastated infrastructure, or on-going war which creates delivery challenges to outsiders who require prompt access in order to help. Such characterisations may be a barrier to considerations of SHL in planning and decision-making, given the emphasis on the devastated infrastructure and on-going war.

There are other definitions of HL which are beyond the scope of this chapter to consider, but it is sufficient to conclude that, despite the variety of approaches available for defining HL, no authoritative or consensual definition exists (Overstreet et al. 2011). This illustrates the complexity, ambiguity, inconsistencies and confusion dogging a clear understanding of HL, and, as a result, leaves little room for designing a sustainable HL that encompasses a broader range of ecological and social considerations. Overall, it seems that HL activities, judging by its labels of 'human,' 'humanity,' and 'humanitarian,' and by the nature of the logistical and other activities undertaken (e.g. fundraising), firmly puts the human being or saving a human life at the its core, with minimal systematic thought having been given to saving or protecting nature in response to natural disasters. In other words, HL is anthropocentric in its fundamental ideological perspective, whereby the human-being is the priority and comes first regardless of social, environmental and other costs.

The United Nations World Commission on Environment and Development (1987) might have further reinforced such non-deliberate adoption of an anthropocentric view of HL with its definition of sustainability (see Purser et al. 1995; Sharma 2007). The United Nations World Commission on Environment and Development's definition of sustainability also puts the survival and welfare of human beings first and foremost in all considerations. Such a view in turn precipitates the human or disaster victim bias in disaster and humanitarian responses. Likewise, beyond HL, in corporations for example, the focus of management has recently been on environmental management, sustainable development and environmental resource management (Porritt 2007; Purser et al. 1995) though still putting human needs and wants, including further human expansion, consumption and economic growth and development, above the survival and development needs of other species. Hence, it is not surprising that such universal parochialism has resulted in other oversights. There are also other challenges in current views of HL as discussed below.

(c) Other challenges in current approaches to HL

It is difficult to incorporate sustainability into HL planning and decision-making ex-ante or as an 'add-on.' Such sustainable HL planning and decision-making must be designed ab initio, in other words from the beginning. Challenges that arise from this fact include the problem that current approaches to HL often tend to ignore issues of pre-existing social vulnerability, such as building urban settlements in high hazard areas, such as flood plains or earthquake zones, which render such settlements ultimately unsustainable for habitation due to the risk of a natural physical event coming to fruition (Overstreet et al. 2011). Likewise, issues at the level of the individual such as pre-existing individual disaster resilience and preparedness are often ignored in HL responses. These issues may include financial issues, social issues, health issues and other indicators of resilience. For example, when a disaster occurs, rich people have relatively greater resources to fall back on than poor people. Also, individuals with social networks have more friends and relatives to help them get back onto their feet than those without social resources and networks. The current approaches to HL planning and response ignores such issues of pre-existing social vulnerability, because the focus of HL in humanitarian and disaster response is often narrowly construed. It tends to ignore existing environmental hazards and increasing vulnerability (Overstreet et al. 2011). HL similarly ignores the pre-disaster risks of increasing urbanization, globalization, unmitigated population growth, global climate change and rising sea-levels (McNamara and Prasad 2014).

HL has a narrow focus on the sourcing, transportation, delivery and distribution of goods to meet the immediate physical and physiological needs of affected populations, such as the provision of medical relief, food and water and the associated fundraising. The socio-psychological and emotional aspects of caring for affected persons are not often addressed. Other challenges in current approaches to HL planning and decision-making include the relatively high levels of selectivity, and sometimes inequities in the response to humanitarian crises. Research has

shown that the logistics of relief distribution often tends to ignore ethics and equity (Sumathipala 2014; Flynn and Speier 2014; Schwartz et al. 2014; Zach 2014). One ethical issue that is seldom discussed is the wise spending of tax payer and/or donor funds. Governments have a fiduciary duty to taxpayers to spend tax funds wisely, and the HO who undertakes HL should also spend funds sustainably (McGee 2008). It seems that this has not always been done.

Another ethical question that is not often asked is whether governments should get involved at all in disaster relief, recovery and rehabilitation using tax payers' funds (McGee 2008). People in general often assume, without thinking, that the government should get involved and use tax payers' money; however, an ethical analysis of this issue might reveal that it is less efficient for government to get involved in such activities, than for the private sector (such as insurance companies and disaster insurance). If someone who wants to live in a flood zone is not able or willing to pay market rates for insurance coverage, they should move. People who have enough sense not to live in a flood zone should not be forced to pay the insurance premiums of those who do live in such places. It is inherently unfair to force the general public to subsidize this kind of risk-taking behavior (McGee 2008).

Other challenges emanating from the current approach to HL include the sheer diversity of actors in a humanitarian response (convergence of people, responders, volunteers and relief material), and the sheer diversity of disaster contexts, beneficiaries, stakeholders and requirements. This diversity of actors and stakeholders is a source of challenge to the implementation of sustainability in HL planning and decision-making, as various actors will have various goals that may be in conflict.

Further, the disconnection between governments and NGO humanitarian organizations ensures a disconnected and fragmented response with limited holism or systems in HL decision-making. As a result of the above discussion, HL planning and decision-making must be based on a differentiation that helps to isolate specific characteristics that will inform a sustainable, superior and consistent approach to both humanitarian interventions and sustainable HL decision-making. In Australia, the Cyclone Larry humanitarian response is thus far perceived as the benchmark for HL as it incorporates elements of sustainability such as ethics, social responsibility and environmental conservation.

To delineate the properties of sustainability, Belz and Peattie (2009) suggest a framework that features a holistic and systems-based view, and an open-ended timeframe. The current approaches to HL planning and decision-making as discussed are inadequate, as the focus seems to be to exclusively mobilize and deliver tangible relief goods to meet the life sustenance needs of human beings very quickly.

SHL is not just about logistics. Implementing SHL requires collaboration and consensus with stakeholders of both responders and receiving communities. Such a 'community' and 'beneficiary' would need to be clarified, as there are currently multiple understandings of the terms (Crow and Allan 1995). For example, 'communities of place' have to do with varying locations, while 'communities of interests' have to do with the different demographic groups such as tourists, infants, farmers, nursing mothers, etc. (Oloruntoba 2010; Thomsen 2008). Also, socio-demographic

and environmental contexts often come to the fore. Section 3.3 argues the case for incorporating elements of sustainability into the planning and decision-making processes of humanitarian logistics (HL).

3.3 The Case for Sustainability in Humanitarian Logistics (SHL) Planning/Decision-Making

Criticisms of HL and disaster relief planning and management are common, most often in the global media. Common criticisms often have to do with the delivery of incorrect goods, or delays in the delivery of relief as well as inequitable distribution of relief (Oloruntoba and Gray 2006). However, it is relatively uncommon to hear criticisms of a lack of sustainability in HL decision-making, despite the broad search for innovative practices in humanitarian practice (Weiss and Hoffman 2007; Ramalingam et al. 2009). However, as understanding of sustainability and sustainable business practices in the business world develops, the demands for SHL will grow ever more loudly together with the recognition of the need to preserve flora and fauna when undertaking HL activities.

As at the time of writing, most debris from earthquakes, cyclones, floods and tsunamis end up in landfills, with minimal effort made to appropriately sort, separate, recycle and properly dispose of such disaster waste and debris (Srinivas and Helmys 2015; Takeda et al. 2014; Grzeda et al. 2014; Tanaka 2014). In addition, bio-quarantine issues, such as the accidental transfer of indigenous species around the world, or the spread of pandemics such as Cholera, and the Ebola virus disease (EVD) through international HL, will become more visible and high profile in the near future. Also, there will be demands about issues of bio-sanitization, for example, of returning merchant and navy fleets, aircrafts and various personnel from other parts of the world in the aftermath of disasters. Additionally, there will be more stringent calls for the inclusion and participation of disaster-impacted people in decisions that affect them.

Belz and Peattie (2009) suggest a framework of sustainability in which they delineate the important characteristics and elements of sustainability, of which taking a systems-based holistic view instead of an anthropocentric, 'human only' view is of paramount importance. Belz and Peattie (2009) also suggest an open-ended timeframe, unlike the short timeframes of most disaster relief and disaster management interventions and associated HL that tend to focus on providing short term 'relief' succor for the needy. The framework by Belz and Peattie (2009) advocates a global perspective that focuses on ecological sustainability rather than mere economic efficiency, as well as recognition of the inherent value of nature, the environment and the ecosystem.

Sustainability in HL demands a clear recognition of limits upon the resources of nature, such as forests and fisheries, and nature's limits as a repository for waste, such as transport effluent and other emissions. Sustainability in HL demands that we distinguish between unsustainable, unlimited and even wasteful uses of

resources. For example, unnecessary use of airfreight and non-recyclable tents and bags in disaster response. Sustainable HL implies a qualitative improvement in how we undertake HL, as well as a careful determination of the means and ends, to ensure well-being for all species (Ekins 2000; Guest 2010). As sustainability in HL implies a basically different way of looking at the world and the place of HL in it, it demands an enlargement of the limits of logistics research in general and HL research in particular (Gronroos 2007; Hult 2011; Varey 2011). In other words, logistics and HL as a discipline and an area of research must adopt a more systemic, macro-focus and a greater number of multi-disciplinary approaches.

Current HL philosophy and approaches, however stresses greater speed of response, flexibility, responsiveness, agility, and the prevention of stock-outs (financial and tangible products) as the means of saving lives in danger, and so a worthy end-point, but this is not enough. Such aparochial approach perpetuates an anthropocentric view and aims to maximize donor funding as quickly as possible, as well as to maximize the global media exposure of large international humanitarian organization (IHOs) for their business continuity and competitive advantage (Oloruntoba and Gray 2006; Schaefer and Crane 2005). Also, such an approach perpetuates conventional views of international humanitarian organisations (IHOs) raising money to procure products and services to deliver to the needy (Schaefer and Crane 2005). More importantly, it may mislead governments, donors, the public and others into thinking that HL, as currently practiced by humanitarian organizations (HOs), is helping us all while conveniently ignoring the impacts of such HL and disaster response practices on the environment (Peattie 1999).

Perpetuating an anthropocentric ideology through conventional HL activity cannot lead to sustainability in HL, especially in the face of the growing scale and frequency of disasters, as well as the exponential growth in the global population of those who reside in high risk, hazard-prone areas of the world. This is all the more pertinent in a world experiencing over-consumption, waste-accumulation, resource depletion and habitat destruction. Addressing such manifestations of the excesses of human activity through existing approaches, mental filters and mind-sets will do little to embed sustainability in HL activities.

As a result, this chapter suggests a different approach to undertaking HL activities that is based on ecological and environmental sensitivity, i.e. an eco-centric approach and a participative approach that takes into account beneficiary views, experiences and cultures in taking decisions that pertain to such beneficiaries and their communities, i.e. a socio-centric approach (Oloruntoba 2013; Oloruntoba 2010; Oloruntoba 2005). The two approaches in HL and disaster response decision-making should contribute significantly to sustainability in HL.

At this point, it is important to discuss the basis of the whole concept of sustainability. Borland and Lindgreen (2013) citing Porritt (2007) define ecological sustainability as the capacity for continuance into the long-term future, by living within the constraints and limits of the biophysical world. It represents an endpoint, a goal or a desired destination for the human species, as much as for other species; because without such a goal and such a world, human life perishes catastrophically as the bio-physical world can no longer sustain life on this planet. Based on this

logic, if HL continues in its current 'unsustainable' path, there will ultimately be no HL activities or practitioners, as the practitioners, HOs and those in need of relief will also cease to exist. Therefore, in the pursuit of ecological sustainability this is non-negotiable (Borland and Lindgreen 2013; Mort 2010; Porritt 2007), and so ecological sustainability thus becomes the 'mother' of all other types of sustainability (e.g. social and financial).

Sustainable development, on the other hand, refers to the step by step process of moving towards sustainability in small increments (Borland and Lindgreen 2013). Sustainable development implies trying to achieve sustainability, but is often poorly defined and difficult to measure, largely because there are usually no hard verifiable goals (Borland and Lindgreen 2013). Many 'sustainable development' activities seem to be hyped on the pages of corporate reports and the media (see the literature on 'greenwashing' for example, Bowen and Aragon-Correa 2014; Thomas 2014; Marquis and Toffel 2014).

To achieve sustainable HL, we must include social and economic elements, as well as environmental ones (Porritt 2007). Hence, sustainable humanitarian logistics (SHL) implies socially responsible and proactive decision-making and innovation by responders and logisticians, as well as host governments that minimize any negative impacts, enable the long-term maintenance of community well-being and maintain a balance between life-saving, social, ethical, environmental and economic goals. SHL clearly implies a longer term view, and a focus on life-saving, ethics, social, environmental and economic goals. These should not be considered to be secondary goals, as they seem to be under the conventional viewpoint and approach to HL, because all else is conditional on living sustainably within the Earth's systems and limits.

The urgency of the ecological sustainability predicament drives the search for new ways of conducting HL activities (Mort 2010) without merely pursuing efficiency drives or HO competitive moves disguised as sustainable HL (Unruh and Ettenson 2010). To truly suggest sustainable HL strategies, this chapter adopts a multidisciplinary, interdisciplinary and trans-disciplinary (Gladwin et al. 1995) approach based on case examples of HL activities that comprise elements of sustainability (such as) in Australia to discern what sustainable HL strategies might look like if they were underpinned by the sustainability motive.

An eco-centric and socio-centric approach which is a key indicator of a sustainability mindset offers an alternative logistics, and a mental and cultural framework that focuses on the whole system and the balance of all species and elements. Hence, humans will have to move from their cosmologically central, and egocentric position, in which the whole of nature exists only for human exploitation (Gladwin et al. 1995; Kilbourne et al. 2002; Purser et al. 1995), to a more balanced and holistic view of the world.

Section 3.4 outlines the first steps towards this goal, namely a sustainable HL planning and decision-making framework that incorporates the key elements of sustainability such as economic, environmental/ecological sensitivity, and equity and community participation, as well as joint decision-making with beneficiaries of relief.

3.4 An Outline of Sustainable HL Planning and Decision-Making Framework

Based on the foregoing discussions, and pulling all the strings together, humanitarian practitioners and their logisticians, as well as donors and governments, may need to consider four components that comprise the suggested framework: (a) the economic/environmental rejuvenation of affected communities; (b) the careful sequencing and prioritization of the phases of humanitarian assistance and humanitarian logistics; (c) social inclusion, community participation and consensus building; and (d) keeping an integrated view of all humanitarian logistics activities and the programs that they support. Each of the four components is now discussed:

(a) It is necessary to extend planning and humanitarian responses beyond the narrow provision of relief to include longer term economic/environmental rejuvenation of an affected area. The disaster relief chain and overall recovery effort of Cyclone Larry in Australia is generally agreed to be one of the more effective in the history of emergency cyclone responses in northern Australia. The response undertook what could be termed a "whole of care approach" (Oloruntoba 2010, p. 97), providing for the environmental, infrastructural, informational, emotional, financial, psychological, medical and nutritional needs of those affected beyond the provision of food, water and medicine. For example, pre-event typologies and pre-identification of social, economic and environmental groups in the impacted areas was utilised in the Cyclone Larry response.
Identification of pre-event typologies, and demographics of regions and countries and the identification of key population segments are significant contributors to SHL. The development of pre-event typologies of regions and the identification of key population segments for targeted service helped to identify areas that share similar and different characteristics, challenges or trends before Cyclone Larry struck (Oloruntoba 2010). Pre-identification and segmentation helped provide more accurate information more quickly regarding specific areas of affected towns, vulnerable areas of affected towns, areas with critical infrastructure and areas with vulnerable people. For instance, people who might have been immobilized in a normal residential situation for whatever reason, or children who might have been isolated in a school environment. Such pre-disaster information could be used to complement the usual needs assessment estimates.
Pre-event data helps responders provide better services, and improves responsiveness. It enables an accurate response configuration, and calibration to the unique type and context of the crisis and impacted population segments. Humanitarian logisticians and responders are able to better tailor their technology, equipment and assets to the unfolding scenario.
Similarly, this principle was applied to the macro-economic and regional perspective where the State and Commonwealth governments in Australia made special pre-planned interventions for affected economic segments of the

region, and the communities that were impacted in order to ensure broader socio-economic sustainability through saving and restoring livelihoods as well as preventing 'refugee' outflows. Responders and the government working together ensured that immediate government financial aid and goods in kind were provided to businesses and industry, as well as long term employment support programs such as 'work for the dole' type arrangements. The aim was to get many people back to employment under those arrangements, with a fractional financial top-up from the companies, industries or the farms that were receiving disaster-related assistance from government (Oloruntoba 2010). The banana, avocado and sugar cane plantations in north Queensland, as well as vessel owners and operators in the tourism sector in the Great Barrier Reef were examples of such arrangements. Special grants and longer term soft loans for the key industries were promptly approved by the government to ensure sustainability. Primary producers and businesses were given concessional loans of up to $500,000 on favorable terms. The loans were accompanied by employment support programs designed to enable employers to pay a viable wage to their work force (Oloruntoba 2010).

In addition, hundreds of emergency electricity generators were distributed free of charge to the dairy and aquaculture industries to maintain animal welfare. Portable cow milking machines were air-freighted to scores of north Queensland dairy farms, including trucks and trailers for six weeks for each week in order to kick-start the milking of cows and economic output. Without the Queensland and Commonwealth governments concurrently providing such financial relief to the regional economy as well as environmental clean-up, all of the relief processes and measures targeted at individuals would have simply been unsustainable in the short term, and ad hoc in focus, because livelihoods would have been permanently lost in the cyclone (Oloruntoba 2010).

The preservation of natural and cultural heritage such as environmental and ecological systems and regeneration was also given priority in the Cyclone Larry relief and recovery process. Attempts were made to restore damaged cultural artifacts and sacred sites belonging to the indigenous Australian peoples. Wildlife, plants and animals in the impacted area were also carefully restored. Volunteer wildlife carers were flown in from across Australia, and the local James Cook University ecologists dealt with hundreds of inquiries about displaced and starving native animals ranging from the cassowary to snakes and crocodiles, as well as possums, tree kangaroos, wallabies, and flying foxes. Environmental-related relief activities that would usually rely on a fragmented permit approval system, with multiple government agencies that usually required several months to grant permits and approvals, took only a few hours under a new expedited regime of permits and approvals in response to Cyclone Larry.

The Preventative Waterways Debris Removal (PWDR) program, a waterway clean-up program, focused on clearing a number of high economic priority waterway sections in the Cyclone Larry affected area immediately after the cyclone. Such pre-event typologies of regions and countries and

pre-identification of key population segments should be based on multiple dimensions, that is, physical, socio-economic, demographic and environmental indicators.

(b) Sequencing of the phases of humanitarian assistance and humanitarian logistics: The careful planning, sequencing and prioritization of the phases of delivery of humanitarian assistance can contribute to the sustainability of the humanitarian logistics process. For example, during the Cyclone Larry relief, restoration of important infrastructure such as roads and electricity supply were given concurrent priority with food, water and first aid as responders targeted the rapid restoration and delivery of specific utility services for affected communities rather than targeting individual victims of the cyclone. Responders and logisticians were given clear guidelines that were focused on the rapid restoration of infrastructure and the quick restoration of the environment in order to quickly restore the perception of normalcy, hence the longer term sustainability of the disaster relief and recovery process. As a result, there was concurrent and rapid deployment of a range of heavy engineering response capabilities to restore roads, communications, electricity and the regional local radio station 4KZ, as well as repair and clear local schools of debris.
Such careful planning, sequencing and prioritization of infrastructure restoration underpinned the sustainability of the whole humanitarian relief project by ensuring the safe and free movement of road vehicles of responders and the public without the obstruction of foliage and other debris. This was the basis of sustainable community recovery. Furthermore, clearing roads first was crucial to securing access to disaster sites by secondary relief teams. Access meant the ability to assess requirements of the victims and to subsequently deliver services and goods to meet beneficiary needs.
As noted, these early 'services' and restoration of infrastructure was not directly targeted at individual beneficiaries, but at the quick restoration of the regional disaster site and environment, to bring it rapidly to a semblance of normality through the restoration of critical infrastructure such as electricity, water, communications (satellite phones), and roads from which relief targeted at individuals could unfold. Such sequencing and prioritization fits with the philosophy of sustainability in disaster response and HL.

(c) Social inclusion, community participation and consensus building for the long term is important for SHL and sustainability. This has traditionally been difficult to achieve due to a range of differences between responders and communities that are the beneficiaries of relief and longer term aid. Participatory approaches are conducive to beneficiary targeting and this impacts the responsiveness of HL. It also gives a sense of ownership and inclusion to affected communities. Itensures the longevity and sustainability of medium and longer term community recovery projects as community members take ownership and guarantee its continuity. Consultations with and inclusion of civil society, such as groups, NGOs, churches, and pressure groups in communities

receiving aid, are prerequisites for disaster affected people to contribute their local knowledge, skills and resources to processes that influence their lives. This approach included listening to beneficiaries and ensuring that beneficiaries understand the aims and goals of relief and recovery programs. Local within-country institutions and supportive institutional arrangements will foster innovation and facilitate formal and informal exchange of context specific knowledge. Lastly, an important element of the framework is to keep a systemic and integrated view of all sectors involved.

(d) Keeping an integrated view of all sectors: Existing laws and policies within responding humanitarian organizations should be continuously re-examined to avoid a mono-sectorial focus. The integration of humanitarian projects and programs should be encouraged, along with the coordination of competing interests, jurisdictions, communities and actors. The goal is to avoid a fragmented/ad hoc approach. Hence, policy coupling should combine synergies of environmental, ethical, social, demographical and economic considerations to build resilient and cohesive communities. Public agencies such as those in charge of the children and families, as well as those in charge of employment and housing, and other relevant agencies should work together in an integrated manner. This view may include planning the logistics of longer term community recovery projects, such as healthcare, nutrition, education and gender issues in humanitarian programming and evaluation.

3.5 Summary and Conclusion

SHL is proactive decision-making by responders and logisticians that minimizes negative impacts SHL enables long-term maintenance of community well-being and maintains a balance between social, environmental and economic goals. This chapter has outlined important and implicit assumptions about HL from the literature by analyzing the nature, process, and activities of HL. The chapter has discussed previously unaddressed issues such as environmental responsibility and community participation in humanitarian assistance and disaster response, and outlined a flexible and evolutionary framework of SHL developed from case examples of the range and type of disaster response related logistical activities that contribute to sustainability in the field of HL.

The broad foundations of sustainable HL planning and decision-making framework as suggested in the chapter are designed to evolve as the humanitarian, sustainability and research policy environments and theory evolve. Broadly, an effective framework for SHL should have: (1) an anticipatory governance mechanism; (2) an ability to assess the adverse impacts of HL tools in use such as the technology in use in its various forms; (3) socio-technical integration of the technology to be used in disaster response to be appropriate, and to fit with humanitarian decision-makers and beneficiary communities; and (4) deliberate

engagement with beneficiary communities for community participation and inclusion in order for responsible and sustainable development to result. HL and disaster response decision-makers and scholars must address important questions of the framing and conceptualization of SHL, and address pathways to practical implementation in the humanitarian sector, and in disaster management. Such framing and conceptualization should include inclusive deliberation and responsiveness to current and future needs (evolutionary ability) and the articulation of the important question, "Exactly what kind of sustainable future do we want HL, and by extension humanitarian practice to bring into the world of the needy and disaster impacted?" This should be the departure point for framing and evolving the concept of SHL.

This departure point should create spaces for an inclusive discussion of envisioned applications and impacts, in the context of social and environmental values, and for empowering social agency in the choice of technological tools to be used in SHL. We need to ask: "Why do it? How should we frame it? What future could it bring? What are the motivations? Is it desirable? Who will benefit?" We must consider the purpose, motivation and intent. And this is more than a discussion of risks, safety, environmental damage, funding sources, costs, effectiveness and accountability to donors or regulation, important though these are. These questions and ideas challenge us to create open and transparent spaces to identify opportunities for innovation in developing and implementing SHL and undertaken in the interest of the humanitarian sector, the beneficiaries and other stakeholders including donors.

These issues, as discussed in the suggested framework, definitely raises tensions concerning long-standing traditions of the freedom and autonomy of humanitarian organization decision-making, and their guiding moral, religious and ethical principles, values and philosophies. Some of the ideas in this chapter also challenge the principle of market choice as the pre-dominant mechanism to direct goods and services to their most desirable end use. The chapter also challenges the established roles and responsibilities of humanitarian head office staff who manage overall organizational strategy, fundraising, donor relations and the social and political aspects of their organization on the one hand; and the field staff who often manage logistics and supply chain management, and are in direct interface with beneficiary communities on the other hand.

The suggested framework may also raise tensions within humanitarian organizations as regards community participation and inclusive approaches, because humanitarian organizations often see themselves, and are often seen as 'experts'. The theoretical definition of HL by Thomas (2003) as "the processes and systems involved in mobilizing people, resources, skills and knowledge to help vulnerable people affected by natural disasters and complex emergencies" casts recipients and beneficiaries as passive while responding organizations are seen as actively "doing." Further, this definition of HL includes the phrase "…encompasses a range of activities including *procurement, transport, tracking and tracing, customs clearance, local transportation, warehousing and last mile delivery*". Thomas (2003, p. 3), seems too narrow for achieving anything close to SHL. Hence, SHL needs to be abroader concept than the current anthropocentric/speedy approach to HL, which

is merely the mobilization of people, resources, skills and knowledge—i.e. a focus on mobility, transport and delivery and short response times. This definition will need to include other activities that encourage SHL and sustainability as discussed.

Nevertheless, we should place a premium on the idea of the anticipation of intended and unintended impact of HL activities. We should reflect on previous and current HL activities, and the results of their evaluations, as well as undertake a robust deliberative process—how key HL decisions were made and how SHL might look different in disaster response in the future. Flexibility should be a key feature of the above process, and a range of scholars and disciplines should be supported that will promote partnerships with other disciplines and spheres of expertise, working together in imaginative and creative ways. Merely ticking boxes as another compliance measure would not work, as the suggested framework would be a significant and an ambitious cultural change; it must be a deliberative and responsive process of development, shaped by the research community and the stakeholder base.

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Chapter 4
Sustainable Humanitarian Logistics Research—A Conceptualization

Matthias Klumpp

Abstract Sustainability in its long-term perspective is agreeably sometimes hard to imagine and implement in short-lived crisis situations. But nevertheless, the future demand regarding research as well as practical implementation for sustainability principles in humanitarian logistics is huge. This chapter therefore provides a basic definition drawn from existing sources as well as a draft structure with interesting research questions for this new field of sustainability in humanitarian supply chains. Furthermore, limitations as well as a case study regarding Syria as a large and long-lasting humanitarian crisis are outlined. For the case a new principle in international aid and political answers is suggested as one possible input from research regarding sustainability principles in humanitarian situations.

4.1 Introduction

Research in humanitarian logistics has been driven by two main thrusts in the past, (i) the urge for *operational optimization* in order "to save lives and alleviate suffering" and (ii) the comparison and adaption towards as well as from *commercial logistics*. Examples for the first strive are e.g. research publication such as Falasca and Zobel (2012) regarding personnel planning and optimization, Balcik et al. (2010) discussing the optimization of operational coordination among actors, Martinez et al. (2011) regarding fleet management improvements, Holguín-Veras et al. (2012b) informing about alternative logistics concepts in crisis situations as well as Liberatore et al. (2014) describing the optimization of good distribution schemes in emergency situations. Research publications addressing the second basic approach comparing to commercial logistics are i.e. Bagchi et al. (2011) regarding the application of game theory towards humanitarian procurement processes, Li et al. (2013) discussing the application of open source software

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development in humanitarian logistics, Heaslip et al. (2012) explaining the possible transfer potential from military logistics systems, Yang et al. (2011) describing the use of RFID systems in disaster situations and also Fadiya et al. (2014) providing details regarding the use of bi date in humanitarian logistics.

Altogether, these endeavors have led to a situation, where *long-term* and therefore *sustainable thinking* and concepts within humanitarian logistics are on many accounts absent. And the few exceptions are not known and numerous enough to establish a further research alley for an active interaction of research and practical implementation in humanitarian organizations. This contribution—as well as the whole book—aims for a solution to this problem by outlining some basic thoughts about long-term and sustainable research in humanitarian logistics.

A basic concept approach regarding research for sustainability in humanitarian logistics would have to touch the following "bases" as outlined in this chapter: First, the definitions and concepts of the involved word have to be outlined, namely "logistics", "sustainability" and "humanitarian"—which is described in this section. Second, one may think about possible concepts and research streams and questions in order to integrate different actions according to an overarching framework for sustainable humanitarian logistics research (Sect. 4.2). Third, limitations and borders for research regarding sustainable humanitarian logistics may be relevant as outlined in Sect. 4.3. A holistic case analysis may complement these conceptualization efforts, herewith exemplified with the Syrian humanitarian crisis and "sustainability options" (Sect. 4.4). Finally, an outlook regarding further research endeavors regarding this question is added in Sect. 4.5.

Regarding a *definition of sustainability* the commonly used description is the basic explanation from the Brundlandt Report: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: (a) the concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given; and (b) the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs" (WCED 1987: 43).

In terms of a *definition of logistics* it can be referred to the US council of supply chain professionals (CSCP): "Logistics is that part of the supply chain process that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements" (CSCP 2013).

Regarding a *definition of humanitarian* things are less clear and a byline explanation has to be used e.g. by the UN Charta of Human Rights (Article 25): "Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care and necessary social services, and the right to security in the event of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control" (UN 2013).

To outline a little bit more in detail the ambiguous question of humanitarian actions, a reference can be taken to the example of the UN OCHA objective system,

outlining the overall setup and corridors of global humanitarian management support (Fig. 4.1). The concept is construed by the three basic goals "A more enabling environment for humanitarian action (1)", "A more effective humanitarian coordination system (2)", "Strengthened OCHA management and administration (3)".

An interesting example from the further detailed objectives in connection with the concept of sustainable humanitarian logistics may be No 1.4 "Humanitarian response and response preparedness are underpinned by integrated analysis and rigorous learning". This indicates that improvements and long-term perspectives are important for such a concept—which in itself would lead to a sustainable approach by improvements and long-term developments in order to safeguard quality and efficiency at the same time, leading to less resource consumption as well as a positive development of several aspects of human life and social interaction.

From these background definitions and concepts a *general definition* for sustainable humanitarian logistics may be proposed to guide research endeavors and connect research question in this field among themselves and with other research fields.

Sustainable humanitarian logistics has the objective to assure every human being—especially in situations of disasters and emergencies—a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care and necessary social services by planning, implementing, and controlling the efficient, effective forward and reverse flow and

Fig. 4.1 UN OCHA strategic framework goals and objectives

storage of goods, services and related information throughout the whole supply chain in a manner that meets the needs of the present without compromising the ability of future generations to meet their own needs.

4.2 Research Streams and Research Questions

In order to identify possible research streams and research questions in the field of sustainable humanitarian logistics research a triangular analysis can be conducted between the three constituting topical fields as outlined in Fig. 4.2. The basic field (A) representing the interaction of humanitarian and logistics concepts has been established in the humanitarian logistics research during the past two decades with topics such as operations and optimization, transport concepts, performance management and application of information management systems (i.e. like described by Gösling and Geldermann 2014 or also summarized by Zary et al. 2014). The second field (B) would be directed towards the application of sustainable and green logistics measures and concepts in the humanitarian sector—transferring existing green concepts like e.g. modal shift, recycling and energy conservation as well as renewable resource use to the humanitarian sector (see for example Franceschi et al. 2014).

A third field for interesting research questions (C) could be the question of sustainable humanitarian management—in short to establish long-term and intergenerational thinking for humanitarian aid (i.e. as exemplified by Curran et al. 2014 as well as Zissman et al. 2014 for evaluation). The simple question what disaster relief measures today are implying for future generations and their social and economic well-being cannot be answered immediately and requires in-depth research and analysis methods (Table 4.1).

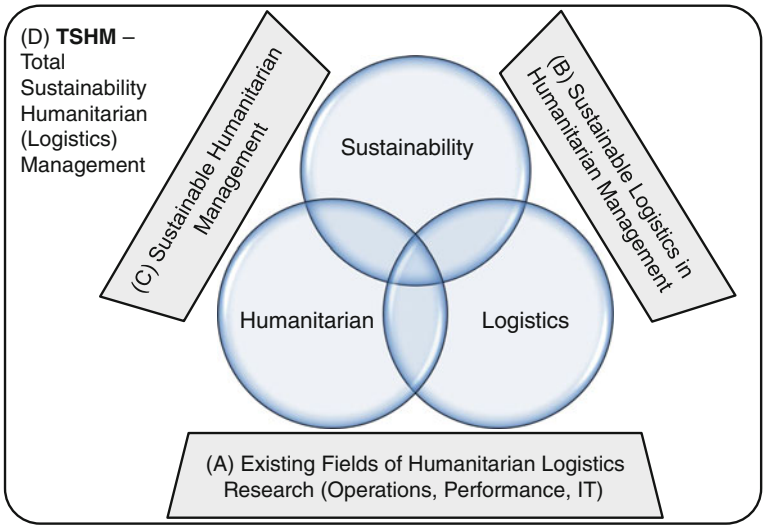

Fig. 4.2 Research streams and connected questions

Table 4.1 Exemplified research questions and methods

Topic	Research question	Methods (examples)	Contributions
(B) Sustainable logistics in humanitarian man	How to organize sustainable transport?	–Concept transfer from green logistics –Operations research –Technology enhancement	Less energy, less emissions, less costs, less work
	How to organize sustainable warehousing?	–Location optimization –Technology improvement –Renewable energy use	Less energy consumption, less emissions, less costs
	How to implement sustainable procurement?	–Auditing and evaluation, certification schemes (ISO 14001 etc.)	
	How to implement sustainable reverse logsitics?		
	How to organize sustainable ICT and transparency?		
(C) Sustainable humanitarian management	Social evaluation	–Social integration and labor conditions analysis (ILO standards) –Eairness/justice evaluation	Acceptance and social improvement contribution
	Generations evaluation	–Evaluation of generation fairness and long-term consequences of HumLog	Intergenerational fairness, long-term prevention
	Ecological evaluation	–Auditing and evaluation, carbon footprint of HumLog concepts –Resource efficiency evaluation	Prevention of ecological disasters
	Global evaluation	–Global distribution evaluation of humanitarian activities	Global balance of humanitarian operations
	Participation evaluation	–Participation rates –Gender analysis	Equal participation in humanitarian SC

(continued)

Table 4.1 (continued)

Topic	Research question	Methods (examples)	Contributions
(D) Total sustainability humanitarian (logistics) man	Total fairness evaluation	I.e. inclusive fairness evaluation along different supply chain steps and also in short- and long-term perspectives	Comprehensive fair humanitarian supply chains
	Total efficiency evaluation	I.e. efficiency evaluation along several supply chain steps and also in short- and long-term perspectives	Long-term efficient humanitarian supply chains
	Total human development evaluation	I.e. human evaluation along different supply chain steps and also in short- and long-term perspectives	Humanitarian supply chains contributing to long-term humanitarian development
	Total ecological evaluation	I.e. ecological evaluation along different supply chain steps and also in short- and long-term perspectives	Long-term ecological humanitarian supply chains
	Total feasibility evaluation	I.e. feasibility evaluation along different supply chain steps and also in short- and long-term perspectives	Long-term humanitarian supply chains

Finally, a fourth area (D) can be identified in combining all aspects in the given picture as concepts regarding a *Total Sustainability Humanitarian Logistics Management* (similar to Total Quality Management)—where for example the question of trade-offs between green humanitarian measures today and the economic situation of future generations may be discussed; similar questions are for example discussed by Pateman et al. (2013), taking into account the *specifics* of humanitarian logistics (Holguín-Veras et al. 2012a, b). The further details and outline of these approaches can be recognized in the table above too.

4.3 Research Limitations

The outlined research streams may be limited in various ways, four major restriction areas are outlined in this section: (i) An ethics perspective may limit the research endeavors regarding sustainable humanitarian logistics research i.e. with the core question of how to evaluate a human life—not only one against another nowadays but also in an inter-temporal perspective: If for example not undertaking a specific measure today (i.e. not to send expensive equipment and humanitarian goods into a crisis region) may possibly safe more lives in the future as with the same amount of money in other regions with other crisis situations—what shall research and humanitarian practice do about such evaluation problems?

Second, a further limitation area (ii) may be the question of existing research disciplines: Within a sustainable perspective even more as already today in humanitarian logistics such disciplinary borders i.e. between economics, management, political and social sciences, medicine, engineering and geography, sustainability and biology research as well as the national sciences may obstruct important research questions and projects in this field. The first important step therefore to overcome this possible limitation is the unequivocal recognition, that especially sustainable humanitarian logistics research is a very inter-disciplinary research field. The described limitation areas are also interconnected as depicted in Fig. 4.3 as ethics problems for example may multiply facing different science disciplines: Whereas i.e. medical researchers may have found concepts and solutions regarding the dilemma situations of saving lives, these aspects may be evaluated very differently in neighboring fields of political and social science.

A third limiting area maybe (iii) the available technology as due to funding, awareness and specialization restrictions research could be severely impeded. This implies that many research and analysis processes have to rely on limited and old technology—so in case for example the use of GPS localization technology in this setting. In many cases, humanitarian logistics research technology is lagging behind business application by many years like with RFID or GPS. And as logistics is usually largely determined by the available technology applications, therefore results for the humanitarian logistics area are also restricted by this.

Finally, in a fourth restricting area (iv) the available budget for research into sustainable humanitarian logistics may be small as a new field usually has no "standing" in science and has large "legitimization" problems compared to

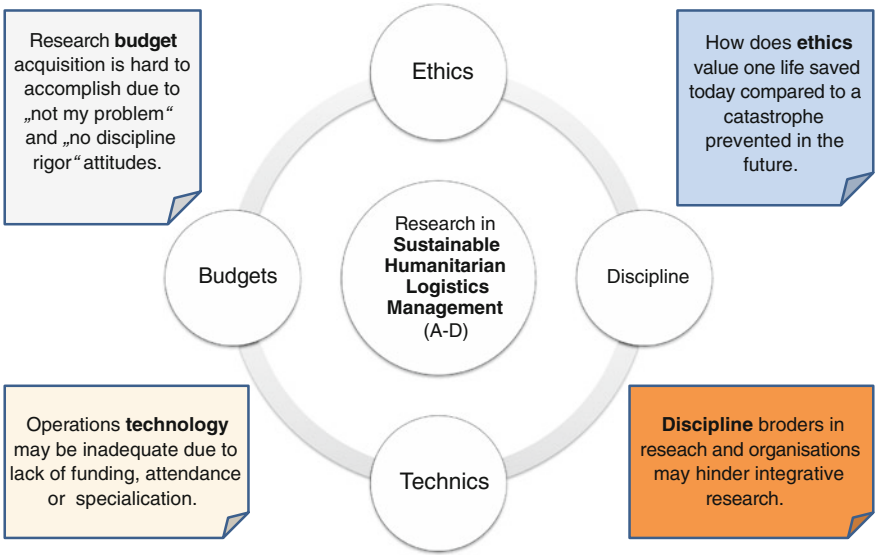

Fig. 4.3 Research limitations overview

established research fields. For example existing research programs (i.e. EU Horizon 2020) have major avenues and budget lines for many fields such as innovation from natural and engineering sciences as well as social sciences—but no direct applicable budget line for global humanitarian logistics (only "disaster management" within Europe for example).

4.4 Case Study: How to Apply Sustainability Principles to Humanitarian Work

In general there are two types of disasters that trigger humanitarian aid: natural events on the one hand and man-made crisis events on the other hand. For both cases it can be established, that the most sustainable strategy to tackle these events is first to prevent them and second—if not possible—to mitigate their effects as soon and completely as possible. For the latter the general objective may be termed as '*establishing* civil society and *basic human functions* with security, economic well-being (food, housing. medical support, education, employment and economic development perspectives) for as large a share of the population as possible.' This general description can be applied to all kinds of disasters, man-made wars (Yugoslavia/Kosovo, Sudan, Syria) as well as natural disasters (Haiti, Pakistan, Philippines).

Sustainable answers to major humanitarian crisis developments as for example regarding Syria are hampered by the restrictions of international state law and politics. This also diminishes the reach and possible positive engagement of several UN institutions, foremost the UNHCR which can only passively react even to major refugee situations. Long-lasting refugee situations like today in Syria and the neighboring states—i.e. Lebanon and Turkey with more than a million refugees each—are severely undermining international support for humanitarian affairs and the affected people in the long run by draining resources into long-lasting refugee situations. Therefore, innovative concepts are necessary in order to put the UN system as well as the international humanitarian community in a position to strategically live up to their expectations. The current crisis hot spots in international politics—namely Ukraine, Syria and others—are all hinting to a major flaw in international law: Whereas *within* states, the UN system acknowledges rights of individual people ("universal human rights") and promotes values as democracy, the rule of law and free market systems in order to further human life as perceived from an individual's point of view, *in-between* states these objectives are trumped by the basic principle of non-involvement in internal affairs of specific states (Aalbertsa and Gammeltoft-Hansen 2014; Berga and Mölder 2014). This can be labeled a basic "paradox of international law" regarding the rule and prosperity of the people—an oxymoron which is sadly present in all major international conflicts in the last three decades. As within these days around the 9th of November 2014—the fall of the Berlin wall is celebrated for the 25th year since 1989—this event may possibly inspire a new principle of international law, guided by the basic objective

of "people's rule" in combination with the "voting-by-feet" approach applied and experienced in those times when the iron curtain fell, especially within Germany.

This sustainable *new principle* for international state law and politics, to be administered by the UN organizations, can be suggested in the face of the described problem areas and recent crisis experiences in order to allow for a long-term humanitarian aid concept:

(i) If the number of misplaced persons (refugees) can be established for one UN member country to exceed 20 % of the total population (at least 2 million people), 10 % thereof *outside* the borders of the specific country (at least 1 million people), as reported by the relevant UN organization (i.e. UNHCR), the UN security council declares with at least 75 % of all votes (*without* any veto rights from the P5 members) an international "state of refugee emergency" regarding the specific country addressed.

(ii) After this declaration, the addressed state is granted a guaranteed "correction time period" of 9 months, during which time all actions shall be undertaken with UN support to alleviate the position of the refugees as well as the internal state of the country. Immediately after the nine-month period, the UN receives a further report from the UN agency in charge (regularly UNHCR).

(iii) If the report after these 9 months states that the refugee status still exceeds the above mentioned limits, the UN security council (again *without* any veto rights) decrees with at least 75 % of all votes a *UN refugee estate mission*, to be implemented by a multi-national military force under the directive of the UN, to begin earliest 3 months after the declared mission.

(iv) In the remaining 3 months before implementation, a joint council of the UN (lead), the nations taking part by order from the UN as well as officials from the specific state (advisory role) are drafting a UN refugee control zone plan, defining a specific part of the territory of the specific state to fall under the UN control zone. The size of this zone is to be tailored towards the proportion of the misplaced share of the total country population. Access and transportation (i.e. airports and seaports, transport routes) are equally guaranteed for the UN control zone as well as the residual state territory of the specific state.

(v) The sole actor and institution implementing state power (security, military and otherwise) in the UN refugee control zone is the UN and the institutional bodies and nations directed by the UN on their behalf. Especially the specific state from which the state territory is requested has no sovereignty rights, including the right regarding the airspace above the declared UN refugee control zone.

(vi) The UN and the institutions acting on their behalf establish this refugee control zone and promote its own political and economic self-reliance in order to create a sustainable long-lasting societal organization.

(vii) After 2 years in existence, the people in the refugee control zone—where people are let into at any request ant without discrimination—are asked in a popular vote if they want to re-merge with the former state territory or if they prefer to be established long-term as an independent state.

This principle is as *case study* applied to the situation in Syria: *Syria* is by the complexity of the political, humanitarian and military development since the crisis outbreak in January 2011 one of the saddest and most tragic international crisis situations. The UNHCR even labels it "The biggest humanitarian emergency of our era" (UNHCR 2014a). The civil war situation between the state of Syria and also in-fighting several other groups within the state area of Syria is constantly changing and very diverse, rendering many international initiatives against violence as well as in humanitarian aid for the people of Syria invalid as conflict areas and parties change constantly. The UN estimate for *incurred deaths* was 190.000 persons as of April 2014; the number of *misplaced persons* has reached 4.5 million people (UN 2014). As in many conflicts worldwide, the cruelest burdens of the crisis are faced by the weakest, women and children, as about.

An example for this is the following map depicting the conflict zones and controlled areas by different groups (status October 2014, Fig. 4.4).

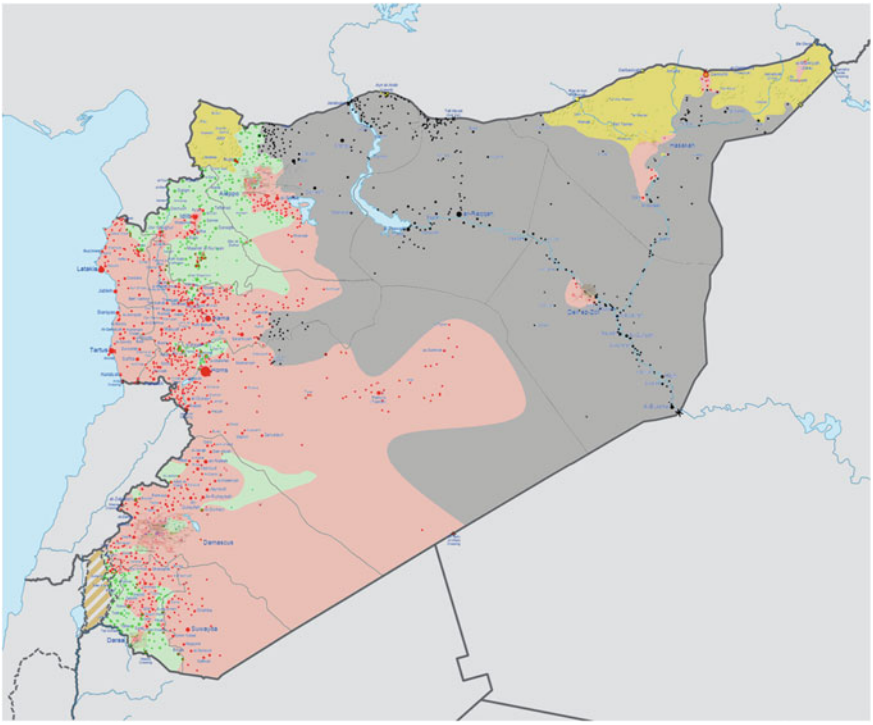

Fig. 4.4 Conflict parties and control zones within Syria (November 2014, Wikipedia 2014); *red* government forces; *green* opposition forces; *yellow* kurdish forces; *black* terror forces

When applied to the case of Syria, the following guidelines and results may arise in the current situation (November 2014) regarding Syria, following the suggested principle of "voting-by-feet"-intervention and state-building:

(i) The number of refugees registered officially with the UNHCR *outside* Syria and within the neighboring states has reached *3.2 million people* by 1st of November 2014 (Fig. 4.5). It can be assumed that the unofficial number is even higher. The percentage of the total Syrian population of 23 million people has therefore reached 13.9 % regarding outside refugees. This would legitimate an establishment of a special UN refugee control zone *within* the state territory of Syria according to the suggested "voting-by-feet"-principle.

(ii) The *timeline* for the case of Syria could be suggested as follows: In January 2015, the UN security council could state the "emergency" situation regarding refugees from Syria based on these numbers. Following up, the second milestone would be a re-evaluation by UNHCR in October 2015. In case the refugee numbers have not diminished significantly (below the 4.6 million refugee/2.3 million external refugee threshold in relation to the total population of Syria), the following enacting of a Syrian UN refugee control zone would be decreed by the UN security council, including a military no-fly zone over the whole country of Syria for the implementation period of November 2015 until April 2016. The official start of the establishment of the UN zone within Syria could be dated 31st of March, 2016.

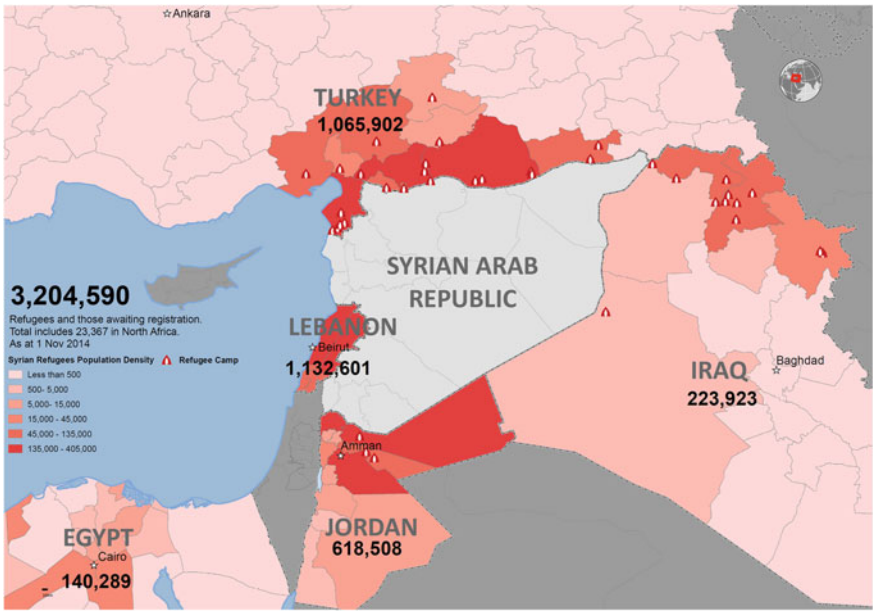

Fig. 4.5 Refugees statistics from Syria outside the country (November 2014, UNHCR 2014a, b, c)

(iii) The acting institutions and nations on behalf of the UN could be the EU-NATO Eurocorps force, established in 1989 and experienced with UN and other peacekeeping missions in Bosnia, Kosovo and Afghanistan; the command and control structures of this military unit are enabled to steer a total security force of up to 65,000 troops (EUROCORPS 2014). This number should be sufficient to establish the specific UN refugee control zone within Syria and the personnel could be seconded from all willing EU states. An initial force of about 20,000 troops could be deployed in order to guarantee the safekeeping of all private and aid personnel as well as refugees in the UN zone (avoiding possible "Srebrenica Scenarios"). The air cover and control of the established no-fly zone could be secure jointly i.e. by Turkey, the US, China and Saudi-Arabia as a "Joint UN Air Command" in the area. Such co-operations are formerly "unthinkable" but with the new strategic challenge of IS terror regimes suddenly feasible.

(iv) The refugee zone within Syria could initially encompass the north-western province of Latakia (*muhafazah latakia*), which is easily accessible by sea (i.e. port of Latakia) and on the land route via Turkey. Military and humanitarian logistics for this zone should therefore be no major concern. If the number of refugees is still rising over passing months, the further provinces of *Idlib* and *Aleppo* could be added to this geographical area.

This procedure would not only provide a perspective and securing basic human rights for the people of Syria, but also lay down basic guidelines for the involvement of the international community (namely the UN organizations) as well as the existing state of Syria, namely in specific new state areas. Furthermore, it would also enable regional actors (neighboring states, humanitarian organizations) to improve their humanitarian support for the people of Syria. Finally, it would also prevent possible future conflicts and human tragedies—as for example the 1.1 million Syrian refugees living currently in Lebanon and Turkey *each*—are unavoidably in the verge of creating further internal conflicts within the neighboring states and the region. A major population group of such sizes without official status (work permits, basic societal integration and perspective, participation in public life and also individual rights to vote etc.) will always and under any circumstances create potential for future conflict and humanitarian crisis. The UNHCR for example lobbies in order to reduce the number of stateless people (worldwide currently about 10 million, UNHCR 2014b)—but the Syrian refugees in neighboring states alone have added *50.000 stateless newborns* to these number since the start of the crisis in 2011 (UNHCR 2014c). Again, an example that humanitarian crises are mostly carried by the backs of the most helpless ones: In this case *newborns* who have definitively neither guilt nor any interest in the raging civil war within Syria—but pay the highest price possible by a very disadvantageous start into life as a *stateless refugee* ("Unregistered children are especially at risk of becoming stateless, as without birth certificates they lack a key means of proving their nationality. They may also be denied access to health care and education, and face an increased risk of exploitation, such as trafficking for commercial sex work, illegal adoption, or child labour", UNHCR 2014c: 1). Therefore, the

international community has not only a duty towards the people of Syria, the many involved but seriously overstretched governmental and non-governmental humanitarian aid organizations, but also towards the people i.e. of Lebanon and Turkey, who extended the unwavering support and welcome to refugees from Syria since the start of the conflict in 2011. Such long-term refugee situations in large numbers themselves embroid future conflicts and humanitarian problems and should therefore be curtailed as soon as possible in a sustainable, long-term humanitarian aid concept.

This new suggestion may also brings about major risks and ruptures in international state law and international politics. Among these risks there may be:

(a) The basic principle of a rule of the people by introducing the international imperative of a newly created state in the UN community and system according to a "voting-by-feet"-approach can possible not be implemented against the will of major states and powers (e.g. states armed with nuclear weapons due to their retaliation potential, Brown 2014, Morrisa and Wheeler 2007). This may be executed through the UN Security Council or other political measures such as blockades, embargos and threatenings.
(b) The principle is also possibly endangered of being misused and hijacked by ill-willing groups of individuals who might use the rule and the international UN community by requesting assistance on the basis of this principle but with worse intentions compared to the original "left" state (Reus-Smit 2007).
(c) It may be feared that a "dam break" can be following the implementation of such a principle as the basic rule of "non-interference" with internal state affairs is disrupted at least partially (Collins 2014). This may enable further initiatives along these lines and therefore be feared by many states as well as peoples, whose well-being and human development today also relies in large parts on the successful application of this basic rule as many international conflicts and wars are prevented by this.

Anyhow, many chances and positive developments can be connected to this suggestion of a new "voting-by-feet"-rule for sustainable large-scale humanitarian aid in crisis situations; among the chances and advantages may be:

(a) The people in states with insufficient state authority and rule of law (e.g. "failed states" Buegera and Bethke 2014) as well as the international community would have a clear route for large-scale refugee situations in different regions and states.
(b) The humanitarian organizations as well as their personnel and the refugees themselves would have a secure base for economic and social development—instead of increasingly endangering the "welcome" gestures of neighboring states.
(c) Most important the economic bases of the refugee zone and potentially a new state can be used to *sustain* more humanitarian support by the refugees and within the area themselves, enabling international aid to diminish over time and concentrate on more pressing incidents in other regions.

This "out of the box thinking" suggestion may therefore not be applied immediately, but still enlighten the way forward i.e. for interdisciplinary research towards

a more human international state law and humanitarian aid concepts, supporting instead of forbidding the rule of the people within the international state community. Also, this may further the idea of strategic humanitarian concepts, enacting long-term thinking and development rather than sole reaction and care for refugees in a crisis situation. This is closely linked to the assumption that NGO's have severe limitations in helping in humanitarian crisis situations in a long-term perspective as e.g. Banks et al. (2015) argue—and therefore possible government organizations' roles and political solutions have to be found.

4.5 Conclusion

As shown with the concepts of research fields in sustainable humanitarian logistics as well as the specific case study on Syria, many new thoughts, concepts and ways are to be explored in order to improve the basic ideas and principles stated here. This can be seen as a task for a new "generation" of researchers, problem-oriented and interdisciplinary as well as internationally connected. This is a sort of new vision for such research from this chapter and book.

Finally, as this may prove hard to tackle, it also may bear important rewards in alleviating the suffering of millions of people world-wide if applied professionally and in an increasingly aware global community towards long-term and sustainable humanitarian activities. Sustainability in humanitarian logistics may therefore require research to look out for the complex, global and long-term consequences of humanitarian crisis situations—as we are all currently forced to recognize for example regarding the case of Syria with the increasing refugee problems in neighboring countries as well as all over Europe. Obviously the former decision not to intervene or act has not been the most sustainable and effective answer to this ongoing crisis, still a severe and tragic dent in the conscience of the whole world.

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Part II
Sustainable Operations in Procurement and Preparedness

Chapter 5
Investigating the Barriers to Sustainable Procurement in the United Nations

Jacob Hasselbalch, Nives Costa and Alexander Blecken

Abstract The purpose of the article is to investigate the barriers that constitute obstacles to implementing effective sustainable procurement practices in the United Nations system. The research approach of the paper is inspired by Grounded Theory. We targeted the largest procuring UN entities as well as sustainability leaders in the UN system and approached a procurement practitioner and procurement policymaker at each for 30–45 min semi-structured telephone interviews. Twenty interviews were carried out. Drawing on the resulting qualitative data, we develop a framework of barriers in eight different categories each containing a number of individual barriers. By tallying the number of interview subjects that mention each barrier, a preliminary ranking of the barriers' relative importance can be attained. The discussion of the barrier framework leads us to propose a sequential model of sustainable procurement implementation in public sector organizations. The paper should be useful for public sector procurement officials who are in the process of introducing sustainability measures. For the UN organizations that are working on this, the paper offers empirically demonstrated focus areas where it can help sequence the measures and prioritize resource investments. The research addresses a gap in the sustainable procurement and supply chain management literature: that of the understudied public sector, broadly, and the United Nations, specifically. The analysis also employs a novel split between the procurement policymaker and practitioner levels, which suggests an innovative approach to addressing the identification of barriers in sustainable procurement.

5.1 Introduction

On the World Environment Day on June 5, 2007, the United Nations Secretary-General made a pledge "[…] to explore ways of making the United Nations (UN) more climate friendly and environmentally sustainable, and to develop a climate

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neutral approach to its premises and operations." This pledge positioned sustainability as an overarching goal for the entire UN system, and kicked off a process of acknowledgement, commitment, and implementation of sustainable practices across its various agencies, funds and programs. Procurement in the United Nations is no exception to this trend, and policymakers have been exploring different ways of integrating sustainability into procurement practices.

With a total procurement volume of $14.3 billion (in 2011), the UN holds significant purchasing power that substantially influences the markets in which its entities participate. Sustainable procurement (SP) presents a formidable opportunity for the UN to influence both its associated organizations and projects towards practices that favor the environment, social progress, and economic development while optimizing costs. The purpose of this paper will be to assess to what extent the UN is implementing sustainable procurement. This presents us with the following research question:

What are the main barriers to implementing sustainable procurement in the UN system?

The paper is organized as follows: first, we briefly discuss how sustainable procurement has been treated in the UN in the recent past and present an official UN definition. Second, we conduct a short literature review in order to cover the state of the art. This is followed by a section on methodology and research approach. Namely, we are proposing to conduct a series of in-depth interviews with UN procurement professionals in various organizations in order to discover the most pertinent barriers to sustainable procurement implementation they experience in their daily work. In the analysis and discussion section we present our findings and discuss the implications. A conclusion wraps up the study.

5.2 Sustainable Procurement in the UN

5.2.1 History of Sustainable Procurement in the UN

Following the Secretary General's pledge to a sustainable UN in 2007, numerous initiatives took place to establish a fledgling policy framework for sustainable procurement. A Sustainable UN (SUN) unit was created in the UN Environment Program (UNEP) to coordinate the sustainability performance of the agencies. Also, an Interagency Working Group on Sustainability Management was formed to track greenhouse gas emissions and report to the Environment Management Group (EMG), a UN system-wide coordination body hosted by UNEP. Two reports from UN internal oversight bodies in 2009 and 2010 highlighted the need to involve the procurement function in the efforts towards sustainability. In one effort to meet this call, the United Nations Office for Project Services (UNOPS), UNEP, the International Labor Organization (ILO) and the International Training Center of ILO (ITC ILO) published a manual in 2011 on sustainable procurement for managers and practitioners titled "Buying for a Better World."

5.2.2 Definition of Sustainable Procurement

UN organizations have endeavored to reach an agreed definition of sustainable procurement aligned to their priorities. As defined by the High Level Committee on Management Procurement Network (HLCM PN), "Sustainable Procurement integrates requirements, specifications and criteria that are compatible and in favor of the protection of the environment, of social progress and in support of economic development, namely by seeking resource efficiency, improving the quality of products and services and ultimately optimizing costs" (HLCM-PN 2009). Sustainable Procurement thus considers economic, social and environmental factors (Elkington 1997), and it entails looking beyond initial purchase price and short-term costs to realize the long-term value, both for the organization and society in general. Various techniques, such as whole-life costing, life-cycle assessment, or the incorporation of sustainability criteria into solicitation documents, make it possible for procurement practitioners to balance the need to effectively meet organizational goals while contributing to sustainable supply chains more generally.

5.2.3 Current Status of Sustainable Procurement in the UN

In spite of the streamlining of the sustainability concept across the higher echelons of the UN, it is currently unclear to what extent procurers are expected to adopt SP practices. While the UN is committed to sustainability in general and sustainable development in particular, the acceptance of sustainable procurement has not been without its controversies (Lund-Thomsen and Costa 2011). The General Assembly (GA) has still not officially endorsed SP. SP was intensely debated in the Fifth Committee of the General Assembly in 2009, and a typical North-South divide seemed to emerge in the proceedings. While the European Union (EU) argued for SP in order to raise awareness and discover best-fit solutions, the Group of 77 (G77, the largest intergovernmental grouping of developing countries), opposed the concept of SP due to concerns that suppliers in their countries would not be treated according to the principles of equal, fair, and non-discriminatory sourcing. Furthermore, the G77 were not convinced of the need to implement SP as they felt they had not been provided with sufficient details on how suppliers and international competition would be affected. A final decision was reached to postpone the decision on official endorsement of SP.

In this environment of increasing prioritization of sustainable procurement in the UN, but also significant obstacles to its widespread adoption, it thus makes sense to have an in-depth look at the current state of SP and to gauge the most pertinent barriers to its effective implementation. This is the purpose of this paper, and its aspiration is to initiate research on the issue and construct a rudimentary framework of barriers which should be of interest to policymakers, practitioners and researchers involved in sustainable public procurement.

5.3 Literature Review

Sustainable procurement is a field that has been gaining increasing interest from practitioners and academics alike in the past few years. In this article, we treat the term 'sustainable procurement' as encompassing the various related terms such as sustainable supply management, sustainable purchasing, or purchasing and supply management sustainability. Walker (2012) carried out an analysis of 35 journals which showed more than a doubling in the number of articles published on sustainable procurement from 2009 to 2010 (from circa 40 articles to more than 100). Similar spikes from 2010 onwards can be found in the number of special issues published on sustainable procurement and the number of papers presented at IPSERA conferences (International Purchasing and Supply Education and Research Association) on the subject (Walker et al. 2012). Being a recent phenomenon, there is still a relative dearth of literature on the subject, in spite of the growing interest. This leaves investigators with a number of methodological challenges and research gaps.

The literature on corporate social responsibility (CSR) has provided practitioners and academics in the procurement field with the useful tool of the Triple Bottom Line (TBL), whereby one measures not only economic performance, but also social and environmental (Elkington 1997). The TBL advocates an integration of all three factors, but research in sustainable procurement has tended to favor environmental matters by a magnitude of 2–1 (Walker et al. 2012). Also, researchers have been insufficiently explicit about their level of analytic focus. Sustainable procurement studies span several levels: individual, organizational, buyer-supplier dyads, supply chain/networks, and market/society/stakeholders. In order to further the conceptual clarity of the field, it is important to consider which dimensions of the TBL are being addressed as well as the level of analytic focus on which you are working (Hoejmose and Adrien-Kirby 2012).

There are numerous studies on SP in the private sector in industrialized countries (Pagell and Wu 2009, 2011; Pagell et al. 2010; Giunipero et al. 2012). The Supply Chain Management (SCM) literature has traditionally linked sustainable sourcing to corporate social responsibility initiatives (Carter and Jennings 2004), although several recent studies focus on the use and diffusion of environmental practices by suppliers (Tate et al. 2011, 2013) and the link between environmental and social practices and performance (Pullman et al. 2009). Barriers and enablers to the inclusion of sustainability in the private organizations' supply chain have been extensively analyzed in literature (Walker and Jones 2012; Giunipero et al. 2012). However, this body of research is not yet endorsing the holistic Triple Bottom Line view of SP, and it is unconcerned with SP in public organizations (Tate et al. 2012). There are several other reasons one can assume private sector SP barriers to be less applicable to a public sector context. The legal and economic environment constraining firms is markedly different from the one constraining public sector organizations in general. Furthermore, the UN's political environment is unmatched in terms of scale and complexity.

Sustainable public procurement, meanwhile, is best covered in the developed world (Brammer and Walker 2011, 2012; Preuss and Walker 2011; Walker et al. 2008),

and especially on the scale of local government (Meehan and Bryde 2011; Nijaki and Worrel 2012; Preuss 2009; Thomson and Jackson 2007). Several recent studies are looking into the various issues that crop up when extending sustainable supply chains into the developing world (Hall and Matos 2010; Muller et al. 2012; Boons et al. 2012). Sustainable public procurement in developing countries is the most significant research gap (Walker et al. 2012; Vermeulen and Seuring 2009), and SP in the United Nations seems almost completely unstudied (Lund-Thomsen and Costa 2011; Walker and Harland 2008). Our contribution thus addresses a gap both in terms of SP in a developing country, public sector context and in terms of UN procurement. Due to the specificity of the UN's context and the unstudied current situation, it is clear that an inductive approach to determining the main barriers is required.

5.4 Methodology

5.4.1 Grounded Theory

Our research design is inspired by the Grounded Theory (GT) approach, while not following its tenets to the letter (Glaser and Strauss 1967). This methodological approach has been chosen because there is little previous research on the chosen field of study. Specifically, we encounter limitations in adapting some of the existing theoretical frameworks developed in the literature on barriers to SP and sustainable SCM in the private sector to UN procurement. This is mainly due to its structural complexity and to the politically charged decisional process (Walker and Harland 2008). Furthermore and as previously discussed in our literature review, this study seems to be placed at the crossroad of some overlapping research gaps: those on UN procurement, on SP in developing countries and on SP in the UN specifically. This warrants the use of the Grounded Theory inductive research process for theory development.

Grounded Theory is a methodology that aims at the generation and discovery of theory through the analysis of (typically) qualitative data, and is therefore well suited to exploratory studies (Stebbins 2001). One of the tenets of GT is to avoid pre-existing conceptualizations of the studied field, which means that the analyst should refrain from doing excessive literature review and building hypotheses. Instead, analytic codes and categories should develop through inductive reasoning, drawing on the data gathered from e.g. interviews. This ensures that the analyst minimizes the impact that his bias or preconceptions may have on the research, thus 'grounding' the theory in reality.

Central to the Grounded Theory approach is the idea of constant comparison, which posits that data collection and analysis should be carried out concurrently (Glaser and Strauss 1967). The most common data collection method is in-depth interviews (Berg and Lune 2011). However, another tenet, 'all is data,' states that the researcher need not constrain his analysis to only treating the collected interview data.

The existing literature can also be used as data and be constantly compared to the codes and categories emerging from the analysis. The same applies for hypotheses; they can be considered as data collected from the researchers instead of analytical constructs to be verified or falsified. Therefore, literature reviews and hypotheses are useful and allowed as long as categories are not made to fit the literature. Rather, hypotheses and the extant literature should inform the analysis, but not direct it.

Data collection usually follows the idea of theoretical sampling, which entails letting the unfolding analysis inform the data collection process. In other words, instead of choosing interview subjects at random, the researcher should selectively target subjects that maximize the potential to discover relevant, new data (Corbin and Strauss 2007). As data becomes collected, it should be subjected to analysis immediately. Rather than spend time recording and transcribing interviews, GT urges the analyst to field-note interviews and quickly consider how the information gathered from the interview subject develops the theoretical picture of the studied field. This is typically done by coding the general notes taken during the interview, i.e. identify different codes (such as words, phrases, ideas) that allow the key points to be gathered and then extracting from these codes more general concepts that capture different collections of codes. From these concepts, categories (higher-order constructs) may be built in order to arrive, ultimately, at a more condensed theoretical overview of the key factors that explain the observed social behavior. Grounded Theory thus aims at theory generation, but for the purposes of our study, it makes sense to use it in order to arrive at a framework of barriers to sustainable procurement that is grounded in the daily experiences of UN officials. GT has been used extensively in the SCM literature (Denk et al. 2012).

5.4.2 Data Collection

Table 5.1 presents the UN entities we interviewed for the study, as well as their procurement volume. Added together, they make up more than 92 % of the UN system's total procurement volume (roughly $13.2 billion of $14.3 billion). We targeted the largest procuring entities and added three more organizations which we identified as sustainability leaders in the UN system (the bottom three organizations in the table: UNEP, ILO, and the United Nations Population Fund (UNFPA)). These are the agencies that have been highly involved in formulating sustainability policies, raising sustainability awareness, or working on cross-cutting sustainability initiatives.

At each agency we approached a procurement policymaker and procurement practitioner for interviews. This decision was taken on the basis of the realization that sustainable procurement is carried out both on a policy level and a practitioner level (Preuss 2009; Thomson and Jackson 2007). The policy level has to do with setting the strategic direction, formulating policy, and setting strategic priorities, while the practitioner level involves carrying out actual procurement transactions. Hence, procurement practitioners are those professionals that work on carrying out actual procurement transactions in their respective organizations. Ideally, they are

Table 5.1 UN entities targeted for the study

Agency	Abbreviation	Total procurement volume 2011 (USD million)[a]
UN Procurement Division	UN/PD	3,173.75
UN Development Program	UNDP	2,691.97
World Food Program	WFP	2,532.34
UN Children's Fund	UNICEF	2,153.57
UN Office for Project Services	UNOPS	778.25
Pan-American Health Organization	PAHO	606.67
UN High Commissioner for Refugees	UNHCR	535.10
UN Relief and Works Agency	UNRWA	281.97
UN Environment Program	UNEP	n/a[b]
International Labor Organization	ILO	93.49
UN Population Fund	UNFPA	362.36
Total procurement volume of agencies in sample		**13,209.47**
Total procurement volume of all UN procurement		**14,276.04**

[a] Only 2011 figures were available at the time of research. Updated figures are available at: https://www.unops.org/english/whoweare/publications/Pages/Annual-Statistical-Report-UN-Procurement.aspx

[b] UNEP does no procurement of their own. Instead, they buy through UN Office at Nairobi (UNON) and UN Office at Geneva (UNOG)

the people who are already doing sustainable procurement in their daily work. In the policymaker group we find senior level professionals and directors who are responsible for incorporating sustainable procurement into the daily work of their organizational units. By splitting the interview subjects into the distinct groups of practitioners and policymakers, our study focuses on providing a holistic picture of SP in the UN, including how it functions both strategically and practically as understood at various levels in the organizations. This approach, informed both by personal experience and the literature, directed our theoretical sampling strategy for the data collection (Corbin and Strauss 2007).

The interview subjects were identified by drawing on the professional networks of the researchers, and referrals were used when gaps occurred. This provided us with 22 research subjects in total, and 11 in each of the groups (practitioners and policymakers). We consider this sample representative of the community involved in sustainable procurement in the largest procuring UN entities, on the basis of our practitioners' knowledge and of the outreach done within the organizations to identify the research subjects. Furthermore, the interview process confirmed that we were reaching the saturation of the research topic. At the time the research was carried out, all the authors of this paper were employed in the procurement division of UNOPS, the organization with the mandate to be a central procurement resource in the UN system. Furthermore, the authors were heavily engaged on sustainable procurement matters in the UN and active in cross-organizational working groups and harmonization initiatives. This positioned us uniquely well in order to affirm

that the interview subjects we targeted were indeed authorities on the matter in their organizations. We emphasize that the 22 identified interviewees were not a random sample of procurement staff, but were indeed the specific staff that were charged with SP tasks in their organizations. The practitioners we targeted generally held the title of Procurement Officer, while the policymakers were either senior level procurement managers or SP subject matter experts.

An interview manual was followed so that each interviewee was asked the same set of questions (as a starting point), and notes were taken on each response. Interview subjects were asked for their personal opinions instead of official, organizational stances. For this reason, it was also advantageous to refrain from recording the interviews, so that interviewees were more at ease and could speak more freely (Berg and Lune 2011). The interviews proceeded as outlined in the interview manual in the appendix. During the interviews, the researchers took notes on the responses of the subjects in a standard document that mirrored the contents of the interview manual.

5.5 Analysis

Of the twenty-two interviews that we were aiming for, twenty interviews in all were carried out. We succeeded in getting at least one interview subject from each of the eleven organizations, meaning that the two remaining interviews stem from two different organizations where we only interviewed one person. In both of these cases we spoke to policymakers, making them slightly overrepresented in the study. The use of a standard document for recording responses of subjects on each interview item allowed for ease of comparison across interview subjects. These interview notes made up the data that the researchers coded according to the Grounded Theory approach. After each interview, the notes were coded and analyzed in order to determine which barriers to sustainable procurement each respondent brought forward. Once all the interviews had been carried out, the interview notes were revisited and re-coded by the researchers several times to arrive at a condensed and consistent framework of barriers.

5.5.1 Barrier Framework

When the final framework of barriers was decided upon, all interview data was analyzed once more to ensure that the number of times each barrier was cited by interview subjects was correct. Our findings are summarized in Table 5.2, showing the categories of barriers, the individual barriers, the number of times cited by policymakers and practitioners and the number of times cited in total. The final column provides an overview of the barriers and of how many times they were cited by respondents—the lowest frequency being 2 times and the highest 13. Within this

Table 5.2 Barrier framework

Category	Barriers	N_{policy}	$N_{practice}$	N_{total}
Information	Difficulty with defining sustainability criteria	5	3	**8**
	Difficulty in addressing social issues	5	3	**8**
	Need for more information on SP	3	2	5
	Awareness-raising needs	2	2	4
Tools	Procurement procedures need updating	7	5	**12**
	Lack of tools/guidelines/manuals	5	3	**8**
Policy/strategy	Lacking SP policy	7	6	**13**
	Policies focused on cost effectiveness	3	6	**9**
	Lacking top management commitment	4	1	5
	Lack of interagency collaboration	2	1	3
Performance measurement	Lack of monitoring/auditing of SP performance	3	4	7
	Lacking goals/targets/incentives/ sanctions	0	2	2
Mandate/politics	Lacking mandate	7	5	**12**
	Risk of conflict w/developing countries	4	3	7
	SP distracts from carrying out primary tasks	2	2	4
Supply	Market barriers in program countries	5	5	**10**
	Risk of limiting competition/supply base	5	4	**9**
Demand	Resistance to SP by internal customers	2	4	6
	Requires stronger cooperation with end users	1	1	2
	Local governments uninterested in SP	2	2	4
	Resistance to organizational change	1	3	4
Resources	Dealing w/short-term cost increases	7	5	**12**
	SP is too time intensive	0	3	3
	Training needs	4	1	5
	Funding issues	4	3	7
	Lacking staff to support SP	2	4	6

N frequency of response in data set

range, we focused our analysis on the categories with a citation frequency on the upper half of the range (8–13 citations). Eight categories that encompass all the individual barriers emerged from the analysis: information, tools, policy/strategy, performance measurement, mandate/politics, supply, demand, and resources. In the following sections we will touch upon interesting individual barriers in turn.

5.5.2 Most Cited Barriers

The lack of an organizational sustainable procurement policy was found to be the most frequently cited barrier (13 of 20 interview subjects). Subjects argued that without a high-level policy or strategy in place to deal with SP, no initiatives would be taken towards implementation. Furthermore, those initiatives that were taken without a solid policy in place often encountered problems such as a lack of staff or funds because these resources could not be granted to sustainability initiatives without the legitimacy accorded by their incorporation into the organization's formal policy or strategy. In this way, many of the different types of barriers in fact had the lack of a SP policy as their root cause. The same argument explains why the lack of a political mandate was such a frequently cited issue. UN organizations largely depend on member state funding, and thus their operations are determined by the specific mandate they are given in the General Assembly (Lund-Thomsen and Costa 2011). Devoting large amounts of time or effort to realizing sustainability efforts is, thus, believed to be unrealistic without securing the political go-ahead.

The barriers presented by dealing with short-term cost increases and the need to update procurement procedures are likewise connected. The core issue with these two barriers is the difficulty of balancing short-term costs and long-term savings, but several factors explain why this is very difficult for UN agencies. Often, sustainable procurement solutions require higher up-front costs, which can be recuperated over time. However, UN agencies typically receive core budget funding from member states, i.e. a lump sum of money that they have to put to best possible use. Under such circumstances, it is difficult to justify spending more money than allotted for the procurement of sustainable solutions, because the long-term savings do not figure into any envisioned business plans or budgetary cycles. Additionally, the procuring entities and the implementing partners are typically separately budgeted, so that once the handover of goods has occurred, the long-term costs and savings will only fall on the implementing partner, prompting procurers to seek the lowest initial costs in these cases.

The issue of market barriers in program countries is cited 10 times. UN agencies typically operate in the developing parts of the world, and when sourcing from local markets, sustainable solutions are often nonexistent or prohibitively challenging. When half of the interview subjects are of the opinion that this constitutes a barrier to SP, this finding lends credence to the appeal by developing countries in the GA that sustainability criteria in UN procurement risks cutting off a significant share of their suppliers. These markets may have to mature further, or SP initiatives have to meet these challenges more directly and assist suppliers in meeting sustainability requirements (Ehrgott et al. 2013).

On the lower end of the range of important barriers we find barriers cited by 8–9 of the interview subjects. Since they are important issues, they warrant a short consideration here. Concrete information and tool needs, such as definitions of sustainability criteria and updated procurement manuals, are holding several interview subjects back. The fact that these issues are mentioned less than the policy

and mandate barriers suggests that SP implementation has not progressed to the point that these issues are making themselves more felt. It can be deduced that had the policy and mandate barriers been cleared, more agencies would be looking at the first steps of implementation (information and tools), and perhaps these issues would have been more cited in that case. They are significant barriers for those agencies working with SP already, but non-issues for those who feel blocked already at the policy and mandate level. Thus, this indicates a sequence of SP implementation, a series of steps to be taken in order, which we will explore further in the discussion.

The policy barrier in this section ("Policies focused on cost effectiveness") represents the issue that an agency's policies guiding procurement prioritize cost effectiveness and financial goals, and do not incorporate social and environmental considerations. This barrier is connected to "Dealing with short-term cost increases" and "Procurement procedures need updating," but reflect the issue at a policy level instead of the resource level (cost increases) or tool level (procedures). If the organization reports on its effectiveness to stakeholders in terms of financials, these measures would currently not take social and environmental factors into account. This results in policy that leads procurement staff to seek cost effectiveness above all else. The supply side issue in this category is also akin to the one reported in the previous table, but rather than representing the issues with sourcing in program areas, this barrier represents the risk that the global supply base may become too limited by the incorporation of sustainability criteria.

5.6 Discussion

In general, we find that the status of sustainable procurement in the UN has progressed significantly since this issue was last researched five years ago (Lund-Thomsen and Costa 2011). At that time, SP was a very new concept in the UN, and the majority of agencies that were contacted had a very tenuous grasp of the concept and often no immediate plans to implement SP in their organizations. That picture differs considerably from what we discovered this time around. All interview subjects provided a definition of the concept, expressed a keen interest in the subject, and talked about recent and future plans and examples of SP. Although implementation has by no means progressed very far yet, it would be fair to say that the issue has gained a lot of traction in the UN.

5.6.1 An SP Implementation Model

Looking at the framework as a whole, it is evident that the core issue preventing further implementation of SP in the UN is a need to formalize the requirement for sustainable procurement in the agencies, both in the form of a political mandate and

an organizational strategy and SP policy. UN entities are public sector, rule-bound organizations that have to demonstrate accountability to member states while also appearing responsible towards stakeholders in general (Brammer and Walker 2011). This sometimes becomes a difficult balancing act, as in the case of sustainable procurement (Lund-Thomsen and Costa 2011). On the one hand, the UN has to show leadership in sustainability and signal this to the market. They have to pursue sustainability to display social and environmental responsibility and appear legitimate to stakeholders such as the general public (Walker et al. 2008). On the other hand, the UN spends public money and therefore must be accountable to member states. This accountability is derived from the formal mandates accorded to the agencies through General Assembly resolutions, and as stated, there has been no formal endorsement of sustainable procurement at this level as of yet. UN agencies are thus caught between the demands of satisfying stakeholders by appearing sustainable and satisfying member states by being thrifty. Sometimes you can be thrifty and sustainable simultaneously, and sometimes sustainability carries a premium. This short explanation accounts for the haphazard and ad hoc implementation of SP currently. Agencies are picking the low-hanging fruits, i.e. doing SP when it is easy and cheap.

This is a natural way to go about SP implementation, but to progress beyond the easy wins and take on more ambitious and long-term sustainability, the formalized requirement for SP (mandate and strategy/policy) has to be secured. The notion that SP implementation progresses through several steps in sequence, i.e. that you must have the mandate, then policy, then manuals and tools, etc., has led us to propose the following model to explain SP implementation in public organizations (Fig. 5.1).

The model mirrors the categories that emerged in the barrier framework from the Grounded Theory analysis. The respective relationships between the categories in the framework we posit on the basis of evidence from the interviews (see also the practical example in the next section). What the model entails is that higher-order issues must be resolved before the lower ones can be taken on effectively. For instance, training staff in SP makes little sense before securing the political mandate

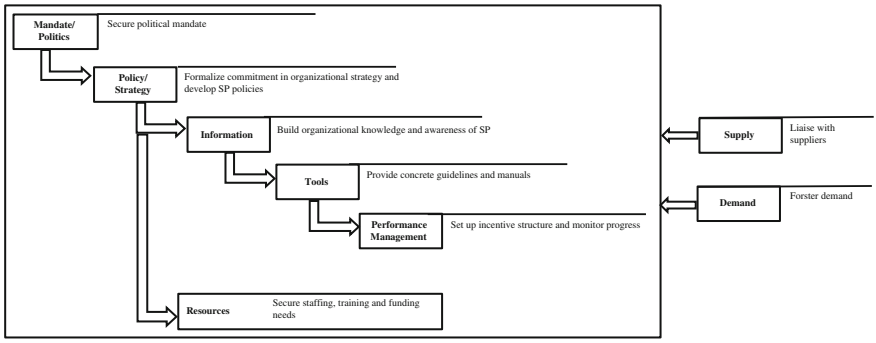

Fig. 5.1 Sequential implementation model

to do SP and institutionalizing this mandate in the organization's strategies and policies. What we have seen in the UN agencies and SP-connected working groups and networks to date is an appetite and ambition to address these issues, but little recognition of the sequential implementation process, or plans to tackle the higher-order barriers. The focus has been on developing training programs, manuals, and guidelines, and while these things are necessary, their impact will be limited before clearing higher-order barriers. Organizational resources that are devoted exclusively to furthering SP should be provided as soon as SP is formalized into policy and strategy at the level of the individual organization, and the resources must be secured for the duration of the implementation process and subsequent operational stage. While most of the categories describe internal organizational processes, the categories of supply and demand capture the effects of external actors as well.

This brings us to the most pertinent implication of our research: where should the UN direct its focus in order to progress on SP implementation? The five most cited barriers represent two core issues, and they respectively represent different manifestations of these two issues. The first issue can be summarized thus: market barriers to suppliers in program (developing) countries are the reason that the political mandate has not been given by the GA, which prevents many UN agencies from legitimizing the practice of SP by incorporating it into formal organizational strategy and policy. To address this issue, the focus should be on how to tear down these market barriers to SP in the developing world. Accomplishing this successfully should lead the way towards GA endorsement, by making sustainability requirements uncontroversial. Different strategies can be envisioned towards this end: first, UN agencies are already making efforts towards upgrading local suppliers through their program activities. These efforts can be up-scaled and more focused on meeting sustainability requirements (Ehrgott et al. 2013). Second, efforts must be made to analyze and communicate the business case for SP in UN operations (Tate et al. 2013). Widely held beliefs state that SP entails paying a premium in order to 'do good,' and many interview subjects voiced this exact concern. SP, when done correctly, ought to bring about long-term savings, and it is important to convince stakeholders that SP is best management practice and not philanthropy.

The other issue relates to the procedures and resource needs that guide and constrain procurement in the UN, and also touches upon the notion of realizing long-term economic savings. As previously mentioned, procurement procedures in the UN are generally not well-equipped to balance the higher initial investments with long-term savings that you often find in cases of sustainable procurement. For private sector companies this is an easier exercise, because by presenting a compelling business case to banks or investors, higher initial investments can be merited. When relying on donor funding, there are limited possibilities for acting on long-term propositions. The culture of accountability in the UN presently dictates a demonstration of short-term cost effectiveness. Currently, donors need to be convinced that their money is put to good use, and results and impacts should be quickly achieved and measurable. One idea to address these issues includes revisiting the agencies' budgetary cycles and reporting requirements to allow for better representation of long-term savings.

5.6.2 Practical Example: UNFPA and Sustainable Procurement of Male Condoms

In the following practical case example, we highlight and demonstrate the issues brought forward in the discussion. The data in this section stems from the two interviews carried out with UNFPA, and explicit permission has been granted to discuss this particular case in the study, since it serves as an integrative example that provides some empirical basis for several of the barriers.

At the time of writing, UNFPA were in the process of developing their 'green procurement' strategy with the help of external consultants. The basis for developing this strategy originated in recent experiences in carrying out actual SP transactions. Earlier in 2013, UNFPA issued a solicitation for a Long Term Agreement (LTA) on the supply of male condoms. What was interesting about this solicitation was that it was the first instance of including environmental requirements into solicitation documents in UNFPA. Bidders were asked whether they lived up to requirements such as an ISO14001 certification, whether they complied with local laws governing air and wastewater pollution, to document a long-term plan for saving energy and using renewable energy, and to progressively introduce more recycled and biodegradable materials and sustainability certifications for their packaging materials over the next few years.

The move towards including environmental requirements in condom solicitations had been discussed with suppliers over a multi-year period. UNFPA has been active in the International Organization for Standardization (ISO) in the development of a standard for environmentally friendly produced condoms. Through this forum, existing suppliers had gradually been sensitized to a market shift. When development began three years ago, very few of the suppliers showed any willingness or interest in this new standard, but in a recent vote over 50 % of the suppliers voted for the establishment of the standard. This fact shows the importance of sensitizing suppliers early to a shifting market. The introduction of sustainability criteria will be more successful if an incremental approach is taken, with ample warning given.

On this particular LTA, UNFPA did not experience a reduction in the supply base, which was comprised almost entirely of bidders from developing countries and economies in transition. An expected number of bidders submitted, and their sustainability measures were better than expected, although spanning the range from full compliance to none. The evaluation of the bids made another issue apparent. For those requirements that were easily measurable, such as whether or not the supplier had attained ISO14001 certification, compliance was easy to demonstrate and believable. However, on the requirements that were more loosely defined, such as documenting a long-term energy saving plan, bidders demonstrated compliance in a variety of different ways such as loose promises, energy saving projects and plans for monitoring factory processes. Furthermore, some of the

requirements were very well-defined and concrete, but in reality they would be very difficult to measure compliance on. For example, the requirement for recyclable materials gradually increases from 20 % in 2014 to 40 % in 2016. At the time of the solicitation, suppliers could do no more than promise to live up to this in the future. With no plans from UNFPA to audit suppliers on their performance on these requirements, this promise is also rather easy to make.

These difficulties, surmountable as they may be, gloss over a more conspicuous absence. None of the environmental requirements have any actual bearing on the evaluation of the bids. In other words, suppliers' performance on these requirements did not figure into the final scores. Rather, the environmental requirements were offered as optional requirements. Suppliers knew they were going above the minimum by reporting performance here, and yet the majority of suppliers made an effort to demonstrate compliance regardless. Rather than making the entire exercise pointless however, the inclusion of environmental requirements served a distinct and very important purpose: that of signaling changing preferences to the market. Through the LTA, UNFPA can effectively communicate that these types of requirements are going to become more common. Thus, the LTA should be regarded as an extension of the process of sensitization that started already three years ago when first discussing environmental requirements with suppliers through the ISO.

However, the case also serves as an illustration of the barriers that arise when working in contradiction to the sequential model we proposed earlier. The green procurement exercise was a bottom-up initiative that originated in the procuring unit. Although tolerated, and perhaps encouraged, by senior management in the organization, no SP policy or strategy existed at the time of the solicitation. Thus, UNFPA were unable to score the environmental requirements on the bids as a part of the technical evaluation, as doing so would be in violation of organizational rules and procurement procedures. Using solicitations to communicate an increasing appetite for sustainability will only be believable if they are followed up by binding or mandatory requirements in the future. UNFPA will have to ensure that a policy is in place in the near future to allow for this, and this is exactly what the agency is working on through the development of its 'green procurement strategy.' However, a less risky approach to this would have been to carry out these actions in the sequence we propose—first ensuring the policy, then signaling, then including binding requirements. This approach ensures that the signals that are sent will correspond with forthcoming requirements.

A final note on the case concerns the lack of any criteria related to social factors in the solicitation. Social factors are covered in the General Terms and Conditions that suppliers have to sign and live up to in order to become vendors to the UN. However, sustainable procurement dictates the inclusion of social criteria in the procurement process itself, and not only in preliminary contracts. The lack of a formal UN-wide definition and endorsement by the GA risks fracturing the approaches taken to SP by the different agencies, which could confuse suppliers and forego opportunities for the UN to achieve synergies in the procurement process.

5.7 Conclusion

5.7.1 Strengths and Limitations of the Study

In general, we concluded that sustainable procurement implementation is in the early stages in the UN, but the issue has gained much traction in recent years. The most significant barriers have to do with a need for a formal endorsement of SP on a UN-wide level, a need to institutionalize this mandate in the agencies' strategic plans and procurement policies, and a need to revisit procurement procedures to better allow for balancing short-term and long-term expenditures. Our focus on providing a holistic view of both SP policy and practice resulted in the conception of a sequential model of SP implementation. We propose that implementation of SP in political organizations has to progress through a series of steps, beginning with mandate and ending with concrete tools, in order to be effective. In our literature review, we have highlighted the existing gap in our understanding of how SP is applied not only in the UN but more in general in public organizations operating in developing countries. Our sequential implementation model serves as a blueprint for identifying causal links between general categories of barriers, and consequently proposing a plan of action for their removal. Because of the generality of these findings, the model may be tested in and applied to other large public organizations that share similar structure, organizational setup, political connotations or operational constraints.

The study's informal approach to acquiring and conducting interviews, drawing on the professional networks of the researchers, allowed us to establish with a high degree of certainty that the interview subjects we had contacted were in fact people who could speak with much authority on the state of play of SP in the UN. By asking for personal opinions and not recording the answers, we were able to get a deeper understanding of the underlying issues and controversies that trigger the barriers. This immediacy to the studied field may also be a limitation of the study, as our personal opinions and bias are strengthened when working on subject matter so close to our daily jobs. Finally, the small sample size, compounded by the fact that only two subjects were approached at each agency, introduces the possibility of a large amount of variance in the barriers reported. This issue is partly accommodated by the fact that only seven UN agencies account for nearly 90 % of the UN's procurement volume, and by speaking to the right people in these agencies, a realistic picture of the field can be obtained.

5.7.2 Suggestions for Further Research

This has been an exploratory study to determine which kinds of barriers procurement policymakers and practitioners encounter in their efforts to implement sustainable procurement. As such, our focus has been on the discovery, identification,

and rudimentary ranking of SP barriers. The proposed framework of barriers should therefore be considered an initial investigation into this subject area, and not a conclusive report on the state of play. To arrive at a more robust and thorough framework, the current research can be expanded on in several directions.

First of all, one possible next step would be to test the framework statistically by submitting a survey to a much larger field of respondents than the twenty interview subjects represented in this study. This would supply our preliminary investigation with some statistical rigor, which would allow us to make stronger claims concerning the relative importance of barriers. Also, this would provide a clearer picture of the variance of responses in different categories, bringing forward the barriers that can account for the different stages of implementation of UN agencies. Another way to test the framework is to expand the analysis through a Delphi study, whereby the same sample of interview subjects would be made privy to the results of the first round of analysis and be given the opportunity to revise and re-rank the discovered barriers on the basis of this information through several iterations of questionnaires. Another research direction could be exploring whether a correlation exist between the organizational characteristics of the UN agencies and the barriers identified within them; and more specifically on the correlation between the level of maturity in SP implementation and the typologies of barriers that emerge from the research. Finally, the proposed sequential model of SP implementation should be tested at other political organizations to examine the generalizability of our findings.

Appendix

Interview Manual

Disclaimer: anonymous, confidential, personal views instead of official, organizations will not be emphasized, not recorded, general notes will be taken, length of interview will approximately be 30–35 min.

Setup: 3-part interview (definition, operation, and impact)
Part 1: Definition

1. Definition
   (a) What is your definition of sustainable procurement (SP)?
   (b) According to your definition given here, does your organization practice SP?
   (c) How would you describe the balance between economic, social, and environmental concerns? Can you give an example of how this would look in practice?

2. Mandate

   (a) Do you think there is a clear mandate for your organization to engage in SP, and where does it come from?
   (b) Does your organization have a clear SP policy or strategy? Is it regularly updated and communicated to staff and stakeholders?
   (c) Do you think that SP has the potential to either further or hinder your organization's efforts to meet its mandate?
   (d) Do you feel supported in your sustainability efforts by a high-level commitment to the issue?

Part 2: Operation

3. Training

   (a) Have you delivered or received training in SP?
   (b) Is there a designated individual in your organization that is accountable for SP?

4. Economics

   (a) Do you believe that you would experience short-term cost increases as a result of doing SP?
   (b) If yes, do you think that these would be outweighed by long-term savings or other benefits, either tangible or intangible (such as better morale, cleaner environment, supporting your mandate, etc.)?
   (c) Do you think your organization's procurement rules and regulations allow you to balance the differences between short-term/long-term financial considerations?

Part 3: Impact

5. Risks

   (a) What are the main risks of engaging in SP?
   (b) Conversely, what are the main risks of not engaging in SP?

6. Impact and rewards

   (a) What are the most important pros and cons of SP?
   (b) How are SP practices impacting your organization as a whole? Positively or negatively?

7. Examples

   (a) Can you provide me with one clear example of where SP worked in favour of organizational and stakeholder goals and needs?
   (b) Can you provide me with one clear example of where SP efforts were detrimental to the procurement process?

END

- Are there any final comments you would like to make, or any issues or concerns you would like to raise?
- Can I mention (specific case studies or examples brought forward during the interview) in my article?

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Chapter 6
Disaster Management Capacity Building at Airports and Seaports

Bernd Hellingrath, Teo A. Babun, James F. Smith and Daniel Link

Abstract Ports—i.e., airports and seaports—are the main points of entry through which foreign intervention delivers aid into a country that is affected by a disaster. Affected countries are often developing nations, where transport infrastructure is limited and disaster management capacity is considerably lower than in industrialized countries. When developing countries' ports suffer direct damage from a disaster or their processes are unable to handle the increased flow of needed goods in an effective and efficient manner, humanitarian aid delivery is delayed and disaster recovery is slowed down. This chapter examines the state of the art of port preparedness in research and practice, identifies gaps and suggests the Mission Dependency Index as a tool to address them.

6.1 Introduction

Humanitarian logistics is "the process of planning, implementing and controlling the efficient, cost-effective flow and storage of goods, materials and equipment as well as related information, from point of origin to point of consumption for the purpose of meeting the beneficiary's requirements" (Blecken 2010). Ports—i.e.,

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airports and seaports—are essential for this process, because they are the main points of entry through which foreign intervention delivers aid into a country that is affected by a disaster, and often they are bottlenecks. Ports must be prepared for disaster, including an improvement of resiliency where resilience is the ability to survive changes despite severe impact. Most of the affected countries are developing nations, where transport infrastructure is limited and disaster management capacity is considerably lower than in industrialized countries (Smith et al. 2013). When developing countries' ports suffer direct damage from a disaster or their processes are unable to handle the increased flow of needed goods in an effective and efficient manner, humanitarian aid delivery is delayed and disaster recovery is slowed down. The seaport at Port-au-Prince and Toussaint Louverture International Airport (PAP) after the Haitian Earthquake of 2010 are prominent examples of ports that have been directly damaged by a disaster. These—like many others—were competent ports that would have been able to handle normal demands but experienced low performance caused by physical damage, disrupted workforces, or unaccustomed amounts and types of service demands.

Supply chain risk management has only been subject to research for three decades and has received considerable attention only for about 15 years, which makes it a very young field from an academic perspective (Husdal 2009a, Vanany et al. 2009). Still, supply chain risk management offers valuable insights regarding how to deal with disruptions in transportation networks, with several publications relating to ports (see e.g. Bloetscher et al. 2013; Boucher and Guimond 2012; Levy and Bissell 2013; McLaughlin et al. 2011). Considering the socio-economic relevance of ports, this is hardly surprising. It may indeed be surprising, however, that empirical evidence suggests low risk awareness in the maritime industry (Berle et al. 2011) that only slowly begins to rise. To the best of our knowledge the situation is similar in the aviation industry, where awareness has to rise before port preparedness can reach its full potential. In recent years, organizations from public and private sectors (including public-private partnerships) came to realize the importance of ports for humanitarian logistics and the issues that ports face. In 2009, the first initiative that gained worldwide recognition for addressing such issues was Deutsche Post DHL's "Get Airports Ready for Disaster" (GARD). GARD helps regional airports and local communities to increase their disaster management capacities and has helped seven airports by the end of 2013. In 2013, AmericasRelief Team's Port Resiliency Program (PReP) joined the stage by completing its first pilot project at an airport in the Dominican Republic. PReP targets both airports and seaports in the Latin American and Caribbean (LAC) region. In 2013, BVL International's[1] Humanitarian Logistics Council (HLC) presented its concept "Get Seaports Ready for Disaster" (GSRD) to the public. GSRD targets African seaports and has yet to be field-tested with a pilot project. These three programs represent the totality of the current state of practice, which are

[1] BVL International is a Germany-based logistics association where BVL stands for "Bundesvereinigung Logistik".

at the forefront of improving disaster management at critical transport infrastructure locations. We acknowledge the developments in both the academic and the practical realm and argue that benefits can be reaped by bridging the gap between research and practice, which today address issues of port preparedness separately and leave an existing potential for improvement largely untapped.

The major question that this chapter seeks to answer is thus, what is the state of the art in research and practice regarding port preparedness, and how can research inform practice, as a first step towards closing the gap? To answer this question we conducted a literature review of the theory and applied research in supply chain risk management and of existing programs to evaluate or improve port resiliency. The literature review was supplemented by interviews with two senior managers in one of the existing port resiliency programs and one outside expert. In addition, direct professional knowledge of the authors was used for the other two existing port resiliency programs. Qualitative analysis—specifically, common theme textural analysis—was applied to the results of the literature reviews, interviews, and professional knowledge.

This chapter is structured as follows. Firstly, we address substantial differences between airports and seaports and argue that airports and seaports can really be treated under the umbrella of port preparedness. We then examine the state of research in the area of supply chain risk management as a foundation for the subsequent examination of current initiatives. We then proceed to describe the initiatives in greater detail and identify gaps. To address the gaps, we present the Mission Dependency Index as a field-tested, practical metric and methodology that helps to address these gaps and which seems promising to introduce into the practical initiatives. Eventually, we conclude with a summary and an outlook on future port preparedness.

6.2 Similarities and Differences Between Airports and Seaports

There are many differences between airports and seaports, and there are also many similarities. Before examining the presented initiatives in greater detail, it is necessary to point out what these differences and similarities are.

This paper is based on the premise that programs to make airports and seaports more effective after disasters can be based on a single set of principles and basic procedures. To some, this may not be obvious. Historically, airport managers and users see their facilities as being unique with little in common with other types of facilities and activities, even ones in the transportation sector. Seaport managers and users take a similar view. Emergency managers and risk managers see the similarities while being aware of the differences. Table 6.1 compares airports and seaports across many dimensions that may matter regarding port preparedness, showing that the similarities outweigh the differences.

Table 6.1 Comparison of airports and seaports for complexity related to resiliency

Dimension of Complexity	Airports	Seaports
Iconic nature of port	Often seen as city emblem, viewed romantically; seen as economic engine	Rarely iconic, viewed as industrial facility; seen as economic engine
Intensity of regulation	Intensely regulated by aviation and security agencies (federal and/or international)	Intensely regulated and often subject to stringent environmental regulations that apply to the juncture of land and water
Number of regulators	Relatively few	Relatively few but probably more that are directly involved with seaports than is case with airports
Ownership	Varying; usually publicly owned and often leased to private operators	Ports are mostly owned and governed by a public authority, which in turn leases facilities to marine terminal operators to operate general cargo/container facilities on a long-term basis. In those instances where local port authorities directly manage terminal operations, stevedoring companies provide longshore labor to ocean carriers to load and unload ships
Complexity of ownership	Usually a single owner of an airport, perhaps tempered by leases or ownership of portions of terminals	May be a single owner, multiple owners, or different owners of parts of the seaport such as piers
Complexity of governance	Simple at a given airport, but a wide range of types of governance	Perhaps more complex than for airports, but also with a wide range of types of governance
Number of operators on site	Usually the owner operates or just one operating company at an airport; terminals at an airport may have different operators	May have more than one operator
Number of operators using site	Usually a relatively small number. Airports range from one airline to over 120 airlines and one to dozens of air cargo companies, depending on size of market	Usually a relatively large number with a very wide range of size of operations; probably less dependent on size of market

(continued)

Table 6.1 (continued)

Dimension of Complexity	Airports	Seaports
Number of tenants and concessionaires	Typically many in order to serve needs of passengers with trend towards master contracts for whole airport	Relatively few, as customer service to passengers is usually not an issue even at cruise ship terminals
Political sensitivity	High, especially when publicly owned	High, especially when publicly owned
Sensitivity to short-term profitability	Extreme	Less extreme
Length of planning horizon	Most airports redo their master plans every 7–10 years with small updates in the interim	Most seaports grow incrementally without master planning
Intensity of pressure to hold down operating expenses from users	Extreme because of competition with other airports and pressure from airlines over rates and charges	Possibly less extreme. Ports often viewed as legitimate subsidy of other economic activities
Cost of fixed infrastructure (replacement cost of typical port)	On order of US$100 million to US$10 billion	On order of US$100 million to US$10 billion
Cost of movable infrastructure	Perhaps 1/10th cost of seaport's single most expensive movable infrastructure (cargo crane compared to jetway)	Perhaps 10x cost of airport's single most expensive movable infrastructure (cargo crane compared to jetway)
Cost to implement "soft resiliency" measures[a]	Similar to seaports	Similar to airports
Intermodal connectivity	Less than seaport although trend is towards greater intermodal connections, especially for major hub airports	More to much more than airport
Insurability	Continued operation is proof that airports are insurable	Continued operation is proof that seaports are insurable
Dependency on outside services (e.g., air traffic control, dredging, electricity, water, sewer)	Absolute but probably less self-aware of dependency than most seaports	Absolute and probably more self-aware of dependency that most airports
Vulnerability to weather	More vulnerable	Less vulnerable but still vulnerable
Vulnerability to flooding	Relatively small but some airports are on flood plains or at low elevations near shorelines	Relatively high because all ports are on flood plains and/or shorelines

(continued)

Table 6.1 (continued)

Dimension of Complexity	Airports	Seaports
Vulnerability to climate change	Less vulnerable	Highly vulnerable to sea level rise
Vulnerability to geotechnical disasters	Highly vulnerable in seismic zones, aircraft movements can be disrupted severely by damage to runways, taxiways, aprons, towers, lighting, and avionic systems	Highly vulnerable in seismic zones, ship movement can be disrupted severely; in a river channel prone to earthquakes, factors include: bridges and other debris in the channel, depth (draft) of shipping channel affected by shaking and displacement of the bottom soils; in tsunami areas, any transition from ocean to river (bars/jetties) may be completely wiped out preventing any navigation into or out of the river channel
Vulnerability to terrorism	Vulnerable, but threats probably have greater effect on public perception	Vulnerable, but threats probably have less effect on public perception
Vulnerability to civil war	Vulnerable	Vulnerable
Vulnerability to labor disputes	Vulnerable	Highly vulnerable because of the use of longshore labor and the constant risk of labor disputes, strikes, and work slowdowns
Vulnerability to disruption at other ports in network	Extremely vulnerable due to airline scheduling and routing	Much less vulnerable
Effect of level of development of country	Each airport may be more important in less developed countries with fewer airports	Each seaport may be more important in less developed countries that typically have fewer seaports
Vulnerability to disruption by disaster in region that does not directly hurt port	Immediate vulnerability extreme as competing users try to use airport, which may have diminished capacity	Longer term vulnerability as incoming aid requiring ability to handle heavier loads (ship-sized vs. plane-sized) will arrive days or weeks later
Time to repair	Relatively shorter—benchmark is time to remove damaged aircraft on runway	Relatively longer, perhaps—benchmark is time to remove sunken ship in channel

[a] "Soft resiliency" measures refer to changes to policies, procedures, operations, personnel protection, relationships, plans, and movable equipment; in other words, everything except major physical infrastructure modifications

6.3 Supply Chain Risk Management

"Any threat to the reliability of the transportation network constitutes a vulnerable spot, a weakness in the supply chain" (Husdal 2009a). Supply chain risk management investigates how adverse events in supply chain operations negatively affect one or more performance measures in the supply chain with negative effects for the firm under consideration, advises how to prepare for such events and how to manage them when they occur (Hofmann et al. 2013; Sodhi et al. 2012). Rather than talking about "adverse events in supply chain operations", it is much simpler to call them disruptions (when they occur) or risks (before they occur) (Rao and Goldsby 2009).[2] Disruptions may fall into various categories[3] and may generally be attributed to cause or location.

Causes for disruptions may lie in poor quality or damaged goods, missed or late deliveries, unexpected increases to supply costs, longer lead times or supply capacity constraints (Minahan 2005). Humanitarian supply chains are not exempt from this, as shown by the "USAID | DELIVER PROJECT task order for procurement and distribution of essential public health supplies", which identified several risk categories, events and metrics, as shown in Table 6.2.

Product registration, freight forwarding and warehousing are also key activities at ports. Quality assurance may be an issue too, for instance if rice sacks are not properly stored and become wet; inventory and stock levels (stocked items) are relevant if the port is used for long-term storage, which is generally not desirable from a supply chain perspective but happens in practice (Möhring and Link 2013).

When viewed through the lens of supply chain risk management, two gaps in port resiliency become apparent:

1. The lack of motivation of ports to invest in resiliency.
2. Insufficient port capacity, whether due to general lack of capacity, operational surges, or disaster-caused damage.

The primary causes of the lack of motivation to invest in resiliency are operational or economic. Ports tend to have either operational specialists or financial specialists as their senior managers. Operational specialists are preoccupied with dealing with normal operations and operational costs. Financial specialists are preoccupied with operational costs and competitive advantages vis-à-vis competing ports. Airports present a special case in that their budgets are almost totally dependent on the concurrence of the airlines. Airlines want the lowest possible rates and charges for using the airport; therefore, they resist the sorts of equipment,

[2] According to Hofmann et al. (2013), this distinction is not universally applied in the literature, so you will find various terms being used synonymously for risk, like hazard, uncertainty, peril or exposure. For the sake of simplicity, we adopted the terms disruption and risk exclusively for this chapter.

[3] Classifications of supply chain risks are given in, e.g., Chopra and Sodhi (2004) or Bogataj and Bogataj (2007).

Table 6.2 Risk categories, events, and metrics for risk performance monitoring (USAID 2013)

Risk category	Event	Metric
Product registration	Product not registered in time	Percentage of countries that could not ship due to registration errors
	Product shipped but not allowed in-country	
Mission ordering and expectations	Missions do not understand how to plan supply and submit orders correctly, within a reasonable time	Mission orders for more than 1 product for next year?
		Percentage of emergency orders
Supplier performance	Supplier has production problems	Percentage of supplies released by supplier within 7 business days of goods available date
	Products do not meet quality standards.	Lot acceptance rate
	Supplier requests a product recall	Number of recalls in a specific period
Funding	Funds not available when needed for procurement actions	
	Missions do not provide adequate funding for orders.	
Forecasting and production planning	Unable to fulfill unplanned orders because of insufficient data to support good forecasting	Planned orders as a % of actual orders
Inventory and stock levels (stocked items)	Inventory falls below optimal levels for several consecutive months	Percentage of products in inventory >15 % of forecasted demand
Freight forwarding	A. Shipments are not delivered on time because of shipper error	Delivery to Plan (DTP) reasons for late shipment (% with this reason)
	B. Pre-clearance process documents not received in time to clear shipment	DTP reason for late shipment (% with this reason)
Quality assurance	A. Product is received that does not meet quality specifications	Lot acceptance rate
	B. Testing lead time effects on-time deliveries	DTP testing ≤4 wks. (% with this reason)
Warehousing	Warehouse does not manage inventory properly for storage or pick and pack	DTP warehouse metric (% with this reason)

personnel, and capability redundancies that are involved with efforts to enhance resiliency. In order to overcome the resistance to investment in resiliency, the economic equation needs to be shifted.

The port capacity gap is illustrated by the airport and seaport in Port-au-Prince. Both facilities had little excess capacity prior to the earthquake, and the earthquake disrupted operations at both. Ad hoc workarounds at the airport allowed a ten-fold increase in operations within a week after the earthquake, but none of the measures

taken had been foreseen in Haiti or elsewhere. Damage to the seaport was far more profound and required heavy construction to repair. Haiti lacked alternative facilities to the airport and seaport.

6.3.1 Robustness, Flexibility/Agility and Resilience

The terms robustness, resilience, flexibility and agility often occur in relation to supply chain risk management. To clarify their meaning, Husdal (2009a, b) attempted to distinguish them, based on various existing definitions, as follows.

- **Robustness** is the ability to accommodate any uncertain future events or unexpected developments such that the initially desired future state can still be reached. In other words, it refers to the ability to endure changes without adapting.
- **Flexibility/Agility** is the ability to defer, abandon, expand, or contract any investment towards the desired goal. In other words, it is the inherent capability to modify a current direction to accommodate and successfully adapt to changes in the environment.
- **Resilience** is the ability of a system to return to its original state or move to a new desirable state after being disturbed. In other words, it is the ability to survive changes despite severe impact.

If a seaport sustainably increases its performance, its ability to deal with demand spikes increases, whether the spikes originate from a disaster or from any other disruptive event.

6.3.2 The ISO 31010 Risk Management Process

As Jereb et al. (2011) point out, there currently is no standard for holistic supply chain risk management, which exemplifies the remaining gap between research and practice. To bridge this gap, we follow their approach insofar that we base our elaborations on a standard that does exist and comes fairly close: the ISO 31010 risk management process (Fig. 6.1).[4]

[4] Jereb et al. (2011) combined the ISO 31010 risk management process with the ISO 28000 international standard on security in supply chains in an online tool to support risk assessment. The tool is available online at: http://labinf.fl.uni-mb.si/risk-catalog/. Jereb et al. focus on risk assessment because they identified it as the single most important activity in the risk management process. ISO 28000 offers categories to hold risks, e.g. natural environmental events (storm, floods, etc.), which may render security measures and equipment ineffective. We do not pick up the ISO 31000 and ISO 28000 families in greater detail here but encourage readers to examine them in the light of this chapter.

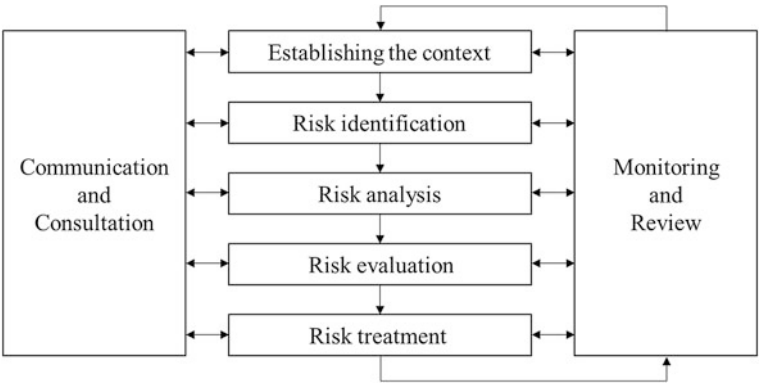

Fig. 6.1 The ISO 31010 risk management process (ISO 2009)

In practice, the process is not as simple as it looks on paper. As noted by Meixell and Norbis (2011), supply chain risk management approaches are already difficult to manage in stable environments and even more so in challenging situations, such as economic crises or natural and man-made disasters. Furthermore, special attention is required when ocean carriage is required with the passage of containers through seaports. The approaches presented in this chapter should thus be taken with care and not assumed to immediately work when applied out-of-the-box. To make the best use of them, it is necessary to develop a sound risk strategy.

6.3.3 Establishing the Context through Strategy Development

In many countries, the board of directors of public companies can be held responsible for risks that are taken in their company (see e.g. the UK's Companies Act 2006). Waters (2011) thus advises top-level company leadership to

- Define the organization's attitude towards risk, its philosophy and the strategic direction of risk management;
- Create an appropriate environment for risk management, with necessary systems and resources;
- Publish risk management policies defining attitudes, approaches and responsibilities;
- Know about significant risks that the organization faces;
- Understand the potential consequences of these risks for stakeholders;
- Ensure that appropriate processes are in place for identifying, analyzing and dealing with risks, and that these work effectively;
- Communicate with stakeholders to ensure that everyone is aware of their responsibilities for risk management;

- Know how the organization will manage a crisis;
- Assess the performance of risk management.

On the one hand, succeeding in all of these aspects is difficult. A study by MacDonald and Corsi (2013) suggests that this is partly due to low resource availability, which has a major influence on the willingness to prepare and can be expected to be even more accentuated in developing countries. It also suggests that even though supply chain management is currently cost-driven, the financial impact of disruptions is hard to quantify. Company leaders should not be discouraged though, as on the other hand well-defined policies for supply chain risk management and its proper implementation tend to reduce costs, improve performance and have various other benefits (Waters 2011).

Buy-in and continuous support from company leadership are important to set up and maintain an effective risk management strategy. However, many risks originate from and have to be handled on the shop floor. It is thus wise to involve people lower down the organization, who identify risks in their normal work and suggest ways of dealing with them; both approaches are needed in practice to give a comprehensive view of risks (Waters 2011). Current port preparedness initiatives apply this insight by ensuring top-level management commitment first, before engaging lower and medium management in workshops.

6.3.4 Difficulties with Risk Identification, Analysis and Evaluation

How does one proceed after defining a good risk management strategy? Common approaches[5] usually involve the definition of concrete risks that would have a severe impact on operations when they manifest, i.e. risk identification and analysis. However, "severity" is difficult to define, and thus supply chain risk management frameworks and constructs that exist to date merely presume that the disruption is severe (MacDonald and Corsi 2013). The assessment of event probability is difficult too and has been relatively little researched; in practice, probabilities are often little more than subjective guesses (Meixell and Norbis 2011; Zsidisin et al. 2004; Waters 2011).

How should one avoid the estimation of risk or prepare for risks that cannot be defined at all, because the disruption only becomes known when it occurs? An effective yet extreme way to handle these problems is to disregard probability completely, preparing instead for the complete failure of individual critical elements. This is the basic approach of business continuity management (BCM).

[5] Waters (2011) presents several techniques to identify risks, e.g. a general five-step procedure that systematically breaks down the supply chain into series of operations and analyses each of them, process charts, the analysis of past events with tools like cause-and-effect diagrams or Pareto charts, or the Delphi method.

According to Waters (2011), business continuity management is a process developed to counteract systems failure by anticipating incidents which will affect mission critical functions and processes for the organization and ensuring that it responds to any incident in a planned and rehearsed manner. It thus develops ways of responding to unidentified or unidentifiable risks. Waters continues to state, however, that most BCM plans do not cover damage to the corporate image, supply chain disruption and severe weather—all of which managers are commonly concerned with (Scarborough 2007). Still we may agree to Husdal (2009a), who contends that in our case,[6] supply chain risk managers should draw on business continuity management for advice.

6.4 Current Initiatives

Various initiatives from the public and private sectors aim to make ports in developing countries more resilient and allow them to perform better by providing assessment and training services, so that relief goods reach their destination earlier and at a lower cost, while supporting the country's economic development and recovery; this chapter introduces and compares these initiatives.

Get Airports Ready for Disaster (GARD)

DHL's corporate citizenship program sought to improve the ability of humanitarian organizations and agencies to respond to disasters more quickly by preparing airports to resist damage from natural disasters and to recover more quickly from any damage that cannot be prevented (UN 2014; DPDHL 2014). In partnership with the United Nations Disaster Program, DHL devised GARD and tested it at two Indonesian airports in 2009. By the end of 2013, GARD had been applied to a total of seven airports or clusters of neighboring airports. GARD was also applied at one seaport, although the program is primarily designed for airports.

GARD helps airports and communities during disaster-free times by

- Reviewing airport capabilities and capacities;
- Understanding coordination requirements;
- Training local people (train-the-trainer concept);
- Helping to formulate a contingency plan and a coordination structure.

GARD is intended to be global in scope. In 2003, DHL put three Disaster Response Teams (DRTs) in place to implement the program: DRT Americas in Panama, DRT

[6] To be precise, Husdal (2009a) speaks of sparse transportation network settings. In the case of ports, this situation is given though, as constraints apply to both transportation mode and transportation link choice.

Table 6.3 Example of a typical GARD training (Meier 2011)

Day	Location	Curriculum
1	Classroom	*Establish need/focus on methodology*
		Post disaster simulation exercise
		Discussion with UN, NGOs and DHL Disaster Response Team (DRT) on disaster management scenarios. Introduction to GARD & familiarization with the GARD assessment method
		Airport disaster management processes and communications
		Detailed analysis of flow, ground handling and outflow management
		Discussion of challenges, constraints, facility requirements, processes
2	Field	*Apply learnings*
		Process brief and review of assessment tools/templates
		Interview with key airport personnel
		On-site airport capacity assessment (inside)
		On-site airport capacity assessment (outside)
3	Classroom/ Field	*Apply learnings/coaching*
		Finalize on-site assessment
		Summary and analysis of airport assessment findings
		Begin developing standard operating procedures (SOPs)
4	Classroom	*Coaching/Refine results*
		Presentation of recommended SOPs
		Feedback, coaching, further evaluation
		Refinement of contingency plan
5	Classroom	*Ensure follow-up*
		Review and wrap-up
		Certification ceremony

Middle East/Africa in Dubai, and DRT Asia Pacific in Singapore. The lessons learned by these teams responding to earthquakes, hurricanes, cyclones, and typhoons between 2003 and 2009 were applied in the development of GARD (DPDHL 2014). One goal of GARD is to make the DRTs more effective after a disaster.

GARD works closely with the United Nations Development Programme (UNDP) and with individual nations, like Indonesia. DHL first obtains a formal commitment from the host nation to the airport that will receive GARD services, and each GARD service delivery ends with a formal, written acknowledgement by the airport, national agencies, and any other parties that participate in the steps taken and the results. Table 6.3 gives an example of a typical GARD training.

Get Seaports Ready for Disaster (GSRD)

Inspired by the need to improve port performance in East Africa to support humanitarian relief in South Sudan and by the example of GARD, BVL International's Humanitarian Logistics Council developed the concept for "Get Seaports

Ready for Disaster" (GSRD) (Möhring and Link 2013). The primary goal of GSRD is "to increase disaster preparedness in seaports, particularly increasing performance and accelerating the processing of incoming relief goods." The focus is on improving the speed and efficiency of cargo handling and therefore a port's throughput capacity.

GSRD's procedures closely follow the GARD model with emphasis on preparedness, training, train-the-trainer, and other resiliency measures not involving changes to physical infrastructure. The basic structure of GSRD has six phases:

1. Kick-off with seaport and key stakeholders
2. Assessment of structures and processes
3. Analysis of assessment results
4. Training
5. Evaluation
6. Workshop to recapitulate and reinforce the results of phases 1-5.

As noted by Möhring and Link (2013), there are several critical success factors for GSRD:

- Seaports that are adequately developed in physical terms must be selected to receive the performance and resiliency enhancing services of GSRD.
- The seaport must be operational before the new training can be effective at creating change.
- The initial focus must be on the handling of goods within the port although GSRD should be aware of hinterland issues and intermodal connectivity issues.
- Local stakeholders must be aware of the need for and possibility of performance improvement as a result of implementing GSRD at the port.
- GSRD needs strong partners, such as intergovernmental organizations, to leverage and mobilize efforts for the first four success factors.

GSRD is still under development and expects to run its first pilot project at an African port during 2014.

Port Resiliency Program (PReP)

The Port Resiliency Program (PReP) is an initiative of the humanitarian nongovernmental organization (NGO) AmericasRelief Team (ART). PReP grew directly out of ART's experience in brokering free air and sea transport for relief and recovery activities by other NGOs in response to the Haiti Earthquake of 2010. It seeks to apply the lessons learned in Haiti and from hurricanes, particularly Hurricane Katrina in 2005, to make ports—airports and seaports—more resilient (Babun and Smith 2013). PReP's goals are to improve ports' ability to speed humanitarian assistance, to quicken ports' return to normal commercial activities, and to reconcile the competing humanitarian and commercial demands on a damaged or recovering port.

PReP seeks to teach ports how to apply soft resiliency measures to existing organizations and physical facilities to optimize their resistance to damage from natural and manmade disasters and to speed the ports' recovery. The program's basic structure has four phases:

1. Guided self-analysis and outside expert analysis of plans, equipment, and capability of port
2. Workshop at ART with port's stakeholders to validate the results of phase 1, identify gaps, and develop plan for targeted training
3. On-site delivery of the targeted training and a table top exercise to evaluate the effectiveness of the training and the port's overall resiliency
4. Aftercare to ensure follow-up.

PReP was developed during 2012 and a pilot project was done with Las Americas International Airport in Santo Domingo, Dominican Republic, during October 2012 through February 2013. In the process, specific gaps were identified in the areas of protection of essential employees and their families, pre-contracting for services to reopen the airport, alternative communication methods for disasters as well as interagency relationships. Customized training was delivered in each of these areas and evaluated as effective. The after action review of the pilot project suggested a number of improvements to PReP that have since been incorporated into the program.

As with GSRD, a number of success factors have been identified. The single most important ones are:

- Involvement of the right stakeholders throughout the process. This especially includes the national agencies for transportation, security, emergency management, and law enforcement as well as the tenants and users of the port.
- Solutions built by improving existing plans, procedures, and relationships.
- Respect for the client port and its stakeholders.

PReP's pilot project was funded by a grant from FedEx. PReP is now seeking to develop a model by which each port and perhaps its stakeholders will pay for all or most of the cost, which is estimated at US$55,000–70,000.

6.4.1 Comparison of Initiatives

GARD, GSRD, and PReP have major similarities and significant differences. In the light of the above definitions of robustness, flexibility/agility and resilience, GSRD mainly aims to make seaports more robust and flexible. This is also because it focuses on seaports that are not directly hit by a disaster. In contrast, GARD and PReP mainly aim at making ports more resilient, so that they would remain operational and continue their business despite taking severe damage. GSRD does also improve resiliency, but more as a side-effect from improving disruption management (Bhamra et al. 2011). GARD applies a combination of robustness and flexibility/agility in its

attentiveness to the evaluation and documentation of an airport's surge capacity, where surge capacity is the ability of an airport to handle the extra operations, passengers, and cargo generated by disaster relief and recovery. Resiliency is an implied component of surge capacity, as lack of resiliency would degrade an airport's surge capacity. This surge capacity perspective may be implicit in PReP's attempt to reconcile the competing uses of humanitarian relief and the resumption of normal commercial activities at a port, but it is not clear in PReP's documentation.

An analysis of the three existing programs—GARD, GSRD, and PReP—in the light of the ISO 31010 risk management process (see Table 6.3) shows that they incorporate all of the process's seven activities. This indicates that a systematic risk management process can be applied to airports and seaports in practice.

Table 6.4 presents the results of a comparative analysis of the initiatives, which suggests underlying principles and gaps, both of which are necessary if a fully optimized approach to port preparedness is to be achieved.

Examination of Table 6.4 reveals that there is very strong agreement among the programs on most programmatic elements. The similarity between GARD and GSRD is expected since GSRD was inspired by GARD and developed with the cooperation of DHL's GARD team. However, GARD and PReP were developed in complete isolation from each other, so the congruency between GARD and PReP is particularly convincing. The most important elements for which there is agreement are:

- Clarity of mission, which is to make ports of either kind more capable after a disaster;
- A focus on speeding humanitarian aid and the resumption of normal commercial activities at the port;
- Close collaboration with national and local agencies;
- Close collaboration with aid organizations;
- A relatively short-term orientation that seeks quick, relatively inexpensive fixes through "soft resiliency" measures rather than through major physical infrastructure changes;
- Insistence on the involvement of a broad range of stakeholders in all phases of the program;
- Emphasis on careful review and analysis of the initial state of a port and the port's existing capabilities;
- Transfer of outside expertise to local persons by train-the-trainer, hands-on training, mentoring, and follow-up activities;
- Focus on gaps in capabilities and preparedness;
- Substantial capability to produce verifiable documentation that could support a formal certification program;
- An unstable funding mechanism. This weakness is shared by all three programs.

The similarities strongly suggest traits that should characterize a globally applicable port resiliency program. In contrast, the differences among the programs indicate potential cross-fertilization that could lead to improvements in all three programs. Areas where there are major differences among GARD, GSRD, and PReP are

Table 6.4 Comparison of existing programs

Program	Getting airports ready for disasters	Get seaports ready for disasters	Port resiliency program
Acronym	GARD	GSRD	PReP
Organization	DHL	BVL International, University of Münster	AmericasRelief Team
Type of port (s) served	Airports	Seaports	Airports and seaports
Geographic area served	World	Africa	Latin America and Caribbean
Mission	Addresses risks at airports in disaster prone areas before crises occur	Increase performance of seaports	Increase resiliency of ports
	…in order to…	…in order to…	…in order to…
Goals/ objectives	Improve level of disaster prevention at airports in areas of high risk of disasters	Improve level of disaster prevention at seaports in areas of high risk of disasters	Speed up humanitarian aid
	Bring disaster related authorities and experts together	Bring disaster related authorities and experts together	Speed up return to normal commercial operations to promote economic recovery
	Enable participants to assess the surge capacity of their airport and to develop an action plan	Enable participants to assess the surge capacity of their seaport and to develop an action plan	Reconcile competing users at recovering port
Element(s) used	Policy	Policy	Policy
	Procedure	Procedure	Procedure
	Organizational	Organizational	Organizational
	Relationships	Relationships	Relationships
	Operations	Operations	Operations
	Movable equipment	Movable equipment	Movable equipment
	Not major infrastructure	Not major infrastructure	Not major infrastructure
National agency prior approval	Yes	Will probably be sought	Yes
Trigger mechanism	UNDP request/ suggestion; request by airport; joint decision between DP DHL and UNDP	UN, nation, or port requests GSRD	Port requests PReP service

(continued)

Table 6.4 (continued)

Program	Getting airports ready for disasters	Get seaports ready for disasters	Port resiliency program
Primary contact point to initiate program	UNDP country office/ via UN contacts	UN agency or nation	Individual airport or seaport contacts PReP
Major stakeholders	DP DHL, UNDP/ UNOCHA, Airport, government, country based NGOs, aid organizations, disaster management agencies national police, different national government departments/agencies	Seaport, national agencies (regulatory, infrastructure, emergency management, law enforcement, military), aid organizations	Port, companies using port, port tenants, national agencies (regulatory, infrastructure, emergency management, law enforcement, military)
Other stakeholders	National Airlines	Disaster victims, companies using port, port tenants, passengers, shippers, local governments	Passengers, shippers, disaster victims, aid organizations, local governments
Starting point/ baseline	Disaster Management Theory followed by Airport Assessment, creating awareness on the importance of disaster preparedness at airports by assessing the airport	Review of seaport capabilities and capacities	Self-evaluation and outside expert evaluation of disaster plans, policies, risks, and preparedness; gap analysis of these materials in consultation with major stakeholders
Type of training provided	Standard Program that will be tailored individually, depending on national/ airport circumstances	Customized training tailored to gaps and delivered on-site by GSRD team	Customized training tailored to gaps and delivered on-site by PReP team
Source of trainers/ instructors	DHL aviation experts	Shipping companies, aid organizations, national and local agencies	Volunteers from other airports and emergency agencies, and eventually from alumni of training program
Drills used in program	None	None	None
Exercises used in program	Interactive group exercises, airport assessment, report writing	Interactive group exercises, seaport assessment, report writing	Table top exercise used as “graduation” to evaluate effectiveness of training and to identify remaining or additional gaps

(continued)

Table 6.4 (continued)

Program	Getting airports ready for disasters	Get seaports ready for disasters	Port resiliency program
Highest level organization approving or endorsing program	Airport authorities/ government	Seaport authorities/ Government	ART, requesting port, and participating stakeholders, by consensus
Means of recognizing completion	Participant certificate and surge capacity report	Certificate of completion for participants (perhaps stating achievements since last training)	Unofficial diploma
Repeat frequency	Core program: one-time only; trained local instructors remain at port; recently developed follow-up workshop "GARD plus"	Core program: one-time only; follow-up workshops every 6-12 months	Two to three years recommended by pilot test participants
Formal certification of resiliency	No	No	No, but planned
Program recognized by insurers/ reinsurers	No	No	Being sought
Estimated cost per port	Not reported	Not reported	US$55,000–70,000
Funding method or source	Sponsored by UNDP and DPDHL, national in-kind contributions	Development funded by BVL International; funding for program execution is under investigation	By cash grants from FedEx and in-kind donation of services and transportation from several donors; now attempting to shift to beneficiary port pays for service

- Whether national level approval and formal agreement is required prior to program initiation at a port
- Type of entity leading or managing effort
- Relationship to international agencies
- Top-down direction versus bottom-up request for service
- Role of volunteer instructors
- Types of exercises used
- Highest level organization endorsing, approving or authorizing program
- Methods used to follow-up after initial service by program
- Means of recognizing completion

- Repeat frequency
- Means of recognizing completion
- Nature of documentation
- Evaluation of surge capacity and production of surge capacity report

Lastly, there are three areas for which none of the three programs has found a sure-fire solution:

- Means of motivating ports to enhance their resiliency
- Relationship to insurance
- Funding mechanisms

6.5 The Mission Dependency Index

In 2007, Antelman et al. (2007) published the results from the development and deployment of a risk-based metric that links facilities to mission: the Mission Dependency Index (MDI).

- It deals directly with the criticality of objects that have a mission-related function and occupy a dedicated space, e.g. port infrastructure such as runways, piers or storage facilities;
- It may improve ports' operational and financial management;
- It may be combined with other metrics (Uzarski 2004), such as the Condition Index (CI) to prioritize funding for projects;
- It has been successfully deployed by the US Naval Facilities Engineering Command (NAVFAC), United States Coast Guard (USCG) Office of Civil Engineering, and the US National Aeronautical and Space Administration (NASA), who are all well versed in managing risks. Its practicality has been further underlined by the US General Services Administration naming it a best practice and the US Federal Facilities Council calling it "a promising process indicator for prioritizing projects and funding to support an organization's overall mission"

The MDI thus seems to be a promising tool for addressing the identified gaps of current initiatives by supporting the clear presentation of resiliency issues to port authorities, by quantifying mission criticality in discussions on resiliency with the insurance industry, and by motivating targeted funding.

To calculate the MDI, first a list of critical objects (*functional elements*, e.g. a warehouse) is established. Next, the objects' representatives (e.g. warehouse managers) are asked a series of intra-dependency questions (1 and 2) and inter-dependency questions (3 and 4) about the objects.

(1) How long could the "functions" supported by your facility (*functional element*) be stopped without adverse impact to the mission?
Possible answers are: immediate; brief, i.e. less than 24 h; short, i.e. less than 7 days; prolonged.

(2) If your facility was no longer functional, could you continue performing your mission by using another facility, or by setting up temporary facilities? (Are there workarounds?)
Possible answers are: impossible, i.e. an alternate location is not available; extremely difficult, i.e. using an available location with minimally acceptable capabilities would require either a significant effort, dislocation of another major occupant, or contracting for additional services and/or facilities to complete; difficult, i.e. using an alternate location with acceptable capabilities and capacity would require a measurable level of effort; possible, i.e. using an alternate location with sufficient capabilities and capacity has been budgeted or can easily be absorbed.

(3) How long could the services provided by *functional element* be interrupted before impacting your mission readiness?
Possible answers are basically the same as for question 1.

(4) How difficult would it be to replace or replicate the services provided by *functional element* with another provider from any source before impacting the command's mission readiness?
Possible answers are basically the same as for question 2.

The coded answers are then used in conjunction with risk assessment matrices to determine intra-dependency scores and inter-dependency scores. The resulting scores are then used as variables in a linear equation with weighted coefficients to calculate the MDI for each functional element.[7] Eventually, the average MDI is calculated. MDI scores may range from 0 to 100 and are associated to five categories (low, moderate, relevant, significant, critical), which are also color-coded. The color-coding is useful to create maps that give a visual overview of critical elements in the area under examination.

Port-au-Prince, Haiti, provides examples of how the MDI approach can be applied to an airport and a seaport. Toussaint Louverture International Airport (PAP) prior to the 2010 earthquake had a single runway and paved parking spaces for 10–12 aircraft. The airport averaged about 70 operations a day, which included international flights, domestic flights, and cargo flights. It was the primary entry point for both tourists and business travelers and the shipping point for high-value exports. The earthquake on 12 January 2010 destroyed the air traffic control tower and damaged the terminal and baggage handling building. All operations were disrupted for about a day, but within a week, total operations reached about 700 per day. The airport was the primary location for medical evacuations, arrival of incoming aid workers, and arrival of incoming relief supplies. Once a temporary air control tower had been established and air control and ground control procedures had been established, the main limiting factors were the ability to unload planes, to

[7] The matrices and weighted coefficients have been determined empirically during extensive field-testing by Navy, Coast Guard and NASA facility engineers and managers. They may be directly applicable to the ports we are interested in or require tweaking, which could be examined by field-testing.

Table 6.5 Normal economic operations

MDI questions	Airport	Seaport
How long could the "functions" supported by your facility be stopped without adverse impact to the mission?	Brief	Short
If your facility was no longer functional, could you continue performing your mission by using another facility, or by setting up temporary facilities?	Impossible	Impossible
How long could the services provided by the facility be interrupted before impacting your mission readiness?	Brief	Immediate
How difficult would it be to replace or replicate the services provided by the facility with another provider from any source before impacting mission readiness?	Extremely difficult	Impossible

move incoming materials out of the airport, and fuel for refueling planes. Fuel supplies were quickly exhausted and replacement fuel could not be imported because of damage to the seaport.

The seaport prior to the earthquake was Haiti's main import point for bulk cargo including fuel, food supplies, containerized freight, and heavy items. The earthquake damaged the port so that it was totally unavailable for operations on any scale. The damage included collapse of cranes, damage to the pier, cracks and slumping of unloading and marshalling lots, and an oil spill. Even prior to the earthquake, the port had little excess capacity and was constrained by limits on its connectivity to land transport. The seaport was critical for disaster response as heavy equipment was needed to repair and reopen the port and land transportation facilities. Furthermore, fuel was needed for the airport and all other economic activities in the southwestern part of the country.

When applied rigorously, MDI must be applied to the functional elements of a facility; however, the approach can be applied heuristically to an entire facility, as described in Table 6.5.

Using the Risk Assessment Matrix from OPNAVINST 3500.39b to compute the intra-dependency scores for questions 1 and 2 gives 3.6 for the airport and 3.2 for the seaport. The inter-dependency scores for questions 3 and 4 are 3.0 for the airport and 4.0 for the seaport. If the coefficients developed by the U.S. Navy, Coast Guard, and NASA (see Antelman et al. 2007) are applied, the MDIs for the airport and seaport at Port-au-Prince are 81.8 and 74.5, which indicates "significant criticality" of the facilities.

6.6 Conclusion

Airports and seaports are critical nodes in nearly every supply chain involved in humanitarian aid after disasters. Even when rail, highway, or canal transport can be used, air transport will almost always bring the first response and assessment teams.

When heavy or bulk materials are needed for long-term relief, recovery, and rebuilding, sea transport will be necessary even when the disaster may be inland from the seaports. Numerous disasters have shown how airports and seaports with inadequate resiliency have been unable to handle the surge of activity inherent in disaster response and recovery or even to maintain any activities at all.

Supply chain risk management is directly pertinent to efforts to make ports better prepared for handling the demands of humanitarian aid for relief and recovery following natural and manmade disasters. Firstly, it enables us to better understand the similarities between the initiatives' methodologies. Furthermore, it offers valuable insights for the managers of similar initiatives, which may lead to programmatic improvements. It may also inspire port authorities, aid organizations, governments and other port stakeholders to engage more actively in port resiliency program development or to make a financial investment. Lastly, it inspires readers to take a supply chain risk management perspective when addressing other processes, such as warehouse management or last mile delivery.

A comparative analysis of the current initiatives—GARD, GSRD and PReP—shows major opportunities for cross-fertilization and collaboration, which are necessary to find solutions for three critical areas:

- Means of motivating ports to enhance their resiliency
- Relationship to insurance
- Funding mechanisms

One way to solve the problems of motivation and funding of efforts to improve the risk management, robustness, flexibility/agility, and resiliency of airports would be to create a formal program to certify that an airport has achieved a clearly defined level of preparedness. Creating a formal program would not achieve the goals of motivation and funding; however, doing it completely and verifiably invites recognition by the insurance and reinsurance industry. The resulting financial benefits to the ports or their primary users will tend to engender both motivation and a willingness to invest in preparedness. Such an airport certification program (ACP) should involve the constellation of interrelated activities to promote and document the actions taken and their effectiveness. These actions might include:

- Global standards tied to specific activity types with adjustments to specific risk types and levels
- Technical assistance to build on ports' existing facilities, plans, programs, and procedures to reach greater resiliency at the lowest possible cost
- Certification–the Port Resiliency Certification–at several clearly defined levels of resiliency that reflect levels of effort and accomplishment by a port seeking to improve and document its resiliency
- On-site verification of level of resiliency by qualified inspectors and evaluators
- Periodic re-certification
- Certification of providers to assist a port develop resiliency programs to qualify for certification or re-certification

- Data collection and analysis to document effectiveness of port resiliency certification
- Development of measures of effectiveness (metrics)
- Registry of certified ports
- Registry of certified providers
- Sponsorship of research into effectiveness of methods to enhance resiliency and new methods

Another, outside-the-box concept for seaport resiliency would bypass the problem of inadequate, damaged, or destroyed ports completely. Inspired by the white hospital ships that have responded effectively to disasters around the world, Rabjohn (2013) has proposed to form a "logistic white fleet" of retired naval amphibious-capable ships such as landing ship tanks (LSTs) and smaller landing craft which have a greater range of applications and are independent of port facilities. The logistic white fleet is deployed at safe ports in regions of the world where isolated areas are at a high risk of disasters. Examples of such areas are the Caribbean Sea for hurricanes and earthquakes, Southeast Asia-Oceania for typhoons, earthquakes, and volcanoes, and the Persian Gulf or Red Sea for earthquakes. The white fleet is manned by retired sailors from the merchant marine and navies led by volunteers from the major maritime companies. Ships of the logistic white fleet serve as containers for pre-positioned relief supplies and are able to deliver those supplies and additional materials to any coastline regardless of the availability of a seaport.

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Chapter 7
Emergency Preparedness of Humanitarian Organizations: A System Dynamics Approach

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Abstract In recent decades, there is an increasing trend in the occurrence and complexity of disasters, while donors are becoming more demanding on the performance and accountability. Hence, there is great pressure on humanitarian organizations to improve the effectiveness and efficiency of their relief operations. For effective response to an emergency, humanitarian organizations must prepare their existing resources well before its start. This chapter develops a system dynamics model as a decision-aid tool for humanitarian organizations to prepare beforehand. The model is able to evaluate the effectiveness of common preparedness strategies such as prepositioning and visualize their impacts in a competitive environment with two humanitarian organizations. Simulation results show that strategy that reduces the lead time is always efficient but not so for prepositioning strategy. In the case of only the small organization prepositioning stocks, the overall performance would be worse. The study would help improve the operating efficiency of humanitarian organizations as well as their sustainability.

7.1 Introduction

As most disasters are characterized by a surge in demand for supplies and other resources such as manpower, relief efforts are geared at procuring and delivering goods in a timely manner, and this, in turn, demands detailed preparation before the emergency. However, the preparedness in relief operations is complicated by the demand uncertainty and various operational constraints. For example, humanitarian organizations (HOs) are often short of funding for their emergency preparations as most of their emergency funding are reactive in nature (Walker and Pepper 2007).

In emergency preparedness, one common strategy used by the HOs is proactive contingency planning (Chakravarty 2011). Based on the plan, HOs would invest in a small range of selected inventory and storage facilities, and work in collaboration

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with suppliers and service providers to prepare for an expected surge in demand. However, most existing literature assumes that the HO is preparing in isolation. In practice, the situation is much more complex. Whenever there is a disaster, there will be a number of HOs activated for relief operations, ranging from the local ones to the international ones. They compete, interfere, or even battle for the limited resources (Holguín-Veras et al. 2012). Such dynamic interactions should be incorporated when analyzing the effectiveness of supply chain strategies. However, there are very few studies examining such a dynamic interaction among the HOs. This chapter is thus initiated to examine the effectiveness of emergency preparedness strategies such as supply prepositioning and lead time reduction strategies like rapid needs assessment in a competitive environment under resource constraints. Such a study may help to improve the efficiency as well as sustainability of HOs in their relief operations.

To study the interaction of the multiple players in relief operations, we use a system dynamics (SD) model as the analytical tool. Among the various tools and techniques, SD is chosen due to its advantage in dealing with dynamic complexity. An SD model will be developed to simulate humanitarian supply chains for two HOs under a funding constraint. The model will help users visualize the dynamic interactions among the different parties and provide insight into the trade-offs of each decision, and hence, facilitate effective and sustainable responses.

The rest of the chapter is organized as follows: we first conduct a literature review on the humanitarian logistics sector in the Asia-Pacific, as well as their challenges in emergency preparedness. The SD methodology is then introduced in Sect. 7.3, and a SD model on emergency preparedness strategies is developed. We then present the SD simulation results in Sect. 7.4. The chapter concludes with a discussion on the model implications and future research suggestions.

7.2 Literature Review

Jiang et al. (2012) have provided an overview of the humanitarian logistics structure in Asia and pinpoints the main challenges involved to draw public attention. In particular, HOs often face lack of government support and basic infrastructure. There are also coordination and communication problems both between the HOs and the other parties such as the local government and the private sector as well as among the HOs themselves.

To obtain an in-depth understanding of the humanitarian logistics sector in the Asia-Pacific, the recent work of de Souza and Stumpf (2012) is worth a visit. With contributors from academia, UN humanitarian agencies, international HOs, and commercial companies working in the Asia-Pacific, this provides a vivid account of relief operations from the ground, and highlights the challenges and opportunities in the field from various perspectives as well. One can find descriptions of large scale disasters in the region such as Cyclone Nargis in 2008 and the Bangkok flood in 2011.

For more understanding on the sector, Decker et al. (2013) compared humanitarian and commercial supply chain practices. In the commercial world, supply chain managers have strived to develop risk conscious management practices to enhance the resilience of their supply chain to large scale disruptions. At the same time, humanitarian organizations professionalized their approach of responding to disasters within a short lead time. Consequently, they could operate effectively in disruptive environments and potentially provide superior strategies. SD simulation was applied to yield performance benchmarks in terms of the disruption impact and the associated response costs.

While the literature mainly focuses on international HOs, small local HOs are often the key players for the effectiveness of relief operations. Sulistiono and Mulyadi (2012) have conducted a case study of a local HO in Indonesia, *Yayasan Sosial Bina Sejahtera.* Their study shares the experience of an local HO in conducting humanitarian operations for a recent disaster in Indonesia. This experience presents the capacity, capabilities, and initiatives by a typical local HO that is not specialized in disaster response. The experience also illustrates humanitarian operation processes conducted by the local HOs. The study can be used as a basis for further capacity building initiatives of the local HOs for disaster response, particularly in supply chain management.

More specific on emergency preparedness, one common strategy is stock prepositioning. In other words, positioning locally procured relief items in areas vulnerable to natural disasters before the emergency. For example, Balcik and Beamon (2008) developed a model incorporating both inventory and facility location decisions for disaster relief. They considered where an HO should locate distribution centers to respond to a disaster under a set of scenarios, and the probability of each scenario occurring. Similarly, Mete and Zabinsky (2010) discussed the optimal location of emergency medical supplies under stochastic demand.

The literature has also highlighted several constraints for emergency preparedness. The first critical constraint is funding. While it is much more cost effective to preposition supplies and other resources, there are relatively limited financial resources available in advance for a disaster as most resources only flow in after a disaster has taken place (Kovács and Spens 2009). Donor governments and organizations are unwilling to pay the cost of what is, in effect, an insurance policy against the scenario of an uncertain future event that typifies a natural disaster (Tatham and Pettit 2010). Furthermore, there is a time lag between the flow of funding and emergency supplies even after the onset of a disaster. The funding limit clearly reduces HOs' flexibility in allocating their limited resources before the emergency.

Another issue is the lack of coordination in the emergency preparedness phase among the HOs, and worse is their competition during the relief operation (Balcik et al. 2010). The pressure to obtain greater media attention and in turn more subsequent funding for the organization has resulted fierce competition among the HOs on the ground (Kovács and Spens 2009). Such competition may lead to duplicity which may waste precious resources and result in operation inefficiency. The influx of unnecessary supplies may congest the ports, creating additional

bottlenecks and causing unnecessary delays for other important resources. Moreover, the strong post-disaster demand and local competition for supplies will inflate local market price, hence increasing the relief expense of the HOs (Balcik et al. 2010). In some cases, the prices for local commodities and services such as trucking can increase by a factor of ten (Tomasini and Wassenhove 2009).

To control operation costs and secure access to critical supplies, more and more HOs are entering into long-term contracts with suppliers (Beamon and Balcik 2008). Such contracts are like options, often called framework agreements in the context of humanitarian logistics. The agreements would include the specification of the goods as well as the price, but not the order amount. The stocks indicated in the contract are typically managed by the supplier and the change of ownership is postponed until the point of actual purchase (Kovács and Tatham 2009). Such a strategy is important to HOs who do not have sufficient funding for stock prepositioning.

7.3 A SD Model on Humanitarian Logistics

7.3.1 Introduction of SD Approach

SD is first proposed by Forrester (1961), defined as "the study of the information feedback characteristics of industrial activity to show how organizational structure, amplification (in policies), and time delays (in decision and actions) interact to influence the success of enterprise". It is particularly applicable to systems that exhibit dynamic complexity due to time delays, feedback loops, and non-linear relationships.

A time delay exists in a system where the effect of an input will only be realized some time later. As a result, it may lead to confusion when exploring the causal effects and the lagged effects of an input may be easily missed if the delay is extremely long. In humanitarian logistics, time delays manifested as transportation lead time, production delay, information delays, and time to raise funds. It is important to incorporate all these delays into the planning phase as such delays will affect the effectiveness of the relief operation.

A feedback loop is defined as a succession of causes and effects such that a change in a given variable travels around the loop and comes back to affect the initiating variables (Besiou et al. 2011). The feedback loop can be either positive or negative depending on relative directions of the initial change and the resulting effect by the initial variable. For a system with multiple feedback loops with time delays and non-linear relationships, it is difficult to obtain an analytical solution. Here an SD model is more suitable given its ability to capture such feedback loops and help users to visualize the impact of decision policies on the system though simulation. For humanitarian logistics that involves multiple actors and operates in an uncertain and dynamic environment, it is quite justifiable to apply the SD methodology.

7.3.2 Model Development

The model was developed according to the processes suggested by Sterman (2000). The first step was to draw the causal loop diagram which describes the key variables, their relations and the feedback loops of their interactions. Subsequently, the main stock-and-flow diagram was developed based on the causal loop diagram. The stock-and-flow diagram consists of both tangible and intangible elements and represents the structure of the model. Finally, mathematical formulas are specified for all variables, so that these variables represent the decision processes which mimic how managers make decisions in a real system given the actual constraints faced and information available. Although SD model can deal with complexity, it is inevitable to make certain assumptions to facilitate analysis and evaluation. The key assumptions will also be highlighted in this section.

7.3.2.1 Base Case with One HO

The main task for a disaster relief operation is to design and implement the transportation of first aid material, food, equipment, and rescue personnel from supply points to a large number of destination nodes geographically scattered over the disaster region and the evacuation and transfer of people affected by the disaster to the healthcare centers safely and rapidly (Barbarosoglu et al. 2002). Hence, the model would focus on the information and material flows between the HOs, beneficiaries, and commercial suppliers. For simplicity, only the transportation of resources to beneficiaries is considered in the model. Return logistics is excluded. Moreover, all beneficiaries are assumed to be in a common location, such as an evacuation center, to simplify the model.

The entire emergency process is triggered by the onset of a disaster which creates a spike in demand for certain goods for a given period (impact duration). The needs assessment is done quickly to estimate this demand and the information is freely shared. However, the breakdown of communication leads to an information delay, hence, the HOs will only get demand information after some time. Based on this information, the HOs plan their operations and place orders. For a specific HO, it usually does not intend to help all affected people, but would rather choose to focus on a particular group based on its mandates or capacity constraint. This feature is captured in the model by the variable *relief scale*, which is measured a percentage of total affected population that the HO intends to cover. Besides the relief scale, HOs also have a planned duration for their intervention. Relief scale, perceived demand and intervention duration collectively determines the total amount of orders that the HO would place. Upon receiving the orders from HOs, the supplier would start the production and subsequently deliver the finished products to the HOs' local warehouses. This process may be delayed due to production capacity constraints and the transportation lead time. Finally the HOs will distribute the product to the beneficiaries from the local warehouses.

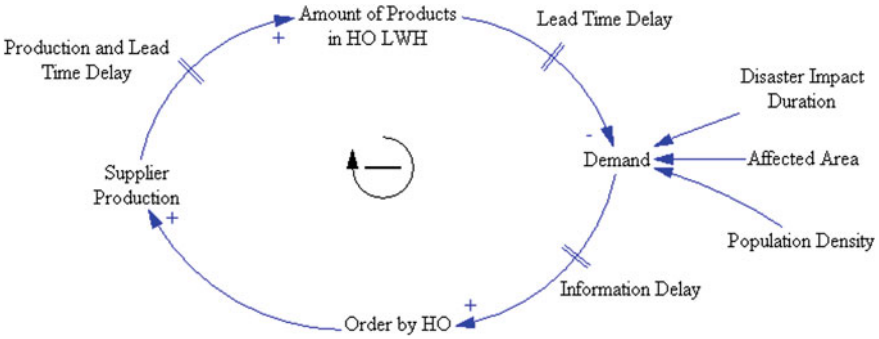

Fig. 7.1 Demand fulfillment cycle

This fundamental negative feedback loop is called demand fulfillment cycle and the main features are illustrated in Fig. 7.1.

In order to respond faster, the HOs may preposition their stocks in regional warehouses or sign contracts with the suppliers to guarantee access to resources as discussed. Such prepositioned stocks are readily available and offer an alternative channel for the HOs to fulfill the beneficiaries' demands as shown in Fig. 7.2. The new feedback loop also has an impact on the main loop as the more the prepositioned stocks, less orders would be placed to the suppliers.

Since most HOs rely on donations for relief operations, it is also important to incorporate the financial flow in the model. The amount of funding available will directly determine how many orders the HO can place. The more the HO orders, the more it would deliver to the beneficiaries, which would be perceived by donors as better performance. It would then attract more donations. Thus we introduce another new feedback loop into the main demand cycle as shown in Fig. 7.2. In this

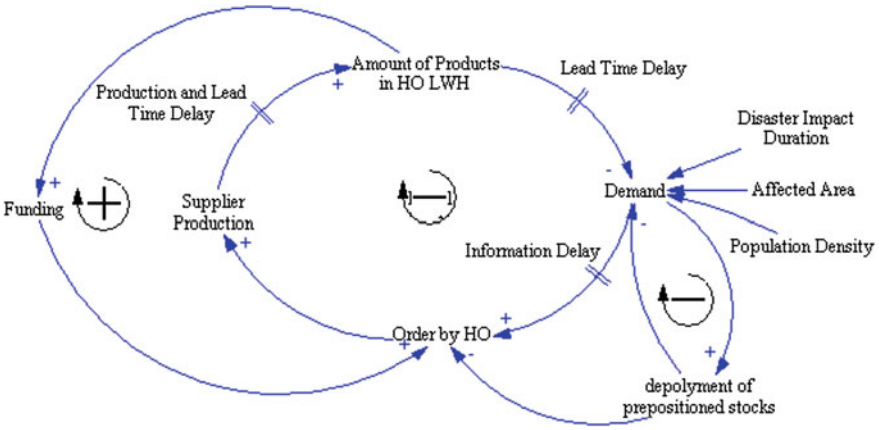

Fig. 7.2 Demand fulfillment cycle with preposition stocks and financial flow

base case, we simulate the supply chain with one HO, interacting with one supplier and constrained by funding.

7.3.2.2 Case of Two Competing HOs

In order to simulate a competitive environment, the base case is modified to incorporate one more HO into the system. As shown in Fig. 7.3, the complete model consists five main parts: two HOs, one supplier, donors and beneficiaries. For the two HOs in the model, one is the focal HO while the other one represents the rest of the HOs operating in the field.

Though the newly added HO has exactly the same supply chain as the one illustrated in Fig. 7.2, we cannot simply add two systems together to develop the model because these two systems will have an impact on each other by sharing the same supplier, approaching the same group of donors, and using same infrastructure such as roads and ports. We need to devise various policies to allocate the supplier capacity, funding and infrastructure capacity between these HOs. In our model, we allocate supply capacity based on orders from the HOs. The supplier's production is allocated to the two HOs based on their unfulfilled past orders if the supplier's inventory is not sufficient to fulfill all orders. Similarly, the infrastructure capacity is shared between two HOs in proportion to their needs. The funding allocation is based on the performance of the two HOs, which is approximated by the units of

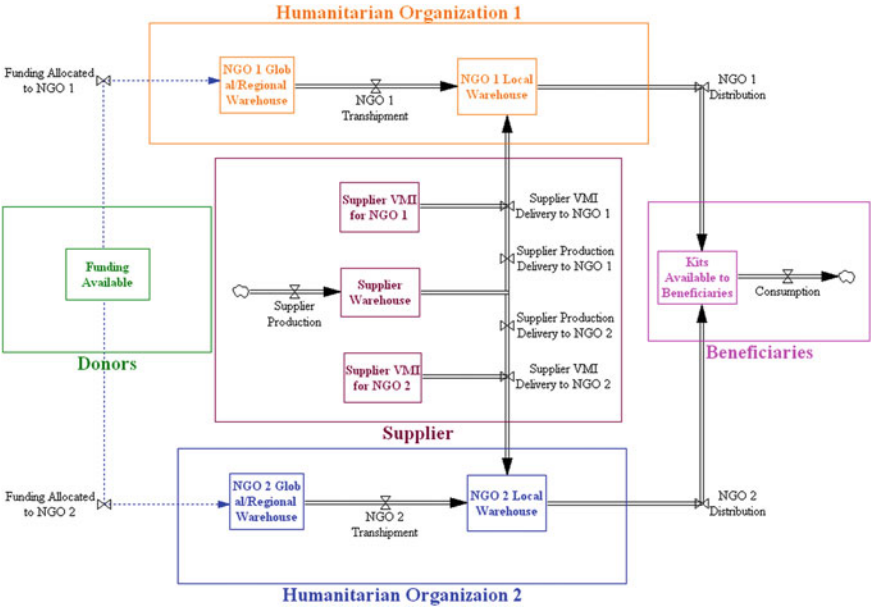

Fig. 7.3 High level structure diagram for the model

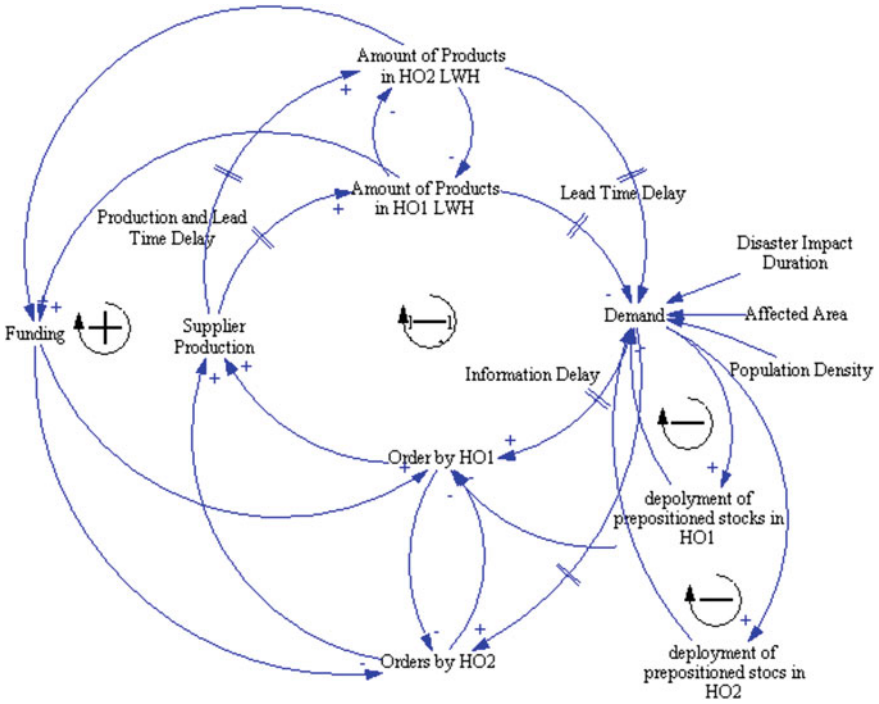

Fig. 7.4 Main interactions in competitive model

relief items they delivered. Such an allocation policy aligns with research findings which report that donors are demanding on performance and accountability (Balcik et al. 2010). Figure 7.4 presents the main interactions in the competitive model, which clearly illustrates the basic logic of the model.

7.3.2.3 Key Variables and Data Sources

The model takes several variables as input data. Some of these variables will be fixed for all simulations as a preset disaster scenario, which allows the model to explore the impact of different strategies. These variables include the disaster impact data, cost information, various delays, and capacity constraints. The last mile distribution constraint is imposed to capture the effects of damaged infrastructure. It is designed to be a step function with a low value for the first few days and a much higher value after a certain period, *infrastructure recovery time*. This is to mimic the removal of the bottleneck, restoring to the normal capacity of the infrastructure after certain period. Other input variables, such as the lead time and initial inventory level are decision variables for the HOs in our model. Hence, they can be changed in different simulations in order to examine their impact on the HO's performance. The full list of the model inputs is presented in Table 7.1.

Table 7.1 List of model inputs

	Category	Variables
Fixed variables	Disaster Impact	Population density
		Affected area
		Impact duration
		Needs per beneficiary per day
	Cost	Unit cost for prepositioned stock
		Unit cost for supplier VMI
		Unit cost for supplier production
	Capacity	Last mile distribution constraint
	Other delays	Information delay for initial needs assessment
		Fund raising delay
		Infrastructure recovery time
Adjustable variables	Prepositioned Stock	Prepositioned inventory at global/regional warehouse
	Lead time	From global/regional warehouse to local warehouse
		From supplier warehouse to organization's local warehouse
		From local warehouse to beneficiaries

To analyze the impact of these decision variables, the model has also incorporated some output variables to capture the performance of each HO as well as their overall performance as shown in Table 7.2. To measure individual HO performance, variables such as service coverage and average service cost are used. Service coverage measures the percentage of needs satisfied by the HO daily, indicating the effectiveness of the HO's supply chain. The average service cost measures the average landed cost of one unit of relief item over the whole intervention period, which is an rough estimation on the cost efficiency of the HO. Variables such as net beneficiaries' stock provide estimation on the overall effectiveness of the relief operations for a particular disaster. The variable *loss* is not a

Table 7.2 List of performance indicators as model outputs and their definitions

Category	Variable	Measure
Cost efficiency	Average service cost	Total operating cost/total number of kits delivered
	Total operating cost	Sum of all operating expenses over the whole intervention period
Effectiveness	Service coverage	Number of kits delivered everyday/daily demand that the organization aims to satisfy
	Loss	Quantified measure for unsatisfied demand
	Service ratio	Number of kits delivered by one organization/ number of kits delivered by both organizations
	Net beneficiaries' stock	Number of kits delivered by both organizations less than beneficiaries' consumption

monetary cost to the HO, but a deprivation cost, measuring the suffering of the beneficiaries due to unmet demand. There are also variables measuring the relative performance of the two HOs such as the service ratio.

Regarding these variables, the available data is limited since only very few HOs actually document their operations. As a result, not all required information can be found. However, since the intention of this chapter is to study the impact of strategic decisions such as prepositioning stocks on relief performance, it is more important to analyze the relationship between the input decision variables and the output performance measures. Therefore, for decision variables, a range of values are tested to evaluate the sensitivity of final outcomes to the variation of these inputs.

7.4 Results and Analysis

This section analyzes the simulation results for different strategies. Two main strategies will be analyzed, namely preposition strategy and lead time strategy by approaches such as framework agreement with suppliers. The sub-cases for each strategy will be tested in a few scenarios. Then the results are compared to explore the underlying causes.

7.4.1 Scenarios and Cases for Simulation

To analyze the result systematically, only variables relevant to one particular strategy is adjusted for each run while the rest of the decision variables are kept constant. Hence, any change in the output results are due to the changes in inputs relevant to the particular strategy under evaluation. To explore the effect of the prepositioning strategy, only variable *prepositioned inventories in global/regional warehouses* is allowed to change. Similarly, for lead time strategy, it is assumed that the two HOs do not hold any prepositioned inventory and can only choose to reduce their lead times.

However, it is recognized that the impact on the outputs is also affected by other factors such as the HO's ordering strategy and supplier production capacity constraint. The amount of safety stock the HO plans to order obviously makes a difference on the final outcome. Therefore, to isolate the effects of the ordering strategy and supplier production capacity constraint, each strategy will be tested in six scenarios with different combinations of ordering strategy and supply production capacity as shown in Table 7.3.

For each scenario, a base run is generated as a reference for subsequent comparison. In the base run, both HOs do not hold any prepositioned inventories and have the same lead times and the other delays apply to both HOs. Hence, they are

Table 7.3 Simulation scenario definition

	Order for the whole intervention period	Order for daily perceived demand + safety stocks covering demand during delayed days	Order for daily perceived demand only
With supplier production constraint	Scenario 1	Scenario 2	Scenario 3
No supplier production constraint	Scenario 4	Scenario 5	Scenario 6

symmetric except for their relief scale. Then for each strategy, a few cases are constructed to run in all scenarios. The cases typically consists of only one HO adopting the strategy, then two HOs using the strategy to the same extent and finally both HOs adopt the strategy but to a different extent.

7.4.2 Base Runs

As mentioned, base runs are generated for each scenario as a reference for subsequent comparison. Besides being a basis for comparison, the results for different scenarios also provide some insights about the ordering strategy. Two observations are presented here but we omit details as they are easy to understand:

- Under supplier production constraint, the best ordering strategy is to be lean (Scenario 3).
- When there is no supplier production constraint, the more you order, the lower the deprivation cost (total loss) but the higher the operating cost.

7.4.3 Prepositioning Strategy Analysis

To explore the impact of prepositioning strategy in each scenario, five cases are considered, namely HO1 prepositioning, HO2 prepositioning, both HOs prepositioning equal amounts, both prepositioning but HO1 50 % more, and both prepositioning with HO2 50 % more. By comparing the results of these cases with the base run of each scenario, we find that:

- Prepositioning of stocks generally improves the supply chain performance, but if only the small HO prepositions stocks, the overall outcome would be worse.

The key variable examined here is the total loss. As shown in Fig. 7.5, prepositioned stocks generally help to reduce loss and operational costs. However, the total loss increases for the case of HO1 prepositioning in almost all scenarios.

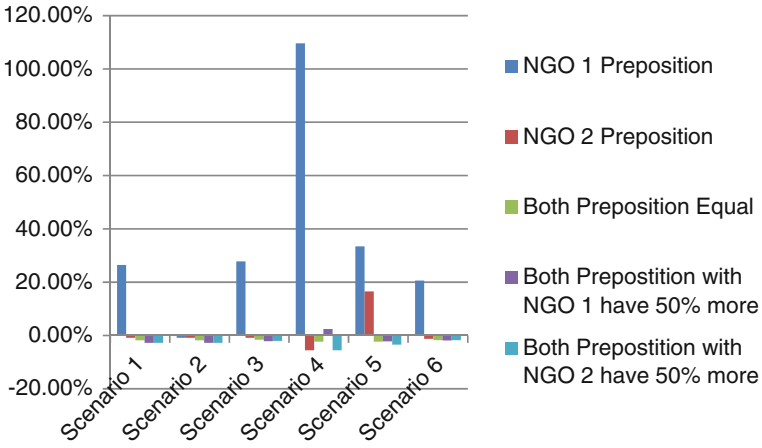

Fig. 7.5 Comparing the performance of prepositioning strategy with base runs by total loss

The observations in HO1 Prepositioning case appear counterintuitive. Being the only HO holding prepositioned stocks, HO1 has an advantage over HO2 and is able to reach the beneficiaries faster than HO2. As a result, HO1 is seen by donors as being more effective and efficient. Therefore, more funding is allocated to HO1. However, HO1 in our model is a small HO only intending to serve 10 % of the total affected population. All its planning and ordering are based on this assumption. Upon receiving more funds, HO1 will eventually upscale its operation to reach more beneficiaries. However, since such an up scaling is not planned for, it takes time for the HO to adjust its orders and eventually reach more beneficiaries.

The situation would be more complex when we consider the supplier production constraint. As more funds goes to HO1, HO2 will receive less funds. Hence, during first few days, the supplier will only receive small quantity orders as HO1 is only ordering for its planned number of beneficiaries and HO2 does not have sufficient funds to order more. Therefore, the supplier's production capacity is underutilized for the first few days. However, in subsequent periods, when HO1 scales up, the supplier is unable to meet the required orders due to a capacity constraint. Such effects can actually be evened out by changing two HOs' ordering pattern.

Prepositioning by a small HO alone not only increases the total loss, but also increases operating costs. Intuitively, average service costs are expected to decrease as prepositioned stocks are much cheaper than spot purchasing. However, the average service costs increase for HO1 prepositioning case in scenarios 1 and 4. Both scenarios have a policy of ordering for the whole intervention period. Hence, the increase in orders when HO1 scales up is huge. As a result, it pushes up the purchasing price as demand significantly exceeds the supply, resulting in much higher average service costs.

7.4.4 Lead Time Strategy Analysis

For the lead time (LT) strategy, five cases including HO1 reducing LT by 50 %, HO2 reducing LT by 50 %, both reducing LT by 50 %, HO1 reducing LT by 75 % and HO2 by 50 %, and HO1 reducing LT by 50 % and HO2 by 75 % are considered, and similar results are reported. Various combinations of the lead time reduction have reduced the total loss in all scenarios. This is due to a faster response by the system.

Unlike the HO1 prepositioning case in previous section, the case of only the small HO reducing the lead time does not worsen the overall outcome. There is also fund reallocation and unplanned upscale in this case, and it still takes HO1 about 20 days to adjust the orders. However, due to the shorter lead time to the beneficiaries, they can still deliver items quickly to the beneficiaries despite the delay in the scaling up. The key difference between the HO1 prepositioning case and LT reduction case is the sustainability of their efficiency. In the prepositioning case, HO1 is able to reach the beneficiaries faster by leveraging on the prepositioned stock. However, this efficiency is not sustainable. Once the prepositioned inventory is depleted, HO1 does not have any competitive advantage over HO2. However, in the LT reduction case, the efficiency achieved by reducing the lead time is sustained throughout the entire operation period.

In terms of the operating cost, the average service cost for both HOs increases in most cases. This is due to the extra investment needed to reduce the lead time in our model. However, if the HO reduces the lead time significantly, the average service cost will eventually decrease due to economies of scale. By significantly reducing the lead time, the HO can consistently perform better and attract more funds to purchase more relief items. The total operating cost can therefore be amortized over a larger number of units. The increased expense to reduce the lead time can be offset by the upscale of operations. This effect is more obvious in the scenarios without supplier production constraints. In scenarios with a supplier production capacity constraint, the kits ordered by the HO may be stuck in the supply network without reaching the beneficiaries before the end of the simulation periods.

For the two cases with only one HO reducing LT, we observe that the other HO that does not reduce the lead time would experience a reduction in average service cost in almost all scenarios.

In short, we can conclude that:

- Lead time strategy reduces the deprivation cost (total loss) but tends to increase the operating cost. Moreover, if only one HO chooses to reduce the lead time, the other HO will also benefit through the reduction of its operating cost.

7.5 Conclusion

This chapter demonstrates an SD model's capability of improving the HOs' supply chain performance, through visualizing the impacts of various decisions through simulation and making insightful observations. We have built a SD simulation

model in a competitive environment with two HOs. Simulation results suggest that a lead time strategy is always powerful but for the prepositioning strategy, if only small HO prepositions stocks, the overall performance would, however, become worse.

The SD model can be used by practitioners as a decision aid to improve the efficiency in humanitarian logistics operations. Logistics managers can use the model as a simulation tool to find the best strategies in emergency preparedness for better performance at the field within existing constraints. Results can also be used to convince donors to change their behaviors. For example, the benefits from prepositioning strategy can be used as a strong evidence to convince donors to invest in preparedness stage and reduce the earmarking of the funds. The observation that only small HO prepositions will worsen the overall outcome can be used to persuade donors to set the right incentives for HOs by not rewarding the first HO on the ground, but HOs with consistently higher efficiency.

Potential research areas could include supplier contract, funding restructure, and coordination improvement among HOs, and adding such information into the SD model. Moreover, this study only focuses on disaster relief operations and treats the supply chain for disaster relief operations independently. The disaster relief operation is evaluated separately from HO's other programs. In reality, one HO, especially international ones, may have multiple programs ongoing at the same time. Temporary supply chain for a particular disaster relief operation may overlap with permanent supply chains for other long term development programs. The costs and impacts for each strategy could be very different if such overlap is considered. Hence, another potential area for future research is to modify the model to simulate the overlapped supply chains to understand its dynamics and tradeoffs between subsystems for a particular disaster relief operation and broader system encompass all ongoing programs, and tradeoffs between short term and long term.

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Chapter 8
Sustainable Humanitarian Logistics Optimization—A Hub Concept for Germany Based on the Shapley Value

Hella Abidi, Christof Kandel, Matthias Klumpp and Solveig Zinnert

Abstract This research paper aims to demonstrate an innovative cooperation logistics concept for different humanitarian logistics phases, namely preparedness, response and recovery in particular for the response phase. Starting of the present lack of cooperation among actors in humanitarian relief chains worldwide the authors argue to build a cooperation logistics concept for German humanitarian organizations by using the Shapley value and showing the allocation of savings among possible partners of a centralized humanitarian distribution hub. The achieved savings and reduction of the logistics costs should be used for investment in relief goods and therefore in saving more lives as well as serving more beneficiaries in disaster cases. Furthermore, the cooperation between different humanitarian organizations would ensure the transit time of the required delivery time of 24/48 h and significantly would reduce transport and logistics costs because of bundling synergies.

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8.1 Introduction

Sustainable supply chain activities vary from organization to organization. Some organizations focus with a greater emphasis on managing green supply chain and other organizations focus on dealing with social issues (Walker and Jones 2012). However customers, regulatory bodies, non-governmental organizations, and even their own employees require that organizations should manage their supply chain with prioritizing environmental and social aspects which are impacted by their operations (Craig et al. 2011). Supply chain manager are capable to address the request for example through optimization and improvement of processes towards supplier selection, vehicle routing, packaging services, carrier selection as well as location decisions (Craig et al. 2011; UN 2006). Further example is cooperation between different stakeholder among a supply chain which increase competition, decrease the bullwhip effect, allocate resources and reduce costs (Becker et al. 2011). However, the current literature emphasizes few research studies on cooperation in humanitarian logistics context (Parmar et al. 2007; Battini 2007; Schulz and Blecken 2010; Maon et al. 2009). In the humanitarian supply chain sector practice a current approach can be seen as a horizontal cooperation namely Logistics Emergency Teams (LETs). This cooperation was started in 2008. LETs consist of four companies from the logistics and transport industry: Agility, A.P. Moeller Maersk, UPS and TNT Express. This cooperation has different corporate social responsibility programs and is experienced in humanitarian relief operations. LETs assist the humanitarian logistics sector with emergency response logistics services after an occurrence of a disaster. Nevertheless, this concept demonstrates a logistics network rather than a hub and spoke system (Hamiache 2001). Furthermore research projects on cooperation mechanisms in humanitarian logistics exist such as Emergency Capacity Building (ECB) or humanitarian horizons project. All these are significant works of significant inhibitors of humanitarian relief to increase cooperation, and to improve effectiveness and efficiency among humanitarian logistics response activities.

This research paper shows a distinctive and practical implementation of a cooperation within a fixed logistics network as a hub-network, operated in Germany for the transports towards the existing UN relief depots.

The following objectives have to be pointed out in humanitarian operations relief for reduction of mortality and vulnerability, save lives, increase the number of beneficiaries that will be served, combat diseases and promote gender quality in the phase of response and in the transition from preparedness to response:

- Sustainable humanitarian supply chain,
- Cost efficiency,
- Timeliness of the response,
- Better cooperation between the actors in overall humanitarian sector and mitigation of the heterogeneous interests of organizations,

- Standardization of humanitarian operation procedures and systems,
- Construction of an efficient logistics plans, concept and system for an innovative procurement, transport, distribution and storage of food, water, sanitation, shelter, energy, medicines etc. and capacity building.

The main research objectives are economic aspect that show how to optimize costs and to address environmental as well as social issues based on a concept centralized logistics network. To define the allocation of savings/costs for the humanitarian actors a solution concept for cooperative games theory with transferable utility, namely Shapley value has to be used in this research. The Shapley value "makes it possible to shift the debate from the sharing rule to the properties of that rule. So that, insofar as a solution is the unique sharing rule verifying a given set of desirable properties, the only possible choice appears to be this particular solution" (Hamiache 2001, p. 3). In this research paper a case study is used that is presented in Sect. 8.4.1.

The research paper is structured in four sections. After this determination of the research objective this research paper first differentiates the humanitarian logistics network from the commercial logistics network. Secondly it describes the general network model. Then it illustrates with a real-life example the Shapely value as a part of cooperative system for an innovative humanitarian logistics network concept and it discusses the hub and spoke network structures based on savings allocation and cooperation between the humanitarian logistics actors. Finally it concluded by showing further research outlook for the future.

8.2 Literature Review

8.2.1 Commercial Logistics

While being essential for business in general, the terminology of logistics networks and its manifestations distinguish in scientific approaches through a wide and inconsistent range of perception. In the following, important literature will be reviewed in order to find a suitable definition of commercial logistics networks.

Broad consensus can be found when reviewing the term 'network' individually. While a net is the genus for all kinds of configuration, which can be described as quantity of geographically fixed knots and connections, a network is the subset of closed and dedicated nets that are geared to the specific requirements of owner and user of the network (Bretzke 2010).

In the literature there is inconsistency about what logistic networks involve. A large amount of authors define logistics networks synonymous to the term 'supply chain' whereas others differentiate clearly between both terms (Table 8.1). For example, Simchi-Levi et al. (2003) describe supply chains, which are also referred to as the logistics networks (Simchi-Levi et al. 2003), whereas Mentzer et al. (2001a) include a minimum amount of three companies that are essential to form a supply chain. Rushton et al. (2010) understands the supply chain as an extension to

Table 8.1 A sample of authors and their definitions on logistic networks and supply chains

	Logistics network	Supply chain
Bretzke (2010)	Distinct organized system of resources, hierarchically and geographically arranged, with the aim to connect sources efficiently and economically with recipients; functional approach	For supply chains to become a super ordinated system, requirements have to be fulfilled such as: explicit goals, formal structure and delegation of authority, identity, closed outer boundaries
Christopher (1992)		Network of organizations, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services
Christopher (2005)		A network of connected and interdependent organisations mutually and co-operatively working together to control, manage and improve the flow of materials and information from suppliers to end users
Corsten and Gabriel (2004)	Supply chain as natural evolution of a sequentially orientated logistic chain due to increased logistical complexity. Supply chain is a network of capabilities with different options of material and information flows	
Hieber (2002)	Network of entities through which material and information flow, encompassing all related activities associated with the flow and transformation of goods in the respective area of the network	
Mentzer (2001b)		A set of three or more companies directly linked by one or more of the upstream and downstream flows of products, services, finances, and information from a source to a customer
Rushton et al. (2010)	Logistics = material management + distribution	Supply chain = suppliers + logistics + customers
Simchi-Levi, Kaminsky, Simchi-Levi (2003)	Raw materials are procured and items are produced at one or more factories, shipped to warehouses for intermediate storage and then shipped to retailers or customers	
Stadtler (2005)	From the perspective of organizational theory, supply chains are a special form of a network organization	

logistics including suppliers and customers (Thun 2005). Bretzke (2010) defines the overall system thinking with regard to logistic networks and supply chains together. According to Sydow (1992) to become a super ordinated supply chains system that is holistically optimized, certain requirements have to be fulfilled: Explicit goals have to formulated, a formal structure with delegations of authorities initiated, closed outer boundaries established and a common identity formed. Few to none supply chain will be able to fulfill those requirements as external opportunities (such as sales to third parties) are often pursued and thus the holistic supply chain fragmented (Christopher 1992). Bretzke (2010) also questions the popular hypothesis that future competition will be among whole supply chains rather than single parts of the supply chain. According to Bretzke (2010), a logistic network is a function within a system that is the company but it is not the system itself.

In the light of such diverse perceptions of how logistics networks are defined, further insight into how logistics networks can be designed might help to outline a clearer picture. To analyze, classify and quantify the structure of logistics networks many authors use the graph theory (Gudehus 2007; Bretzke 2010). The graph theory defines the network as a finite interrelated graph, consisting of knots and edges. Knots in a logistics network are logistics companies, organizational entities or general resources needed to execute logistical performance processes (Gudehus 2007). The structure of a logistics network is defined by the number of knots and edges, hence resulting in a tree-like network (many-to-one) or an area network (many-to-many). Generally two basic network structures are defined in literature: The one-stage logistics network describes the straight flow of goods between the source and the recipient as can be seen in Fig. 8.1 (Gudehus 2007).

Transport systems, where the source and recipient are not directly connected but linked through at least two other logistic notes (e.g. logistic centers), are called multi-stage networks (see Fig. 8.2). Those network systems usually exist in global freight networks that make use of different transportation modes for different distances (e.g. air and sea for long distance transports, rail and road for shorter distances) (Gudehus 2007).

Considering the structure and design of networks shown above, this paper focuses on the characteristics of the specific network design in light of humanitarian aid. The definition of Hieber (2002) links the network specifics to the more holistic

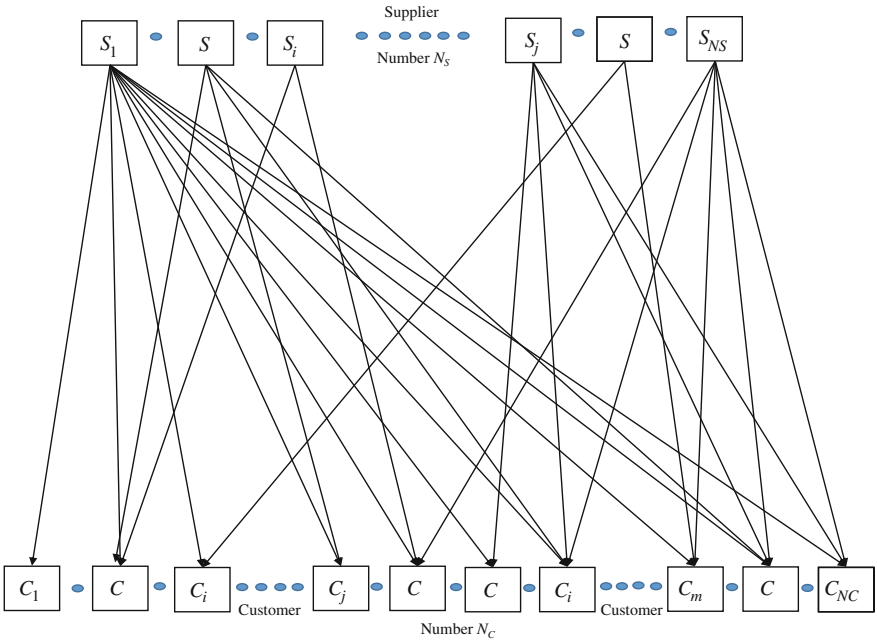

Fig. 8.1 Single stage logistic network (Gudehus 2007). *S* supplier, *C* customer

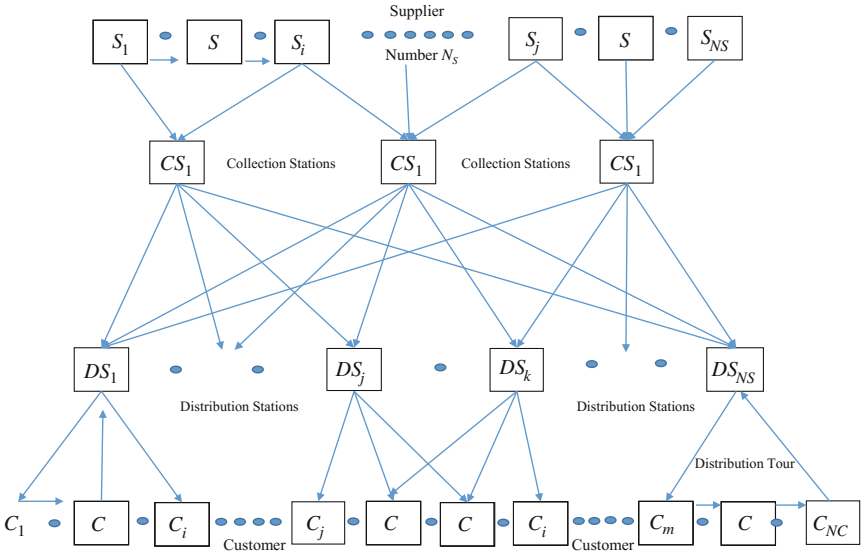

Fig. 8.2 Multi-stage networks (Gudehus and Kotzab 2009). *S* supplier, *CS* collection stations, *C* customer, *DS* distribution stations, *LC* logistic centers

supply chain approach, stating that logistics activities range throughout the whole chain and hence is of paramount interest within a humanitarian supply chain and thus forms the basic definition for this paper.

8.2.2 Humanitarian Logistics

While supply chains become even more fragile and time critical in commercial businesses, stable and efficient logistics networks are even more critical in a humanitarian sense. As Kofi Annan, United Nations Secretary General, pointed out during the Asian tsunami in 2004 logistics is one of the biggest challenges during a humanitarian catastrophe where the local infrastructure is completely demolished. Despite the increasing amount of disasters and the related importance of humanitarian logistics, substantial operational research on this subject is still rare and fragmented compared to other disciplines as Kovacs and Spens (2007) and Altay and Green (2006) have identified. However, slight increases in operational research can be noted in recent years (Kovacs and Spens 2009; Altay and Green 2006).

As with commercial logistics networks, many different terms are used to describe one and the same subject. Kovacs and Spens (2007) divide humanitarian logistics into the two sub-categories disaster relief as well as continuous aid work while others use all terms interchangeably (Kovacs and Spens 2009). Disaster relief logistics is defined by the Fritz Institute as the process of planning, implementing

and controlling the efficient, cost-effective flow and storage of goods and materials, as well as related information, from point of origin to point of consumption, for the purpose of meeting the end beneficiary's requirements (Thomas and Mizushima 2005). On the surface, the difference between this definition and above definitions on commercial logistics is minimal, merely differentiating on the intention that triggers the process. However, differences go far beyond that as Schulz (2009) and Pettit and Beresford (2005) point out: Humanitarian logistic networks are characterized through uncertainty with regard to the time and location of the next disaster as well as the amount and mix of supplies needed (Schulz 2009; Pettit and Beresford 2009), extremely low lead times (Beamon 2004), political issues and dependency of funds (Oloruntoba and Gray 2006) and high staff turnover (Van Wassenhove 2006). While this does not only describes the challenges of humanitarian aid it also forms the requirements for the humanitarian logistics network that is flexible to changing environment and highly focused on the efficient cooperation between different stakeholders.

Some researchers have pointed out the similarities of the state of logistics in humanitarian assistance today with the situation of corporate logistics management 20 years ago (McGuire 2006), followed by the appeal to humanitarian organizations to cease regarding logistics as an expense but rather apply strategic importance to this sector. While the term 'humanitarian logistics' applies a broader view on the logistic activities within a humanitarian supply chain including the preparation and follow-up of humanitarian work, 'disaster relief logistics' is restricted to the immediate aid following a disaster (Schulz and Blecken 2010; Guha-Sapir et al. 2011).

Analogically to the corresponding commercial definition, this paper will assume equality between the terms 'logistic networks' and 'supply chain'. A short review on recent studies on this specific subject is given.

Oloruntoba and Gray (2006) describe a simplified model of a humanitarian logistics network with a direct connection between governmental donor and the beneficiaries (Altay and Green 2006). A more task orientated model is pursued by Thomas (2003). The supply chain is aligned according to the activities it has to fulfill, starting with a general preparedness for such crisis situations. Once a crisis occurs the appeal is assessed and resources mobilized. Procurement and transportation of goods to the designated point of delivery follow as well as the general execution of local distribution. Tracking and tracing and the management of stocks display the next stage of Thomas' supply chain model, ending with extended point of delivery and evaluation of performance. No more details are given as to the activities and processes regarding the long-term recovery of the crisis situation.

Kovacs and Spens (2007) divide their model into three phases: Preparation, Response and Reconstruction (IASC 2008). Haddow and Bullock (2004) categorize four phases for disaster management namely response, recovery, mitigation and preparedness (Haddow and Bullock 2004). Van Wassenhove (2006) classifies four phases: Mitigation, preparedness, response, rehabilitation (Van Wassenhove 2006). Baumgarten et al. (2010) identify four phases as can be seen in Fig. 8.3.

While preparedness focus on the avoidance or minimizing of risks when a disaster strikes (i.e. Building capacities, formulating action plans, educating people et al.)

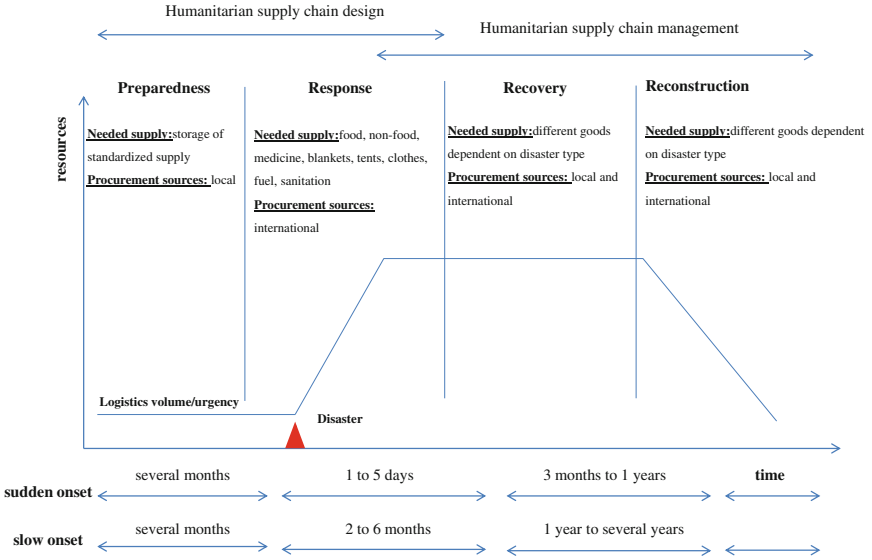

Fig. 8.3 Modified logistics requirement in the phases of disaster (Baumgarten et al. 2010)

(Quarantelli 1997), the response phase concentrates on the immediate rescue of affected people and the removal of damage after the disaster has struck. Recovering and restoring the region and its infrastructure to prior disaster level and learning from the disaster is the main aim of the recovery and reconstruction phase which approximates a time frame of 5–10 years (Haddow and Bullock 2004).

Each of these phases and activities require logistics support, although every phase has its requirements with regard to the duration, volume, the need as well as the variety of supplies, urgency and procurement location. Considering this, efficient collaboration and cooperation between the varieties of supply chain actors is one of the main criteria for the humanitarian network design. Especially in sensitive phases such as the preparedness and response phase a high need of cooperation and collaboration can be noted.

All in all, a quantity of research has been published to cover one, two or all phases of the Kovacs and Spens model. Table 8.2 shows a partial synthesis of corresponding literature (Kovacs and Spens 2009).

Table 8.2 Dividing recent literature into the three phases of humanitarian supply chains (Kovacs and Spens 2009)

Preparation	Response	Recovery
Kovacs and Spens (2007), Pettit and Beresford (2005), Thomas (2003)	Basu and Wright (2005), Blecken et al. (2009), Oloruntoba and Gray (2006), Thomas (2003), Tufingki (2006), Van Wassenhove (2006)	Blecken et al. (2009), Kovacs and Spens (2009), Pettit and Beresford (2005)

While a large quantity of literature on humanitarian logistics and its specific manifestations exist, many articles relate to a practitioner background often in cooperation with humanitarian interested private organizations or are of conceptual nature (Guha-Sapir et al. 2011). There is little profound empirical research to be found with regard to humanitarian logistic networks. This paper strives to fill some of the blank spots by providing a logistics network model using and producing empirical data that gives implications how to shape a humanitarian logistic network more efficiently.

8.3 German Humanitarian Logistics Hub Concept

8.3.1 General Centralized Network Description

To improve service security of relief items from Germany it is proposed to install a central logistics facility as a hub to organize cooperative transports into disaster areas (outbound). This centralization approach can be more efficient in forwarding goods into disaster areas. The increase in efficiency starts with a coordinated incoming goods process to register and store items within the hub. In case of a disaster it is known which amount of goods are available at different humanitarian organizations' facilities and which goods were needed at short notice and for which goods a procurement plan can be defined. So first delivery into the disaster region can be prepared immediately, which results in a shortened preparation time and delivery of relief items. Simultaneously during the transport process a list of transported items can be transmitted to the destination airport to prepare unloading and commissioning of relief items for the last mile. When a plane arrives, a coordinated and well prepared unloading and commissioning process can be executed. This results in a shorter transfer time and an overall shortened delivery time of relief items into the disaster area.

For the central German logistics hub the airport in Frankfurt, as the biggest international airport in Germany, lends itself to be a good location for such a central logistics facility, for example because of HOLM—the house of mobility and logistics—which is located at the airport, which could support relief transports with logistics knowledge. The different network structures before and after installing the proposed hub are displayed in Figs. 8.4 and 8.5.

It is easy to understand that an organized and structured hub network would improve transport efficiency and reduce coordination effort within the UN humanitarian response depots, especially at airports within the disaster region, because the transports reaches the local airports in a better prepared situation. Nowadays it is often an uncoordinated chaotic situation within a local disaster airport because local staff is not able to execute transfer of relief items at short notice without knowing exactly what will be delivered within the next airplanes

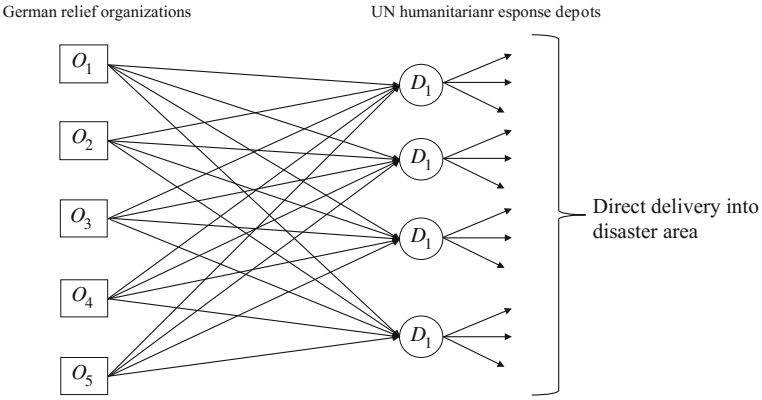

Fig. 8.4 Network structure with single delivery of relief organizations from Germany

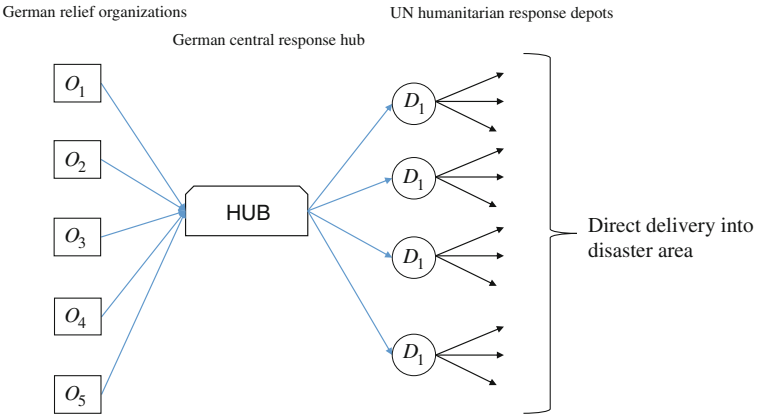

Fig. 8.5 Network structure with proposed central cooperative hub depot in Germany

arriving. Another option for German humanitarian organizations is that they do not need to maintain own storage areas as their suppliers could deliver directly to the central relief hub. A cooperative management team could be responsible for purchasing, inventory management and delivery planning—this results in lower overall logistics cost. Further it has to be estimated which of the cooperating humanitarian organizations can account for which amount of savings to estimate the logistics cost they are responsible for. Therefore the concept of cooperative game-theory's Shapley value is applied in this paper.

8.4 Method Description

Shapley introduced in 1953 the Shapley value as part of cooperative game theory. His theory is generally applicable in n-person games and allocates a definite solution for each player in a set N of n players that must divide a given surplus among themselves if they are cooperating. The Shapley value defines the allocation of surplus e_k to the participating players regarding all possible coalitions as subsets S of N. It is mathematically formulated within following equation:

$$e_k = \sum_{S \subset N; s \in \{0, n-1\}} \frac{s!(n-s-1)!}{n!} mv(S,k) \tag{8.1}$$

where

$$mv(S,k) = (v(S \cup \{k\}) - v(S)) \tag{8.2}$$

The term $mv(S, K)$ is the marginal value that player k generates after his adhesion to a coalition S. The order of the players in a coalition S does not influence the contribution of the player k once he has adhered to the coalition. Because of this the number of coalitions of $mv(S, k)$ needed for Eq. (8.1) is 2^n (Araar and Duclos 2009).

Complexity of calculating Shapley value rises enormously when new players were introduced. For example, if there would just be a cooperation consisting of 10 humanitarian organizations within the logistics network, already 10! = 3,628,800 different joining combinations are possible and 2^{10} = 1,024 coalitions have to be calculated by using the presented algorithm. This demands for computer aided calculation but additionally also for clear and transparent accounting processes to get access to the needed cost data which is in practice most difficult task.

Shapley demonstrated that his concept is the only one that satisfies the following four axioms (Holler and Illing 2009; Shapley 1953; Thun 2005):

- *Symmetry*: All players are regarded as equal. For example if some players provide the same input, they also obtain the same output
- *Pareto-Optimality*: Due to an arrangement made all players will be awarded with an output that is superior to that they actually achieve ('Status quo'). Further, no player may achieve a better output without downgrading another player. The sum of all individual payoffs is equal to the overall payoff that is allocated.
- *Dummy-Player*: If a player achieves the same output within all coalition formations possible—compared to the output gained by working independently—she or he will also just be awarded with the original output. For example marginal benefits achieved by player i in all possible coalition formations are constant and equal to those achieved working in isolation.
- *Additivity*: If a game is divided into sub-games, the sum of a player's outputs within these sub-games is equal to that within the overall game. For example if there is a special coalition formation each player achieves the quota equal to the output within several sub-coalition formations.

8.4.1 Case Study

In order to become more practical a fictitious case study approach is provided demonstrating the capability of Shapley value to define allocations based on the GARD program of DHL. Within this program DHL delegates coaches into potential disaster regions to get local airports ready for handling relief items in case of a disaster. In the regarded coalition DHL acts as a logistics company to transfer knowledge into areas and four other partners receives this knowledge to execute good logistics processes in disaster areas. So DHL could also be the owner of the above described central logistics facility which also improves the local processes. Therefore education and training courses all over the world were planned and executed at airports in potential disaster regions. Logistics company provides coaches and cooperating German humanitarian organizations send their local partners to the airports who receive this special training to execute prepared processes in case of a disaster. The costs for these trainings have to be split in a fair way between the participating companies and organizations. Shapley value defines allocation of savings/costs for these companies which is done consecutively based on the algorithm by Araar and Duclos (2009) was used. They propose following three steps to calculate Shapley value e_k:

1. Construction of a basic Shapley matrix with all possible coalitions.
2. Constructing a Shapley matrix M of coefficients m.
3. Estimating the contribution of factors I according to the level of introduction and calculation of Shapley values e_k.

The total costs during cooperation are lower in contrast to single trainings for each humanitarian organization so that a surplus has to be allocated between the partners. This is mainly due to the fact that costs for DHL delegates do not count for every training for each humanitarian organization. Therefore costs for all coalitions which have to be calculated ($2^5 = 32$) were needed and are displayed in Table 8.3 as $V(SI)$. These costs are based on assumed costs for staff and travel. It is assumed that the more organizations take part within the trainings the cheaper it is for each organization because the costs for experts remain the same. The actual costs within Tables 8.3 and 8.4 were based on estimations for working days and travel costs. The results of the individual calculation steps can be seen in Table 8.3.

The Basic Shapley matrix B in the first columns show the different coalitions, the matrix of indicator displays if a player is joining a coalition or not. The elements of the matrix of coefficients M are defined according (Araar and Duclos 2009) as:

$$m_{l,k} = \frac{u_{l,k} s_l!(n - s_l - 1)! + \bar{u}_{l,k} \bar{s}_l!(n - \bar{s}_l - 1)!}{n!} \tag{8.3}$$

Table 8.3 Results of the Shapley value algorithm steps according to (Araar and Duclos 2009)

Basic Shapley matrix B						Size of coalitions		Matrix of indicator				
Level	c1	c2	c3	c4	c5	∑	∑	c1	c2	c3	c4	c5
1	1					0	3	1	0	0	0	0
2	1	2				1	2	1	1	0	0	0
3	1	2	3			2	1	1	1	1	0	0
4	1	2	3	4		3	0	1	1	1	1	0
5	1	2	3	4	5	4	0	1	1	1	1	1
6	1	2	3		5	3	0	1	1	1		1
7	1	2		4		2	1	1	1	0	1	0
8	1	2		4	5	3	0	1	1	0	1	1
9	1	2			5	2	1	1	1	0		1
10	1		3			1	2	1	0	1		0
11	1		3	4		2	1	1	0	1	1	0
12	1		3	4	5	3	0	1	0	1	1	1
13	1		3		5	2	1	1	0	1		1
14	1			4		1	2	1	0	0	1	0
15	1			4	5	2	1	1	0	0	1	1
16	1				5	1	2	1	0	0		1
17		2				0	3	0	1	0		0
18		2	3			1	2	0	1	1		0
19		2	3	4		2	1	0	1	1	1	0
20		2	3	4	5	3	0	0	1	1	1	1
21		2	3		5	2	1	0	1	1		1
22		2		4		1	2	0	1	0	1	0

(continued)

Table 8.3 (continued)

Basic Shapley matrix B						Size of coalitions		Matrix of indicator				
23		2		4	5	2	1	0	1	0	1	1
24		2			5	1	2	0	1	0		1
25			3			0	3	0	0	1		0
26			3	4		1	2	0	0	1	1	0
27			3	4	5	2	1	0	0	1	1	1
28			3		5	1	2	0	0	1		1
29				4		0	3	0	0	0	1	0
30				4	5	1	2	0	0	0	1	1
31					5	0	3	0	0	0	0	1
32						0	4	0	0	0	0	0

Matrix of coefficients M					Coalition value	Contribution of factors I				
c1	c2	c3	c4	c5	V(Sl)	I1	I2	I3	I4	I5
0.2000	−0.0500	−0.0500	−0.0500	−0.0500	12,500,000	250	−63	−63	−63	−63
0.0500	0.0500	−0.0333	−0.0333	−0.0333	20,000,000	100	100	−67	−67	−67
0.0333	0.0333	0.0333	−0.0500	−0.0500	22,500,000	75	75	75	−113	−113
0.0500	0.0500	0.0500	0.0500	−0.2000	23,500,000	118	118	118	118	−470
0.2000	0.2000	0.2000	0.2000	0.2000	25,000,000	500	500	500	500	500
0.0500	0.0500	0.0500	−0.2000	0.0500	23,750,000	119	119	119	−475	119
0.0333	0.0333	−0.0500	0.0333	−0.0500	20,000,000	67	67	−100	67	−100
0.0500	0.0500	−0.2000	0.0500	0.0500	21,500,000	108	108	−430	108	108
0.0333	0.0333	−0.0500	−0.0500	0.0333	21,500,000	72	72	−108	−108	72
0.0500	−0.0333	0.0500	−0.0333	−0.0333	17,500,000	88	−58	88	−58	−58
0.0333	−0.0500	0.0333	0.0333	−0.0500	18,500,000	62	−93	62	62	−93

(continued)

Table 8.3 (continued)

Matrix of coefficients M					Coalition value	Contribution of factors I				
0.0500	−0.2000	0.0500	0.0500	0.0500	19,000,000	95	−380	95	95	95
0.0333	−0.0500	0.0333	−0.0500	0.0333	19,000,000	63	−95	63	−95	63
0.0500	−0.0333	−0.0333	0.0500	−0.0333	14,000,000	70	−47	−47	70	−47
0.0333	−0.0500	−0.0500	0.0333	0.0333	15,500,000	52	−78	−78	52	52
0.0500	−0.0333	−0.0333	−0.0333	0.0500	15,500,000	78	−52	−52	−52	78
−0.0500	0.2000	−0.0500	−0.0500	−0.0500	13,500,000	−68	270	−68	−68	−68
−0.0333	0.0500	0.0500	−0.0333	−0.0333	16,000,000	−53	80	80	−53	−53
−0.0500	0.0333	0.0333	0.0333	−0.0500	17,000,000	−85	57	57	57	−85
−0.2000	0.0500	0.0500	0.0500	0.0500	18,500,000	−370	93	93	93	93
−0.0500	0.0333	0.0333	−0.0500	0.0333	17,250,000	−86	58	58	−86	58
−0.0333	0.0500	−0.0333	0.0500	−0.0333	13,500,000	−45	68	−45	68	−45
−0.0500	0.0333	−0.0500	0.0333	0.0333	15,000,000	−75	50	−75	50	50
−0.0333	0.0500	−0.0333	−0.0333	0.0500	15,000,000	−50	75	−50	−50	75
−0.0500	−0.0500	0.2000	−0.0500	−0.0500	11,000,000	−55	−55	220	−55	−55
−0.0333	−0.0333	0.0500	0.0500	−0.0333	12,000,000	−40	−40	60	60	−40
−0.0500	−0.0500	0.0333	0.0333	0.0333	12,500,000	−63	−63	42	42	42
−0.0333	−0.0333	0.0500	−0.0333	0.0500	12,500,000	−42	−42	63	−42	63
−0.0500	−0.0500	−0.0500	0.2000	−0.0500	7,500,000	−38	−38	−38	150	−38
−0.0333	−0.0333	−0.0333	0.0500	0.0500	9,000,000	−30	−30	−30	45	45
−0.0500	−0.0500	−0.0500	−0.0500	0.2000	9,000,000	−45	−45	−45	−45	180
−0.2000	−0.2000	−0.2000	−0.2000	−0.2000	0,000	0	0	0	0	0

Table 8. 4 Case study results of calculation surplus by introducing cooperative training based on the Shapley value

Partners	LSP	HO 1	HO 2	HO 3	HO 4	Total
Independent costs (k€)	1,250	1,350	1,100	750	900	5,350
Coalition costs (k€)	770	730	497	205	297	2,500
Surplus allocation Shapley value e_k (k€)	480	620	603	545	603	2,850

where u is the relevant indicator, s the size of the coalition and n the number of players with the indices l for the row and k for the player.

The next column shows the total value of each coalition based on estimated costs and the last columns in Table 8.3 show the contribution for each player joining the existing coalition or the loss of contribution not joining if the player will not join coalition. The Shapley value for the complete coalition for each player can be calculated by the the sum of contributions and losses for all possible coalitions for each player displayed in row 3 of Table 8.4 as coalition costs. The total savings of 2,580,000 € should be allocated to the five humanitarian organizations as displayed in row 4 of Table 8.4. This is the difference of the independent costs which can be seen in row 2 of Table 8.4 and also in the coalition value of Table 8.3 where the coalition exists of only one player and the Shapley value of each player within the complete coalition.

Based on the assumptions especially the humanitarian organizations can account for big surplus. The surplus of the logistics service provider is mainly because of minor quantity of necessary trainings because of the general cooperation. The allocation amounts mainly depend on the costs of the 32 coalitions possible. In practical cases it is difficult to estimate costs of maybe only virtual existing coalitions. So a solution has to be identified how to estimate reliable cooperation costs.

The case study shows the allocation of surplus regarding cooperation and centralization of training. In comparison to a centralization of materials it is more challenging to identify all coalition costs as well as location problems and transportation problems come to the fore. But using methodology of Shapley after solving these problems leads to same advantages in questions of allocating surplus than in regarded training centralization case study.

8.5 Discussion

In general need of cooperation in humanitarian logistics is already addressed (Parmar et al. 2007). It has already been stated that synergies already known from private sector also applied in humanitarian field (Schulz and Blecken 2010). The open question is how to implement cooperation and how to create incentives for

organizations to join cooperation. A structured and centralized transport approach could be one solution to improve cooperation in this field. By this approach throughput time could not been reduced because more effort is necessary but overall costs can be reduced which provides the possibility to invest more money in humanitarian aid instead of paying transports.

Based on results of above case study it can be seen that a cooperation in general leads to cost advantages for all players within the cooperation. But first, it has to be addressed that practical application of methodology of Shapley value only works if input data basis is reliable. And unique company cost data is only reliable if confidence between partners exists and if different donors of single organizations support the idea of cooperation. Additionally for Shapley value an relatively high number of different input data is necessary. On the one hand complexity increases exponentially with an increasing number of players and on the other hand the coalition value V(SI) and the contribution of factors I_i are necessary for all possible cooperation sequences possible. So computer aided calculations would be essential for adopting Shapley value applications within logistics cooperation (Thomas 2003).

Donors' sympathy is also important if logistics cooperation will be introduced because they have to agree that their donation is maybe pooled or transported together with donations of other donors. In terms of humanitarian aid this should not be a problem but in a globalized and high industrialized world this could be.

Regarding incentive of cooperation for single organization also Shapley values could be used: If an investment is necessary, for example for single costs, like building a warehouse or leasing property, the necessary invest could be split in same manner than the surplus of the allocation so that payback period for each partner is identically. This leads to a balanced emotion between the partner within cooperation and supports equality of partners. In reality the LSP should takeover leading function regarding logistics activities within the cooperation.

8.6 Conclusion and Outlook

The calculated example shows that increasingly the application of standard business logistics concepts such as hub-and-spoke-networks and intensive cooperation via the implementation of such networks among independent organizations in the humanitarian relief chain does fully make sense—and even hints towards a cost sharing scheme among cooperation partners based on the Shapley value can be given.

Although this case study for Germany has to be extended e.g. with non-logistics and non-quantitative arguments and methods, the general idea of a preemptive calculation and cooperation for fixed networks in humanitarian logistics is of a high potential value.

Some specific discussion and further research topical items may be the following:

- A SWOT analysis could be implemented in order to identify disadvantages of such a concept e.g. in terms of lead and delivery times.
- A simulation model could be implemented in order to sustain the first results in terms of reduced costs and regarding the named lead time question.
- A field survey and process cost analysis should be implemented evaluating the assumptions of this calculation regarding cost indicator values for typical humanitarian logistics processes. If significant changes to indicator values are detected, a re-calculation of the Shapley value case has to be implemented.
- An enhanced Shapley value model could be implemented based on a larger number of participating institutions as well as transport volumes.

The implications even on the political level are important as governments usually are key players in short-time relief operations, sometimes with their military services. Therefore also politics are called upon by these research results to provide basic support, research funding and even infrastructure for such a centralized outbound logistics facility in a national humanitarian network in order to optimize the logistics processes in disaster relief operations. This should be a primary task for political support e.g. some of the following support mechanisms:

- Government institutions or government-related institutions (e.g. KfW) could provide loans for the shown first-round investments to the cooperating institutions in the humanitarian sector in order to enable the calculated payoffs in terms of cost reductions in disaster cases, especially as large shares of funding for these institutions anyway stem from tax budgets.
- Government facilities could be used for establishing such proposed hub structures e.g. at the military area of the Frankfurt/Main airport as a central location in Germany.
- Existing cooperation alliances as for example the 'Aktion Deutschland Hilft – Bündnis Deutscher Hilfsorganisationen' could be invited to discuss and share the insights of this research in order to enlarge their field of activity towards this central hub concept. Again at least government involvement in moderating such a project could be helpful.
- Government involvement could also include other areas of action such as the coordination processes of the German state department ("Auswärtiges Amt") as here many resources are steered also in coordination with other governments and countries.

Furthermore the value of these research results is interestingly not only measurable in reduced costs but in the humanitarian relief environment also in potential increased help for people in distress and therefore even in saved lives. This should be motivation enough for researchers and practitioners to discuss and use this approach of fixed networks in humanitarian logistics further.

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Part III
Sustainable Operations Preparation and Implementation

Chapter 9
Managing Hazardous Goods in Humanitarian Supply Chains

Dorit Schumann-Bölsche

Abstract The publication focuses on hazardous goods in humanitarian supply chains. The author provides fundamental information about the topic and heightens the awareness of its importance for logisticians and humanitarian aid workers. Hazardous goods can be either the reason for disasters (e.g. in Fukushima) or as relief items part of humanitarian supply chains (e.g. medicines, gases). The publication discusses international standards as well as environmental and health risks, which occur from hazardous goods. Additionally, the standard process reference model SCOR is introduced as a model that is suitable to describe and analyze processes and humanitarian supply chains with hazardous goods. The analysis with SCOR and the identification of weaknesses are first steps to identify further actions for risk reduction.

9.1 Introduction: Do Hazardous Goods Matter?

When dealing with actual disasters and humanitarian logistics in the end of 2013 the relevance of hazardous goods is not apparent at first glance. The Typhoon Haiyan in the Philippines resulted in thousands of deaths and caused massive damages (see www.logcluster.org, Link Operations, Emergency, Philippines). At the same time humanitarian aid is still required in Syria and in several African countries. Looking at theses countries and the people in need, the relevance of the topic "hazardous goods" does not immediately come to mind.

But by getting into the topic of humanitarian logistics more deeply, people can see and understand the extent to which hazardous goods indeed matter. Dangerous goods can be one of the reasons for disasters, like in Fukushima, Japan in 2011. After an earthquake and tsunami, the explosion of atomic power plants caused radioactive releases, which contaminated the area around the plants. This nuclear

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disaster was one of the worst the world has ever seen. “Despite a quick reaction to curtail the spread of radiation and minimize the damage, over 2 years have passed since the accident and radioactive materials are still seeping into the surrounding environment and the Pacific Ocean. In September 2013, estimates put the amount of polluted water dumped into the sea at just over 1,000 tons” (Blacksmith Institute and Green Cross Switzerland 2013, p. 15). Health risks are described inside the report. Humanitarian logisticians have to deal with logistical processes and supply chains in this special environment. Comparable situations occur after explosions of chemical plants or other production plants with hazardous goods. Humanitarian logisticians also have to deal with dangerous goods after accidents with hazardous goods on rail-roads, streets, and other transport modes. Another kind of disaster where dangerous goods often appear are floods, such as after heavy rain or storms in Germany. Whereas water can be cleared out relatively fast, the contamination e.g. with oil from destroyed oil-tanks, needs much longer to be cleaned up and removed (discussed at the 9th European Congress on Civil Protection 2013).

Furthermore a variety of dangerous goods are part of humanitarian supply chains: Some medicines, gases and oils, are just a few examples. The processes of delivery and return as well as their planning and operation need special consideration. Otherwise risks of destroyed environment or health-risks occur. Because of their health and environmental impacts, toxins (Blacksmith Institute and Green Cross Switzerland 2013) and thereby hazardous goods, cause disasters with enormous implications and need special observance in humanitarian supply chains. In this publication the author wants to sensitize the topic of hazardous goods in humanitarian supply chains and gives a fundamental work on this topic for humanitarian aid workers and logisticians.

The next chapter provides definitions and fundamental information. A new international standard for hazardous goods in logistics—the globally harmonized system of classification and labelling of chemicals (GHS)—will be introduced in Chap. 3. This standard changes the framework for humanitarian supply chains and enhances the achievement of logistical goals when dangerous goods occur in humanitarian logistics. Chapter 4 brings together the fundamental contents of the former chapters and discusses the impacts of hazardous goods on humanitarian logistics and supply chains. A general overview will be given and is followed by a deeper analysis which focuses on the application of one of the standard models from the private sector. The Supply Chain Operations Reference-model (SCOR-model) is chosen as an inter-branch standard process reference model because humanitarian organizations from the UN have started to document and analyse their supply chains with SCOR. The model is able to build up processes from the private and the humanitarian sector and to link the processes within supply chains. First experiences from the analysis of food supply chains can be transferred to supply chains in which hazardous goods occur. In this case, processes, performance measurement, and benchmarks focus on hazardous goods with their implications on logistic costs, health risks and environmental risks.

9.2 Definitions and Fundamental Information

9.2.1 Humanitarian Logistics and Supply Chains

Humanitarian logistics is defined "as the process of planning, implementing and controlling the efficient, (cost-) effective flow and storage of goods and materials, as well as related information, from the point of origin to the point of consumption for the purpose of alleviating the suffering of vulnerable people. The function encompasses a range of activities, including preparedness, planning, procurement, transport, warehousing, tracking and tracing, and customs clearance" (Thomas and Kopczak 2005, p. 2). The aims and goals should be "efficient, effective" and "for the purpose of alleviating the suffering of vulnerable people" (Blecken 2010, pp. 57–61; Bölsche 2013a). When dealing with the topic of hazardous goods environmental considerations about risk reduction have to be taken into account, as well. Humanitarian logistics has been developed by several actors from the humanitarian sector, the private sector, researchers and their coordinated initiatives (e.g. by the Humanitarian Logistics Association HLA, the German Logistics Association BVL, the Kuehne Foundation with its HELP-Initiative. See publications in Hellingrath 2013).

The Logistics Cluster of the United Nation plays an important role in the development of humanitarian logistics and especially the exchange of information and coordination among the actors in humanitarian supply chains after acute and permanent disasters. Figure 9.1 provides an example of a humanitarian operation (in the Philippines) and shows the accessible information and coordination through the Logistics Cluster. Such information and coordination is also necessary when hazardous goods occur in humanitarian supply chains; for example, maps with information about hazardous goods as well as expert knowledge about processes like transport and storage are required.

Despite the progress within the last years, several deficiencies and weaknesses still exist in humanitarian logistics; some of them should be mentioned:

- training and education programmes still do not meet the necessary requirements (Bölsche 2013c);
- an evaluation of the logistics cluster documents weaknesses, e.g. lacks in procurement, customs clearing and time in Haiti 2010 (www.logcluster.org); and
- a further deficiency concerns hazardous goods, which are still not the focus of humanitarian aid organizations and humanitarian supply chains.

The significance of humanitarian logistics becomes obvious when looking into current statistics about disasters and actual disasters in 2013. The annual disaster statistical yearbook (Guha-Sapir et al. 2013) which is published yearly by the Centre for Research on the Epidemiology of Disasters (CRED) summarizes for the year 2012: "Natural disasters still killed a significant number, a total of 9,655 people were killed and 124.5 million people become victims worldwide. Contrary to other indicators, economic damages from natural disasters did show an increase to above

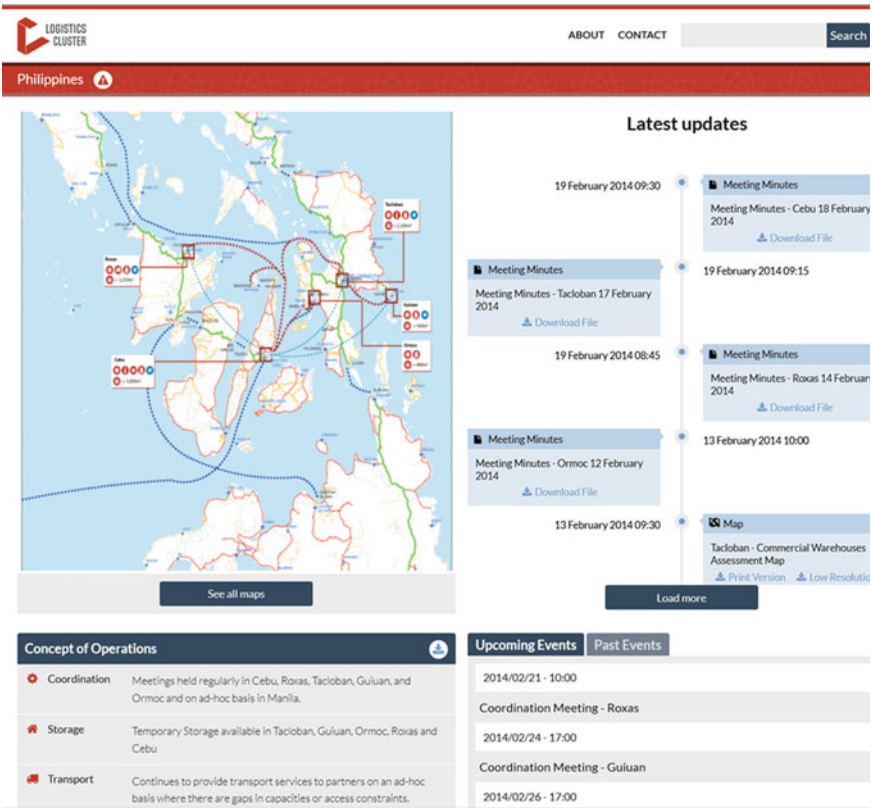

Fig. 9.1 The United Nations Logistics Cluster (www.logcluster.org)

average levels, with estimates … US$157 billion" (Guha-Sapir et al. 2013, p. 1). After the typhoon in the Philippines in November 2013, the estimated amount of dead and affected people is higher than in 2012, and that was solely caused by this one disaster (see www.logcluster.org and www.emdat.be).

Beyond natural disasters, the database of the CRED also registers and measures technological disasters. Some examples are shipwrecks, rail- and road-accidents and explosions of plants. Technological disasters do not always but often occur in attendance with hazardous goods. In 2013, one example is a chemical leak from a factory in Shanghai, China (www.emdat.be, disaster number 2013-0313). In 2012, there were 188 technological disasters in which 6,050 people died, 10,090 were injured and 13,504 were affected in some other manner. The total damage is registered at US$31 million. Such detailed information can be created within the emergency database by individual search, filters and aggregations (www.emdat.be, database, advanced search). But what is not available is a filter for hazardous or dangerous goods.

Technological disasters are reported as a whole and not separated into sub-categories. Some disasters can be identified as disasters with hazardous goods, such as the previously mentioned chemical leak from a factory in Shanghai. However an accident on road, railway or water is typically not registered with special notes on dangerous goods, and therefore the chemical agent would not be declared. A development of the emergency database could be a declaration and classification of different sub-categories of technological disasters, such as sub-categories for disasters with hazardous goods.

In this chapter, two weaknesses regarding hazardous goods have been identified: One concerns the consideration of hazardous goods in humanitarian logistics and the other concerns the statistical database. In the following section, a definition for hazardous goods and foundation will be given before going into detail about the regulation, classification and impacts of hazardous goods on humanitarian supply chains.

9.2.2 Hazardous Goods and Their Relevance in Humanitarian Logistics

"A good is considered as dangerous when it may present a danger on population, environment or on infrastructure according to its physiochemical properties or because of the reactions it can imply." (Gaci et al. 2012, p. 186). The characteristic of hazardous goods is that these goods have a chemical composition (Pan American Health Organization and World Health Organization 2001, pp. 38–39), e.g. toxins, irritants, radioactivity, sensitizing agents, carcinogens, corrosives, or highly reactive substances in the chemicals or mixtures.

The Environmental Toxin Report 2012 documents the health impacts of toxic pollutants and their sources. It identifies the ten most important sources of environmental toxins and quantifies the global scale of health damage due to toxic substances (Blacksmith Institute and Green Cross Switzerland 2013). A recent study of more than 3,000 toxic sites shows that as many as 200 million people are affected by toxic chemicals globally (www.blacksmithinstitute.org).

The world's ten most polluted places of the 2012 report are given in the Table 9.1 (Blacksmith Institute and Green Cross Switzerland 2013; more details like description, impacts and volumes are given in the report).

Humanitarian logistics is one key activity after disasters, especially when hazardous goods were involved, like in Chernobyl (mentioned in the Table 9.1). Dangerous goods, such as medical products, fluids and others, are part of other humanitarian supply chains. To avoid or reduce environmental pollution and toxication, logisticians have to care for hazardous goods within the whole chain. Otherwise the humanitarian logistics goal of "alleviating the suffering of vulnerable people" cannot be fulfilled. Hazardous goods generate vulnerable states and long-term suffering for the affected people.

Table 9.1 The world's ten most polluted places, environmental toxin report, Blacksmith Institute and Green Cross Switzerland (2013)

Location	Kind of hazardous good/toxin
Matanza-Riachuelo, Argentina	Volatile organic compounds, especially toluene
Hazaribagh, Bangladesh	Chrome
Agbogbloshie Dumpsite, Ghana	Lead, cadmium, mercury
Citarum river, Indonesia	Chemicals, such as lead, cadmium, chrome and pesticides
Kalimantan, Indonesia	Cadmium, mercury
Niger river delta, Nigeria	Oil
Dzershinsk, Russia	E.g. chemicals, including sarin, lead, phenols
Norilsk, Russia	Heavy metals
Kabwe, Zambia	Lead
Chernobyl, Ukraine	Radionuclides

The following example and picture gives an impression about the consequences on environment and the affected population. "Agbogbloshie dumpsite in Ghana's capital, Accra, is one of the main hubs for electronic waste (e-waste) disposal in West Africa, particularly from old computers and computer monitors. The main pollutants come directly from the black smoke … Health effects already seen include lowered IQs in children due to lead exposure, nervous system diseases from mercury, and even effects from high levels of cadmium exposure" (www.greencross.ch). Humanitarian aid becomes necessary after such pollution and therefore humanitarian logistics is needed to supply the affected people with medicine and other humanitarian aid. Humanitarian logistics is also needed long-term to decontaminate the dumpsite. Supply chains in western countries, in this case in Europe and especially the United Kingdom, should keep these consequences in mind when designing their logistics of toxic and hazardous—in this case electronic—disposal (Fig. 9.2).

It can be assumed that the humanitarian logistics goal "efficiency" is also influenced enormously by hazardous goods: "Emergency response is extremely costly. It is estimated that every dollar spent on prevention today saves four dollars in emergency response tomorrow. There is no economic sense in spending money on emergency response alone. Years of investment can disappear in minutes if risk reduction and prevention are ignored" (Larson 2011, p. 15). This quotation from Larson has a high significance for humanitarian logistics and with a special focus on hazardous goods it can be assumed that investments in prevention can increase the amount of later savings mentioned within the citation. An estimation of consequential costs after pollutions and toxications is nearly impossible because statistical databases, fundamentals for resilient calculations, are missing, and the question of how influences on health and the environment could be measured is not answered in an adequate way.

Fig. 9.2 Accra in Ghana (Blacksmith Institute and Green Cross Switzerland 2013, photo from www.greencross.ch)

Just few publications exist with a focus on hazardous goods in humanitarian supply chains. Some publications from neighboring fields can be transferred:

- A publication from the Pan American Health Organization and the World Health Organization "Humanitarian Supply Management and Logistics in the Health Sector". This publication treats hazardous materials in one short chapter, but it was published before the new standardization was made operative (Pan American Health Organization and World Health Organization 2001, pp. 38–41).
- Publications about risk management in logistics and supply chain management focusing hazardous goods, such as Gaci (2012). This publication centers around risks during storage and transport with three different scenarios: An aerosol explosion, a fire truck incident and a hazardous liquid spill. Other risks mentioned include overheating, pallet squashing, pallet overturn, pallet loss, gas release, fluid leaks, solid product dumping, and others (Gaci 2012, pp. 188–201).
- The Handbook of Humanitarian Health Care Logistics considers in some parts hazardous goods, e.g. within chapters about risk management, reverse logistics, chemical decomposition and the closing of logistics operations (McGuire 2011, pp. 133, 937, 957, 977).

By taking a look at the international standardization of hazardous goods, it is clear that progress has been made in the past few years. Several years ago, global logistics and supply of hazardous goods was hindered by multiple national standards for the classification of hazardous goods and the regulation within logistical processes like transport, storage and handling. With the "Globally Harmonized

System of Classification and Labeling of Chemicals—GHS" a new standard has been created for global (humanitarian) logistics and supply chains (Bölsche 2013b). The next chapter discusses this in depth.

9.3 International Regulation, Classification and Standardization—A Globally Harmonized System

9.3.1 Introduction into the Globally Harmonized System of Classification and Labeling of Chemicals (GHS)

The work about the elaboration of the Globally Harmonized System of Classification and Labeling of Chemicals (GHS) began on the premise that existing systems should be harmonized in order to develop a single, globally harmonized system to address classification of chemicals, labels, and safety data sheets. It replaces the various classification and labeling standards by using consistent criteria on a global level. Chapter 19 of Agenda 21, adopted in 1992 at the United Nations Conference on Environment and Development, provided the international mandate to complete this task. The GHS addresses classification of chemicals by types of hazard and proposes harmonized hazard communication elements, including labels and safety data sheets. It aims at ensuring that information on physical hazards and toxicity from chemicals are available in order to enhance the protection of human health and the environment during the handling, transport and use of these chemicals at the national, regional and worldwide level. The standard is regularly updated to reflect experiences in implementing its requirements into national, regional and international laws, as well as the experiences of those doing the classification and labeling. The first task was to make the GHS available for worldwide use and application. The first edition of the GHS was adopted in December 2002; since then, the GHS has been updated every 2 years. The 5th revised edition of the GHS was published in 2013 (UN 2013, www.unece.org/trans/danger/danger.html).

One main objective of the GHS is to be able to "enhance the protection of human health and the environment by providing an internationally comprehensible system for hazard communication …" (UN 2013, p. 3). With this objective the reference to humanitarian logistics becomes obvious. The GHS is not able to avoid negative consequences of hazardous goods in supply chains but the risks on health and the environment can be reduced within an international harmonized system.

The European Union (EU) has implemented the United Nations' GHS into EU law as the CLP Regulation (Classification, Labeling, Packaging). This regulation entered into force in January 2009 and will be totally applied in 2015 (Gaci 2012, p. 187; www.ocha.eu). The classification of hazards as a harmonized communication by using labels and safety data sheets are important elements of the international GHS and the European CLP-Standard. Some basics will be described in the following passages.

9.3.2 Classification, Labeling and Safety Data Sheets

A hazard class defines the nature of a hazard and the effects of the substances on health and the environment (UN 2013, pp. 43–248; Gaci 2012, pp. 187–188):

- Physical hazards: 16 categories, e.g. explosives, flammable gases, solids, aerosols, liquids.
- Health hazards: 10 categories, e.g. acute toxicity; skin corrosion, irritation; eye irritation.
- Environmental hazards: 2 categories, namely acute aquatic toxicity and chronic aquatic toxicity.
- Classification of mixtures.

The United Nations document describes each hazard class in detail in over 200 pages within the main document and in several annexes; the author references the UN GHS description but does not go into more detail (UN 2013). Each hazardous good contained in packaging should be labeled according to the GHS rules (UN 2013, pp. 23–34).

One of the objectives of the work on the GHS has been the development of a harmonized hazard communication system, including labeling and easily understandable symbols based on the classification criteria developed for the GHS. Each label contains information about the supplier, the substance, and other information as shown in Fig. 9.3 (UN 2013, pp. 23–34; Gaci 2012, p. 188).

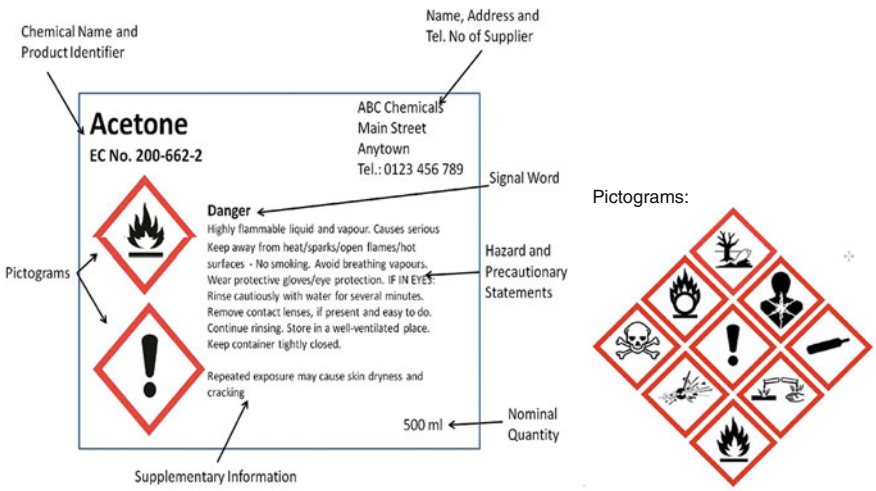

Fig. 9.3 Labeling (www.labelident.com) and pictograms (www.ocha.org)

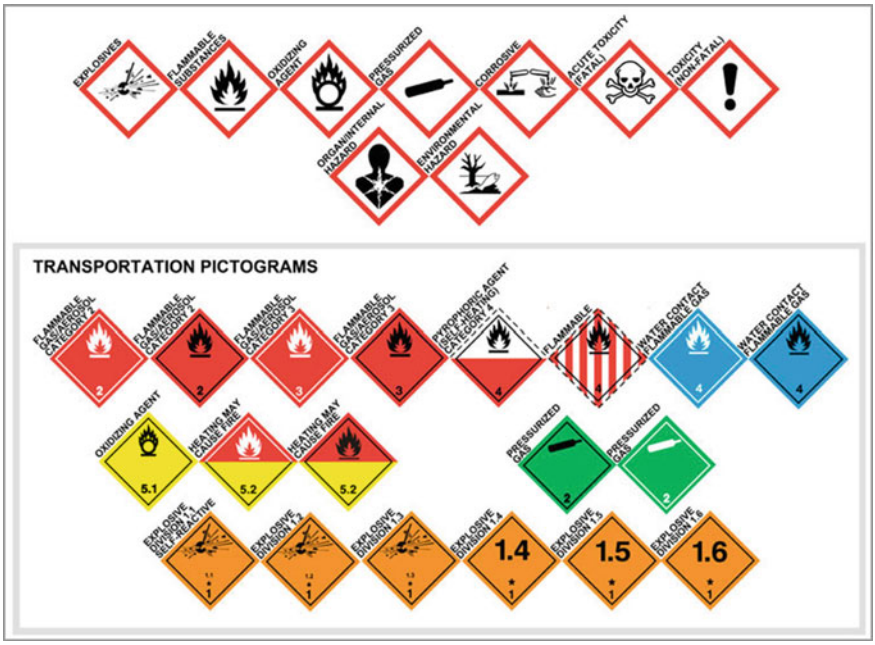

Fig. 9.4 Transportation pictograms (www.duralabel.com)

Special information and pictograms are needed for the transportation of hazardous goods, shown in Fig. 9.4. Detailed descriptions for the transport of dangerous goods are given by the UN recommendations on the transport of dangerous goods (see www.unece.org that is e.g. in Germany in the ADR), in special regulations from the international maritime organization (www.imo.org) and in the dangerous goods regulations for air transportation from the IATA (www.iata.org).

The UN Transport of Dangerous Goods Model Regulations encompass only the most sever hazard categories of the acute toxicity hazard class. It provides label information primarily in a graphic form (UN 2013, p. 23).

Further elements of a standardized and harmonized communication about hazards are Safety Data Sheets, which provide a standardized format for the presentation of information. Although precautionary statements have not been fully harmonized in the current GHS, Annex 3 provides guidance to aid in the selection of appropriate statements (UN 2013, p. 25). The Safety Data Sheet (SDS) should provide comprehensive information about the substances or mixture for use in workplace (UN 2013, p. 35).

Examples and descriptions are shown in http://rayhamil.tripod.com/KoolPages/msds77.html and UN (2013).

9.4 Impact of Hazardous Goods on Humanitarian Logistics and Supply Chains

9.4.1 A General Overview

Hazardous goods in humanitarian logistics can be both a reason for a disaster and as relief items part of humanitarian supply chains. In Fukushima, Japan in 2011, dangerous goods in the atomic power-plant were one of the reasons for the disaster (comparable to disasters in Bhopal, India in the year 1984 and in Enschede in Holland in the year 2000 and many others). Furthermore, hazardous goods as relief items are part of humanitarian supply chains, e.g. pharmaceutical products, laboratory reagents, fuel gases and oils. The processes with dangerous goods need special consideration in both cases. Otherwise health or environmental risks could occur. For example, risks occur from pharmaceutical and medical products and medical waste (xylene or acetone, photographic waste chemicals, refrigerator coolants, heavy metals), such as McGuire (2011):

- health risks: explosion of accidentally incinerated aerosol cans, injury by sharps, accidental distribution of health care goods;
- environmental risks: contamination of water sources, release of toxic pollutants into the air, disruption of sewage treatment plants.

The following is needed to handle, reduce and if possible, avoid the mentioned risks:

- statistical data about hazardous goods in humanitarian logistics and supply chains, as mentioned in Chap. 2,
- manuals and standardized procedures for humanitarian logistics and supply chains,
- training and education for humanitarian logisticians, and
- methods from logistics and supply chain management, especially risk management, process models and performance measurement for deeper analyses, recommendation and implementation into practice.

A deep explanation of all the listed missing aspects would go too far for this publication. Therefore the author concentrates on one possible method from supply chain management, which can be transferred from the private to the humanitarian sector (Bölsche 2013a) as well as on the specific topic of hazardous goods in humanitarian supply chains: The Supply Chain Operations Reference-model (SCOR).

In the following section, the standard process reference model SCOR is introduced as a model that is suitable to describe and analyze processes and humanitarian supply chains (with hazardous goods). The analysis with SCOR and the identification of weaknesses are first steps to identify further actions for risk reduction.

9.4.2 A Special View on the Supply Chain Operations Reference-Model (SCOR)

The Supply Chain Operations Reference-model (SCOR) was developed in 1996 by the Supply Chain Council (SCC), a global non-profit organization. The SCOR model is a global standard for supply chain management, "a model that provides a unique framework for defining and linking performance metrics, processes, best practices, and people into a unified structure" (www.supply-chain-org).

SCOR is composed of three components; not only process modelling is considered but also performance measurement and best practices (Blecken 2010, p. 106; www.supply-chain.org). This established a basis for integrating metrics into the process model, which of course has to be adapted to the humanitarian sector with a special focus on hazardous goods. The model is an inter-branch standard process reference-model that offers the integration of organizations from different sectors, such as the industrial sector, and (logistic) service providers. If the involvement of the humanitarian sector and the special consideration of hazardous goods into the SCOR model succeeds, the complete humanitarian supply chain can be considered.

The SCOR-model is chosen in this publication for several reasons: It is an inter-branch standard process reference model that is able to build up processes from the private and the humanitarian sector as well as link the processes within supply chains. Thus a standard model can be used which is also flexible for individual requirements with view to the involved actors and hazardous goods.

Humanitarian organizations from the UN have started to document and analyse their supply chains with SCOR (e.g. World Food Programme). This practical application has been realized within pilot projects especially for food supply chains, but it can be transferred to medical supply chains and supply chains with other hazardous good. Methodically the model is chosen because of its ability to describe, to measure, to analyse and to compare the logistical processes—in this case with special focus on hazardous goods. Processes, performance measurement, and benchmarks can concentrate on hazardous goods with their implications on logistic costs, health risks and environmental risks. From a practical point of view the model is chosen because humanitarian and private actors already work with SCOR. The analysis with SCOR and the identification of weaknesses are first steps to identify further actions with regard to risk reduction and cost reduction.

As illustrated in Fig. 9.5, the SCOR-model spans over the supply chain from suppliers over the organization to customers. Within the framework five distinct management processes are considered: source, make, deliver, return and plan (Blecken 2010, pp. 105–106; Bölsche 2013a, www.supply-chain.org). Hazardous goods can be an integral part in all of these processes.

The SCOR model breaks down each of the management processes—visualized in Fig. 9.5 on the first level—at various organisational levels and establishes metrics at each of theses levels (www.supply-chain.org). Some modifications are necessary when adapting SCOR to humanitarian supply chains with hazardous goods. The

Fig. 9.5 SCOR, first level (Bölsche 2013a; www.supply-chain.org)

SCOR model is demonstrated below based on the example of medical products as relief items and dangerous goods. Starting on the first level (Bölsche 2013a, b):

- *Terminologies* should be changed with special focus on the actors in a humanitarian supply chain, e.g. "customer". The organization in the center could be a Non-Governmental Organization (NGO) or several NGOs, the suppliers could be—in dependence from the needed relief items—the pharmaceutical industry, or others suppliers with relevance for humanitarian aid, and the ultimate customers should be dominated as beneficiaries, people in need or affected people.
- Another group of "customers" or stakeholders in humanitarian logistics are *donors*. They influence the budget for humanitarian logistics and in some cases donate items or services for humanitarian aid. In addition, they have special demands on the reporting and accounting system. Donors are not considered in the original SCOR model but have to be considered in an adaption for the humanitarian sector along the whole supply chain.
- In most cases "make" in the sense of "*production*"-processes are not relevant for NGOs, and they can be disregarded for service providers (NGOs, logistics service providers and others) or they can be regarded as "make to order" processes. But with regard to hazardous goods, make-processes are relevant because of the production of hazardous goods or with hazardous components. Health and environmental risks that occur from the production processes, especially in the production of the suppliers (e.g. from pharmaceutical and chemical industry), need to be considered when analyzing medical supply chains.
- The other processes are relevant to a great extent for all actors in humanitarian logistics with hazardous goods in medical or pharmaceutical supply chains: Within the processes "*source*" and "*deliver*" risks from hazardous goods have to be taken into account. The new international standardization GHS needs to be implemented especially for the delivery of hazardous goods. When sourcing relief items like medicines, one performance element for the evaluation of suppliers can be risk attributes for hazardous goods.

- The processes "*return*" are relevant especially in the aftermath of a disaster. Medical waste arises because of unused, expired, damaged, or recalled health care goods; furthermore, contaminated medical waste from hospitals has to be considered. Some recommendations for the return processes of medical waste are "no storage in distribution centres" and "safe disposal of toxic compounds and materials" (McGuire 2011, pp. 937–978). Some healthcare goods require regular or repeated return to suppliers; the closure of operations and health care facilities may also require return processes. After accidents with hazardous goods in plants, on roads or other traffic modes return processes are often in the center of the analysis and logistical processes.
- The individual and aggregated process "*plan*" is needed for each organization as well as for the whole supply chain. In addition to other aims and goals, such as costs, service and environmental goals, risk reduction for environmental and health risks are also considered. Organizations who are actors in humanitarian supply chains with hazardous goods should build up a consistent system of aims and goals under the special consideration of risks from hazardous goods. Comparable to Carbon Footprints involved organizations with environmental strategies, aims and goals could think about new evaluation models, e.g. "Hazard Footprints", which could be considered in the plan-processes.

Figure 9.6 considers the previously mentioned requirements concerning the terminologies, integration of donors, and processes. For a better understanding it illustrates a simplified example from Médecins Sans Frontières (MSF, for more information about MSF see www.msf.org). This approach can be transferred to other humanitarian supply chains, e.g. the Red Cross and crescent organizations or

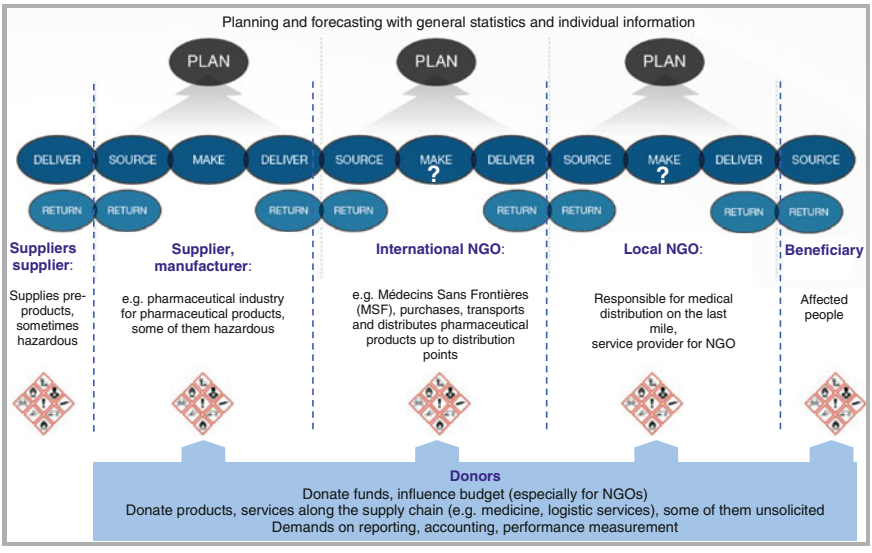

Fig. 9.6 SCOR, first level, example medical supply chain

UN organizations, who are responsible for the distribution of pharmaceutical products in humanitarian supply chains. The special case of hazardous goods and relief items is characterized in Fig. 9.6 through the pictograms from the international GHS standard.

With a special focus on performance measurement in humanitarian logistics, SCOR Level 1 metrics are strategic, high-level measures that cross multiple SCOR processes (www.supply-chain.org). They can be adjusted to the organizations in the humanitarian supply chain and special measures for risks from hazardous goods can be complemented.

The newest version SCOR 11.0, published in the end of 2012, is extended by a new "*enable*" process which focuses on the management of relationships, performance and information of a supply chain. Considerations about risk management, compliance and business rules as well as the needed data and information are part of the core process enable, as can be seen below in Fig. 9.7 (www.supply-chain.org). These elements of SCOR 11.0 include important considerations relevant for humanitarian supply chains with hazardous goods and the management of risks within the supply chain.

On the more detailed SCOR-levels two and three, the processes are defined and described more and more extensively, e.g. with input and output relationships and a foundation for benchmarking and best practice analysis. Level two includes five performance attributes and level three more detailed metrics, which are linked with the performance attributes. These are used to express a strategy but cannot actually be measured themselves. Metrics assess the ability of a supply chain to achieve these strategic attributes (Bölsche 2013a, www.supply-chain.org). Most of the attributes and metrics can be applied for humanitarian logistics, some are not relevant (especially when detailing make processes) and some have to be defined as

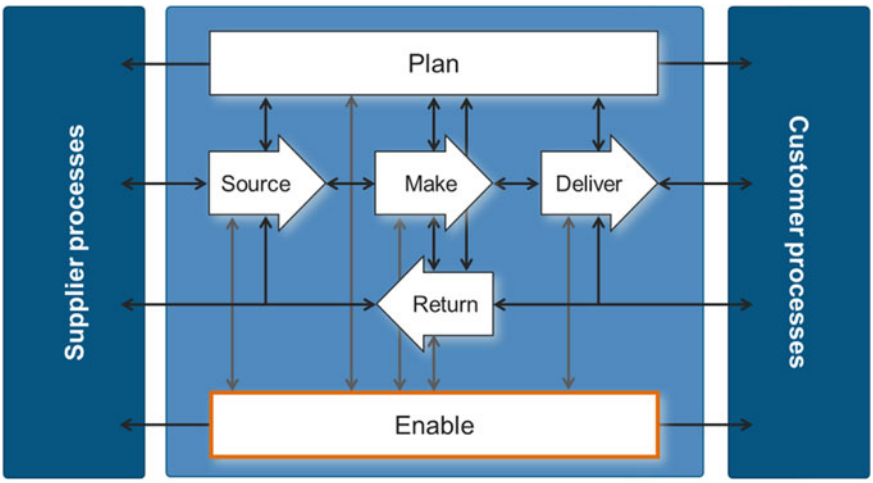

Fig. 9.7 The process "enable" in SCOR 11.0 (www.supply-chain.org)

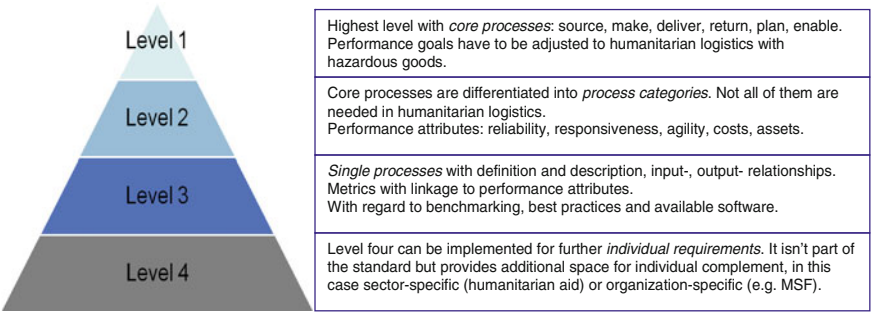

Fig. 9.8 SCOR, different hierarchical levels (Bölsche 2013a)

well (attributes and metrics concerning hazardous goods and donors in the whole supply chain). This hierarchical structure is illustrated in Fig. 9.8.

The fourth level is open for individual requirements. Special requirements can be implemented for the analysis of humanitarian aid, the organizations individual perspective and hazardous goods in the supply chain.

This publication gives a first impression of the SCOR-model and its application for hazardous goods in humanitarian supply chains. A more detailed view into the levels three and four is not part of this publication as well as a critical analysis of the SCOR model and a discussion about quantitative performance indicators. These topics could be pursued in future research and developments.

9.5 Limitations and Future Research

It can be summarized that hazardous goods are of great relevance in humanitarian supply chains. The need for action has been shown within this publication. It can be concluded that

- statistical data are available about technological disasters (www.em-dat.be) and about the effects of hazardous goods on the environment and people (www.greencross.ch),
- manuals and procedures have been standardized on an international level by the GHS and other standards for the transportation of dangerous goods,
- training and education for humanitarian logisticians is in the development, and
- methods from logistics and supply chain management can be transferred and adapted from the private to the humanitarian sector with special focus on hazardous goods.

But at the same time it has to be mentioned that further statistical data is missing, e.g. about hazardous goods within technological disasters and humanitarian supply chains. Additionally, the international standard GHS has not been transferred into

practice in all countries yet. Some training and education programmes for humanitarian logisticians have been developed but do not meet all requirements, especially regarding hazardous goods. And finally this publication analyses a first application of methods and models (the SCOR-model) on a general level but does not go into more detail. These are some important limitations.

The SCOR model needs to be discussed from a practical and methodical point of view: Do small and medium size humanitarian organizations like to use a reference model like SCOR? Do they have the capacity to work with the model? Are there environmental and health risks which can be reduced when weaknesses are discovered by the model? Are there possibilities to enhance the efficiency in humanitarian logistics? These questions can be answered by an evaluation, e.g. by questionnaire. The key performance indicators, performance attributes and possibilities for benchmarking are limited from a methodical point of view within the standard-model SCOR. Adjustments are necessary, both for humanitarian organizations and for the special requirements of hazardous goods (some of them are mentioned on level 1 within this publication). These are relevant aspects for further research, especially considering the methodical research limitations.

This publication can raise awareness about the topic of hazardous goods in humanitarian logistics and give ideas for future research and the application in practice. It does not solve the existing problems but it gives impulses for an enhanced consideration of hazardous goods in humanitarian supply chains in the future.

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Chapter 10
Classification of Technical Requirements and the Means of Addressing the Problem of Waste Management in a Refugee Camp

Alberto Regattieri, Giulia Santarelli, Francesco Piana and Mauro Gamberi

Abstract The problem of refugees has taken on great significance because of the increasing number of humanitarian crises (e.g. wars, earthquakes, floods, but also economic crises and social disparities). The main response of the international community to the increased scale of refugee movements has been that of humanitarian assistance, usually provided within the context of refugee camps. Furthermore, the unpredictability of the disasters and the urgency to face them make the camp design a very difficult task. Due to the importance of this theme, the authors have developed a refugee camp reference framework identifying the main requirements and characteristics of a camp during a manmade or a natural crisis and a set of key technical indicators to support a rapid, effective and fit camp design. Waste management plays a fundamental role in the problem of sanitation and hygiene in a refugee camp. Waste is unavoidable and, if not properly managed, it may cause environmental and health problem, yet it can also represent a great opportunity. The authors have analysed the composition and quantities of waste coming from humanitarian crises and discuss approaches and technical solutions to limit the problems and, wherever possible to convert waste into useful materials, equipment or power sources.

10.1 Introduction

Natural disasters, such as earthquakes and floods, or manmade disasters, such as conflicts, economic crisis and social disparities, usually result in a significant forced population displacement. The main response of the international community to the

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increased scale of refugee movements has been that of humanitarian assistance. This is usually provided within the context of refugee camps where exiled populations wait for several months, sometimes several years, in the hope that they will be able to return home 'in dignity and security'. A refugee camp is a camp set up to assist people who need several types of relief (e.g. accommodation, water, health assistance, etc.), especially after disaster strikes (Langu 2010). In most cases, these people are lacking in basic needs, namely clean water, food and lighting, mainly due to the absence of electricity, cooling facilities, etc. and often they have to live in the camp for much longer than expected (Salehin et al. 2011).

According to UNHCR (2000, 2011), refugee camps provide several advantages for people during the disaster, such as the protection they ensure to people, the ease in finding out how many people live there and what they need, and the ease with which some basic services can be organised (e.g. food distribution, vaccinations, etc.). On the other hand, too many people living in the camp increase the risk of spreading disease, their dependence on aid from all organisations, their isolation and idleness and, finally, the surrounding environment can be degraded. In addition, various parties are involved in the planning, management, provision and maintenance of refugee camps, but the coordination between them is not always as good as it should be. This may be a significant obstacle in giving the best help to people living in refugee camps. Despite these disadvantages, refugee camps are vital and essential for people affected by disasters, as they often represent the last life-saving protection.

Although the refugee problem is recognised by academics and humanitarian organisations and agencies, literature on the topic is scarce. Due to the importance of this theme, the authors have designed a complete refugee camp profile that can be used by humanitarian organisations during the first phase of assessment and can help development. The proposed profile deals with the general structure of a camp and overall with the identification of a set of key technical indicators such as surface area per person, tent area per person, water consumption per person, etc. This approach is well known in the commercial and industrial field and it is applicable to the humanitarian field because of the required speed in response to a crisis. The proposed data is collected by a rigorous study on the few papers existing in literature, unpublished working papers of humanitarian organisations and several interviews with managers of humanitarian organisations, agencies and government authorities.

Moreover, waste management is a crucial issue in a refugee camp; waste has immediate and long-term negative effects if not managed properly. For this reason the authors pay a great deal of attention to this subject. Waste can be debris caused by catastrophes (both natural and man-made) usually called Disaster Waste (DW), but waste also means the packaging materials used in the humanitarian supply chain when supplies are delivered (e.g. packaging of tents, kitchen set, blankets, etc.). Furthermore everyday activities in refugee camps generate a significant quantity of waste (e.g. paper, plastic, food, organic, excreta, etc.).

The authors have analysed the composition and quantities of the above waste categories and discuss approaches and technical solutions to limit problems and, wherever possible, to convert waste into useful materials, equipment or power sources.

10.2 General Structure and Requirements of a Camp

Camps are usually situated on the edges of towns or cities, away from borders and war zones. In general, there should be a substantial distance between camps, which depends on a number of factors: access, proximity of the local population, water supplies, environmental considerations and land use (UNHCR 2007). Usually, a camp is built as a temporary solution, giving refugees a place to live until they can safely return to normality. However it happens sometimes that the camp becomes the permanent home of refugees for many years.

There are several essential aspects to consider when establishing a refugee camp, in particular (excluding food and nutrition that are out of scope of this paper):

- main services and infrastructures;
- shelter and accommodation;
- water consumption and distribution;
- sanitation and hygiene, and in particular the waste management;
- energy consumption.

10.3 Main Services and Infrastructures

The general organisation in terms of infrastructures of a refugee camp is a very critical aspect. An incorrect structure or service design can generate many problems, e.g. the roads are impracticable, local hospitals and health services do not function, schools are closed, food supplies do not arrive on time, markets and small establishments of refugees do not function properly because of their isolated position (Crisp 2005), and so on. Furthermore, the unpredictability of the disasters and the urgency in tackling them, make the camp design very difficult. A preventive reference framework can be crucial in order to avoid errors. There are several main facilities required for a refugee camp. They are roads and firebreaks, water supply and sanitation facilities (defecation areas, latrines, waste disposal pits, ablution places), health facilities (health centres, health posts, hospitals and pharmacies), nutritional facilities (therapeutic and supplementary feeding centres), distribution sites and storage facilities (in separate locations), administrative centre, reception area, other community facilities such as markets, schools, cemeteries, meeting places. Clearly, the number and configuration of these services depend on the number of people involved.

10.3.1 Shelter and Accommodation

It is argued that a safely built environment, including adequate housing conditions, is one of the most primary human needs (Habib et al. 2006). Shelter is likely to be one of the most important determining factors in the general living conditions and is often one of the significant items of non-recurring expenditure (UNHCR 2007).

Inadequate shelter and overcrowding are the main causes of the transmission of diseases with epidemic potential (e.g. measles, meningitis, typhus, cholera, etc.), and outbreaks of disease are more frequent and severe when the population density is high. In addition, protection against sun, rain, cold and wind is essential for the welfare of the refugees, as is the provision of a safe living space for families.

While the basic need for shelter is similar in almost all emergencies, considerations such as the kind of housing needed, the materials and design to use, who constructs the housing and how long it must last, differ significantly in each situation. Over recent years, the importance of providing safe houses that are free from physical hazards has increased (Robert Wood Johnson Foundation 2008), but housing in refugee camps is often overcrowded and of inferior quality. Well known is the case of refugee camps in Sri Lanka that were composed of houses realised in small wooden one room huts with a corrugated iron roof (Turner et al. 2009).

The minimum shelter space recommended is 3.5 m^2 per person in warm and tropical climates (excluding cooking facilities, which are placed outside), and 4.5–5.5 m^2 in cold climates, including the kitchen and bathing facilities (UNHCR 2007, 2011). The minimum distance between shelters must be 2 m and the maximum distance between firebreaks must be about 72 m. A new trend in building temporary houses is the use, whenever possible, of local materials such as wood, metal sheets, tree branches or plastic. This solution can be interesting both due to cost reduction, the utilization of local materials and the employment of refugees in the construction. On the other hand, it requires a very significant effort in terms of planning and coordination by humanitarian staff and volunteers.

10.3.2 Water Consumption and Distribution

People can survive longer without food than without water. The provision of water demands immediate attention from the beginning of a refugee emergency. Water and the environment play an essential role in the spread of many communicable diseases and epidemics. Diarrhoeal diseases, mostly caused by poor hygiene and lack of safe water, are the major cause of unhealthiness and mortality among refugees and displaced populations. The aim of humanitarian organisations is to assure the availability of sufficient water to allow its effective distribution in the required quantities, and to ensure that it is safe to drink and easily accessible.

Minimum daily requirements of water vary in accordance with the climate and the habits of the involved population. Table 10.1 in the Annex 1 shows general indications of the amount of water required for different needs (Minimum requirements: immigrant connect 2010; The sphere project 2013; UNEP 2010; UNHCR 1992, 2007, 2011; WHO 2005). A reduction in the quantity of water available to individuals will directly affect the overall health status of the refugee population. Overall, a larger quantity of reasonably safe water is preferable to a smaller amount of very pure water. It is essential for refugees to receive good quality water since it has a major impact on nutrition, health, and sanitation

Table 10.1 Quantity and typology of transported packages

Packing list no.	Wooden box (kg)	Cardboard box (kg)	Steel crate (kg)	Plastic (kg)	Pallet (kg)	PW/GR (%)
1	–	102	720	–	20	10.00
2	–	–	360	–	40	4.80
3	–	–	–	–	60	0.80
4	2,320	592	200	1,533	1,302	19.20
5	1,421	344	200	33	1,230	16.90
6	–	24	120	–	–	6.90
7	594	1,706	–	2,500	2,200	22.40
8	–	640	–	–	–	6.50
9	–	1,920	–	–	480	9.80
10	200	–	–	–	–	
Total	4,535	5,328	1,600	4,066	5,332	10.80

PW packaging weight per packing list [kg/packing list]
GR gross weight per packing list [kg/packing list]

(UNHCR 2013a, b). Ideally, the supplied water should meet the quality standards defined by World Health Organisation (WHO) (Delmas 1994). However, it is generally difficult or even impossible to adhere to these standards during emergencies. The main goal is to provide clean water to restrict water-borne diseases, i.e. containing the fewest pathogenic germs. The presence or absence of pathogenic organisms is the only criterion of real importance to ensure health and prevent diseases.

The bacteriological quality of untreated water should be assessed. This is based on the detection of the presence of organisms and their number, which are indicators of faecal pollution, i.e. faecal coliforms (always present in large numbers in the faeces of humans and other animals). This bacteriological analysis can be performed by using field-testing kits (e.g. Del Agua/Oxfam kit), which provide results within 24 h but are expensive and require experienced or specially trained sanitation officers. Water for consumption should contain less than 10 faecal coliforms/100 ml.

Sometimes there are nearby water sources such as rivers, lakes, wells or springs. If the water source is clean (e.g. from wells or springs), it can be used without treatment. Water coming from rivers and lakes can be contaminated and must be treated before human consumption (Minimum requirements: immigrant connect 2010). In a refugee camp, where so many people live close to each other, epidemics can start and spread very quickly. Cholera, a disease caused by drinking contaminated water, can kill people within a few hours if they do not get medical help. The most serious threat to the safety of a water supply system is contamination by faeces. Water contaminated by human faeces puts people at a high risk of cholera, dysentery, diarrhoea, and intestinal worms (Practical action 2010). This is the reason why the quality of the water is as important as the quantity.

When water is not available close to the community site, it has to be transported from the well to the camp. Even if the water provided is not contaminated, its transfer between tanks, home storage, and hand touching the inside of water tanks are risk factors for contamination (Roberts et al. 2001).

Another relevant aspect concerning the water issue is that it should be readily accessible, and the water taps should be centrally located. If the water taps are far away, children might have to interrupt their schooling to collect water for their families. In addition, if the water taps are very far away, the physical burden of water collection increases immensely. For example, if a person draws water for all of their family's needs (around 80–120 l) from a well located 200 m away, he/she may use up to 1/6 of his/her rationed calories for the day on this one task (UNHCR 2007) and there is higher vulnerability to health problems.

For this reason, a strong recommendation is that there should be at least one water distribution point for every 200–250 refugees and placed at the maximum distance of 100–200 m from the shelter. Unfortunately, many refugee camps do not meet this basic standard. Refugee camps in Uganda, for example, have particularly poor access to water. Only 43 % of the population has access to water taps within 200 m. In addition, there are over 450 people per water tap, far exceeding the UNHCR standard of 200 persons per water pump (Bruijn 2009).

10.4 Sanitation and Hygiene: The Waste Management Problem

Sanitation and hygiene programmes aim to ensure a safe environment and reduce the incidence of environment-related diseases. Sanitation refers to safeguarding water quality, proper disposal of human excreta, water waste, garbage and dead bodies, insect control, safe food-handling practices, and effective site drainage (UNHCR 2007). Waste management plays a fundamental role in the problem of sanitation and hygiene. Waste is unavoidable; if not properly managed, it may cause environmental and health problems but it can also represent a great opportunity. This is even more evident in a humanitarian crisis. For example construction debris, if properly employed, can become an important resource for restoration.

The waste produced during a humanitarian crisis can be classified as follows:

- Debris caused by catastrophes, usually called Disaster Waste (DW) (both natural and man-made);
- Waste from humanitarian aid packaging (e.g. packaging of tents, kitchen set, blankets, etc.);
- Waste produced from everyday activities in refugees camps (e.g. paper, plastic, food, organic, excreta, etc.)

In the next sections the authors discuss, for each category, materials and quantities available and solutions for their effective management and use.

10.4.1 Waste Composition and Quantities

10.4.1.1 Disaster Waste (DW)

Disasters can take many forms, natural, man-made or technological and their duration can last from few minutes (i.e. earthquakes and tsunami) to several years (i.e. civil wars and radioactive contamination). Most of them create a large amount of debris and waste in relation to their nature.

The management of the disaster waste considers three phases (Brown et al. 2011):

- the emergency response (0–72 h after disaster, short term actions): debris management to facilitate preservation of life, provision of emergency services, removing public health and safety hazards such as unstable buildings, etc.;
- the recovery phase (mid/long-term action): debris management as part of restoring, lifeline restoration and building demolition;
- the rebuild phase (mid/long term action): debris management of wastes generated from and used in re-construction.

The recovery phase is where the majority of the disaster generated waste will be managed. In past disasters this phase has lasted up to 5 years (New Orleans, Hurricane Katrina) (Luther 2008). The recovery phase can be affected by a number of factors outside the control of waste managers including police/coroner investigations which can limit site access for public and waste contractors (Ekici et al. 2009) and slow resident return (New Orleans, Hurricane Katrina) (Cook 2009).

The rebuilding phase is a much longer process and it is hard to define the 'end' of this phase. According to Haas et al. (1977) the rebuilding phase duration could be in the order of 10 years. The aim of waste management is to minimize risks to human life and health, to reduce risks to the environment and to reutilize materials. This last aspect must be over-stressed in the future. Disaster debris must be considered as a fundamental resource to reduce the additional impact on the environment during the reconstruction phase.

Traditionally, waste can be seen as a huge problem, because it causes the spread of contagious diseases; but seen from a different perspective debris may become a resource rather than a mere waste problem. DW can be employed in many different ways: it may contain valuable materials such as concrete, steel, and timber as well as organics for composting. This value can be realized as either a source of income or as a reconstruction material, and can reduce burdens on natural resources that might otherwise be harvested for reconstruction.

Mainly, disasters generate several waste streams (Brown et al. 2011):

- Vegetative debris or green waste;
- Sediment/soil and rock;
- Household hazardous waste (refrigerant, oils, pesticides, etc.);
- Construction and demolition debris from damaged buildings and infrastructures (such as roads, pipe networks and other services);

- Industrial and toxic chemicals (including fuel products);
- Putrescible waste (such as rotting food);
- Vehicles and vessels;
- Recyclables (plastics, metals, etc.);
- Electronic and white goods;
- Human and animal corpses;

Depending on the environment in which disasters happen (coastal/inland, urban/rural) and their nature there are different kinds of waste. The Federal and Emergency Management Agency (FEMA) categorizes materials according to the type of disaster.

The estimation of the quantity of debris produced by a disaster is very difficult due to the high number of parameters influencing this data (e.g. kind and intensity of disaster, type of buildings, environment (coastal/inland, urban/rural), etc.).

Large quantities of materials are usually available. On September 1999, more than 20 million m^3 of demolition waste were created as a result of the devastating Chi–Chi earthquake in Taiwan (Yang 2009). The Hurricane Katrina created disaster debris across a 90,000 square mile (234,000 km^2) disaster area. Disaster debris totals are estimated at 1.5 million m^3 in Alabama, 33 million m^3 in Mississippi and 38 million m^3 in Louisiana (Luther 2006).

Driftwood is a common sight along the coast after a typhoon in Taiwan, in fact after Typhoon Morakot (August 2009) the total clean-up amount of driftwood is 1.03 million tons (Doong et al. 2011). On January 17, 1995, the Hyogoken-Nambu earthquake resulted in devastating damage to the highly developed urbanized region of Kansai in Japan, and created a total of 2,000 million tons of debris (Hayashi and Katsumi 1996).

In general a huge amount of waste had certainly been generated for example by collapsed houses and dilapidated buildings. Therefore, special attention should be paid to the problem of how to assess the total amount of disaster waste scientifically and accurately, and the problem of how to collect statistics of the amount of waste caused by different building materials, thus leading to better waste reclamation. A detailed analysis on disaster waste is helpful in developing a strategy on the treatment of building waste and its use as a resource in post-disaster reconstruction activities. In literature there are some empirical statistics studies discussing structures and building waste produced in an earthquake-hit area (Hayashi and Katsumi 1996; Xiao et al. 2012).

In this paper, based on the field damage investigation in the earthquake-hit area, the relationship between different building structures and building waste produced is established and evaluated. Xiao et al. (2012) propose a mathematical model to forecast the amount of building waste in the earthquake-hit area considering the different structure of buildings and develop an empirical relationship between building waste and seismic intensity. However these studies must only be considered approximate because it is almost impossible to correlate all the factors involved in a disaster. In contrast to machine demolition where massive flows of construction debris is trucked into landfills, deconstruction (the hand dismantling of

buildings for maximum salvage) diverts building material from the waste stream by returning it to homeowners or redirecting it back into the disaster reconstruction. In 2005, Mercy Corps (MC) responded to the disaster of hurricanes Katrina and Rita with an innovative deconstruction program aimed at human empowerment and environmental protection (Denhart 2010). An aggressive deconstruction project at Ft. Lewis demonstrated a fully-closed loop system with 100 % recovery of building material (Biocycle 2007). The Deconstruction Institute estimates that 6,000 board feet of reusable lumber goes into the average 2,000 square feet (sf) home, requiring 33 mature trees taking 10 acres of planted pine. Deconstruction not only preserves the trees but also reduces the CO_2 necessary to harvest, process and transport them.

10.4.1.2 Packaging Waste

When a disaster occurs, a high quantity of humanitarian items, such as tents, blankets, kitchen sets, and the like, arrive in the devastated country and their packages become waste, collected in the surrounding area and usually disposed of openly in dumping areas. In the near future, this could become an important global sustainability issue, and for this reason, it is necessary to find worthwhile alternative solutions to the problem. The Authors are investigating this in collaboration with the World Food Program (WFP).

Table 10.1 shows, for example, the quantities and the materials of packages shipped to the staging areas (i.e. the area close to the disaster area where goods are sorted to be distributed) by analysing several packing lists corresponding to typical humanitarian supplies arranged in 2013 by the WFP.

About 10 % of materials transported (considering weight) are packaging, and about 10 % of the supply costs are certainly no added value costs.

Today, it is important to investigate all the practicable ways to reduce, recycle and reuse waste (Catania and La Mantia 2004), including packaging waste. The solution to this problem is to conceive a general strategy of utilizing various recycling techniques, and/or of recovering energy. These packaging materials should be removed from the waste stream, reprocessed and used again. In this paper we will consider several available materials deriving from humanitarian logistics, and we will propose some new products manufactured using these materials with less environmental impact. Hanna et al. (2009) stated that the contribution from the reprocessing or reuse of the paper waste ranged from approximately 490–1,460 kg CO_2-eq. saved for each ton of paper waste. It may also be assumed that the wood not used for virgin paper production, be used instead for the production of energy that in turn is assumed to substitute for fossil fuel energy. This would result in a contribution from 1,850 to 4,400 kg CO_2-eq. saved for each ton of paper waste. These examples reveal very large potential savings.

In the next section, considering the characteristics of packaging waste, some suggestions and applications on potential reuse and recycling are put forward. This will make the humanitarian logistics more ecologically and economically viable.

10.4.1.3 Waste from Refugee Camps

When refugee camps are established in emergency conditions, waste management has a very low priority. Field-expedient measures of open dumping, burying, and limited burning of waste are standard practice. But immediately from the early recovery phase the waste produced in a camp represents a great problem. An older, poorly-designed or poorly managed waste system can have a number of adverse impacts such as wind-blown litter, attraction of vermin, generation of liquid Leachate, but also injuries of people, social tension and more.

There are several types of waste produced in a refugee camp. Table 10.2 shows the average quantity for the most common types of waste that can be produced in a typical situation (column 1 and 2) (Ruppert et al. 2004; WHO 2005) in comparison with the waste generated in a military camp (columns 3 and 4) (Department of the Army 2008; Headquarters Department of the Army 2013). The differences between the two types are clearly significant due to the different purposes, the different technological level of equipment and the different materials adopted.

Besides the waste listed in the table above, there is another fundamental type of waste produced in a refugee camp: excreta waste. It is very significant from a sanitary point of view. Human excreta are responsible for the spread of many infectious diseases. During the first days of the emergency phase, community facilities for excreta disposal, suitable for a large number of users, should be organised. There are different excreta disposal techniques; the priority is to create an efficient barrier against faecal contamination that can be assured through careful planning of the camp layout and the provision of a sufficient number of sanitary facilities, ensuring that these facilities are properly used and kept clean, and do not become the source of problems such as bad smells, flies and potential collapse when it rains (UNHCR 2007). The importance of having adequate human excreta disposal systems is well documented; 30 % of refugee camps do not yet have adequate waste disposal services or latrines (Frontières 2005; UNHCR 2007).

In the next section some suggestions and applications on potential reuse, recycle and monetization of the waste produced by a camp are put forward.

10.4.2 Waste Management and Re-use

The well-known hierarchical approaches to waste management, based on the 5 R's (i.e. Reduce, Re-use, Repair, Recycle and Residual management) should also be considered in the humanitarian context.

Approaches to solving this waste problem in a sustainable manner led us to a model that uses waste as an input in the production of commodities and monetized value, making waste management a true profit centre. A variety of new technologies (several discussed below) are available to convert waste into a potential source of benefit and value, but in the humanitarian situation a fundamental and distinctive aspect must be considered: people's commitment.

Table 10.2 The most common waste produced in a refugee camp

Waste produced	Source			
	Force provider solid waste characterization study (Ruppert et al. 2004)	Communicable disease control in emergencies—a field manual (WHO 2005)	Solid waste generation rates at army base camps (Department of the Army 2008)	Waste management for deployed forces (Headquarters Department of the Army 2013)
Food (kg per person/day)	0.40	0.37	0.75	0.77
Paper (kg per person/day)		0.25	1.86	1.90
Plastic (kg per person/day)		0.08	0.88	0.88
Glass (kg per person/day)		0.07	0.04	0.04
Wood (kg per person/day)			1.33	1.36
Metals (kg per person/day)		0.07	0.30	0.30
Combustible (kg per person/day)		0.13		
Non-combustible (kg per person/day)		0.10		
Fine material (kg per person/day)		0.06		
Textile (kg per person/day)		0.02	0.11	0.12
Electrical equipment (kg per person/day)		0.02		
Rubbish and kitchen waste (kg per person/day)	1.45			
Other waste (sewage, ashes, miscellaneous) (kg per person/day)			2.90	3.57

A system for the safe management and disposal of waste must be implemented in the earliest stages of an emergency. Consultation with the emergency-affected population is very important, as they may already be motivated to carry out some of the necessary tasks without outside intervention, and may also want to use their waste in a constructive way.

The community's participation and commitment is central to the planning, design and implementation of an effective waste management system. Involving the community will assist in identifying what normal practice is, developing preferred solutions, developing public health and other matters associated with waste management.

The requirements of men, women, young people, children, and those with special needs and disabilities in relation to waste management will be different. In consulting with the community it is important that men and women are both consulted and their needs and requirements identified. For example, women will largely be responsible for household and family waste management while men, for example, may be involved (paid or unpaid) as waste loaders, in waste collection roles, or in waste recycling and re-use. For these reasons, the authors are developing the waste management issue in cooperation with several humanitarian organizations and NGOs.

Below, a non-exhaustive group of "intelligent waste management solutions" are discussed, considering the three different categories introduced.

10.4.2.1 Disaster Waste (DW)

As far as waste management is concerned many components of DW can be used after the disaster. According to EPA (2008), DW can be mainly processed in two ways as composting and re-use/recycling.

Composting is most appropriate in the case of mixed debris in situations where sorting out is costly. Biodegradable materials can be easily composted by means of home composting or centralized composting due to the space problem (Practical Action 2010). Usually a huge amount of waste generated by a disaster mainly consists of concrete and bricks (Hayashi and Katsumi 1996).

These two materials could be recycled through large crusher equipment and other treatment processes. In contrast to machine demolition where massive flows of construction debris are trucked into landfills, deconstruction diverts building materials from the waste stream by returning it back into the building process. In fact, the waste also contains materials which can be reused without reprocessing or just with simple processing, like concrete and bricks, metal, timber and rubber materials (CMRA 2008; Eerland 1995; The Kindred Association 1994). The reuse of building waste does not require complex technology or equipment but just needs manual or simple tools (Xiao et al. 2012). Thus, reuse is the simplest and most effective way to cope with building waste in the disaster area. These materials can often be applied directly in new buildings after being separated especially from building waste with any attached cement mortar removed, which not only saves money, but also protects the land resources. Moreover, waste concrete and waste bricks as well as other kinds of inert materials can be reused as backfill materials

such as soil for landfill cover, bases for floors, etc. Different authors have developed methods for concrete recycling (for example Akhtaruzzaman and Hasnat 1983; Eguchi et al. 2007; Xiao et al. 2012).

10.4.2.2 Packaging Waste

The humanitarian supply chain is a source of significant amount of packaging waste, in particular cardboard, pallets, wood elements, and plastics. They can represent a worthwhile resource. The authors have developed a research project dealing with the recycle of this kind of waste in collaboration with the World Food Programme. First of all, the main needs and requirements of people affected by humanitarian crises were studied, in order to build useful products. From the results, it has been possible to decide on some useful, essential items that can help people to improve their daily life in the refugee camp and return to normality.

Refugees placed in camps faced a variety of problems including violence, lack of privacy and the stress of living without basic facilities. They also have to deal with a loss of role. They no longer can be the parent who can provide for or support their family, they've lost their job, lost their money. They can feel undermined and inferior and unable to get the things they need for their children. They come from homes with gardens, fridges and washing machines. Water came out of a tap in the kitchen not from a communal source. The children had bicycles and went to school. After the disaster they have lost all (Petche 2013).

Several prototypes have been produced in the Laboratory of DIN Department of the University of Bologna by making use of cardboard boxes and pallets. Several solutions are presented below.

10.4.2.3 The Cardboard Backpack

People living in an emergency camp have to go to communal areas (often far from their own accommodation) to collect food, or to get various items useful for their daily life, but often they have nothing to collect and to transport these items. For this reason authors designed and made a resistant backpack from a cardboard box (from the packaging of the kitchen set, size 35 × 35 × 34 cm (h)), to help people in their activities. The resistance of the cardboard backpack has been tested and it can safely contain up to 10 kg. With only a cardboard box and some adhesive tape it is possible to assemble a backpack. Figure 10.1 shows the cardboard backpack prototype.

10.4.2.4 Cardboard Slippers

A lot of people living in an emergency camp walk without any kind of shoes, they walk barefoot because they don't have or they have lost their shoes. For this reason, an idea has been put forward to make a pair of slippers using cardboard boxes. The adhesive tape makes the slippers waterproof. Figure 10.2 shows the cardboard slippers prototype.

Fig. 10.1 Cardboard backpack prototype

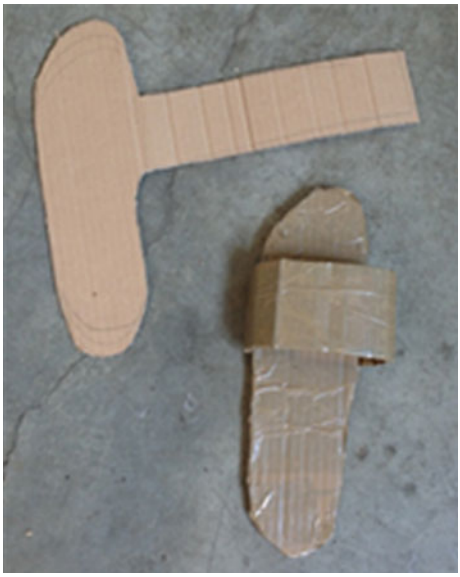

Fig. 10.2 Cardboard slippers prototype

10.4.2.5 The Cardboard Cradle

In a refugee camp there are a lot of children and many of them are infants. People who live in a refugee camp don't have cradle or a specific bed for children and infants, they arrange precarious and insecure solutions for this important problem. For this reason, the idea has been put forward of making a cardboard cradle using

Fig. 10.3 Cardboard cradle prototype

cardboard packaging and adhesive tape, which can hold up to 15 kg. Figure 10.3 shows the cardboard cradle prototype.

The authors have developed and are testing some other ideas, in particular a solar cooker using cardboard and an intensive vegetable garden using blanket packaging. All the solutions can improve in significant manner the condition of refugees; several projects are working to test the presented and other recycled products in the field. First results are very encouraging.

10.4.2.6 Waste from Refugee Camps

Without an appropriate waste management system and support, refugees are likely to resort to burning or burying their waste in an uncontrolled manner. This is often found to be undertaken on the edge of camps or just outside. The possible impacts on the environment and on groundwater resources are rarely considered, potentially resulting in ponds and pools with floating waste which presents a nuisance and a point of pollution and contamination of shallow wells and water sources.

As shown in Table 10.2, in a refugee camp a significant percentage of waste is organic, mainly food and human excreta. This kind of waste can be reused in different ways. The authors consider the production of compost and of biogas to be

very worthwhile. Under aerobic conditions, organic waste can be degraded by micro-organisms in the form of composting. In the first phase, easily biodegradable materials are degraded in a container or bin. This leads to a temperature of up to 70 °C. This process can go on for months. The compost must be turned frequently to help aerobic conditions. In the maturation stage, which takes up to several weeks, the lignin-containing materials are degraded. Ideally, organic waste has 50–60 % humidity. Typically, 50 % of the organic mass can be converted through composting. This substantially reduces the amount of waste to be transported. Compost proved to be a good fertilizer and soil conditioner in agricultural tests. In a closed container recreating anaerobic conditions, organic waste can be microbiologically converted into biogas, in a so-called biogas plant (Taylor et al. 2010).

A biogas plant is filled with organic waste, which is kept anaerobically for a minimum period of 30 days. Biogas is thus formed and collected, consisting of 60 % methane, 30–40 % CO_2, and small amounts of other gases, and, for example it can be used directly for cooking. Also animal dung and toilet waste can be digested in a biogas plant. Biogas produced using the waste in refugee camps may become very important from an energy point of view. In fact it can be used in various fields: cooking, heating and in the production of electrical energy.

Considering the other waste materials coming from the camp, such as plastics, cardboard, paper, wood, and metals, an end of life program should be initiated. This requires sorting out, collection, transportation, recovery and, if necessary, disposal. It is very important to determine if it is feasible and practical to separate and store these materials until they can be recycled, either through contracting to a local/international recycling market, or, after compaction to send material to a controlled disposal site. The two primary disposal methods for non-hazardous materials are burial and burning. In general, the hierarchy for the disposal is, in the preferred order: burial in a properly designed and approved landfill, burial in open pits or trenches when landfill does not exist, burning in incinerators and burning in open-air burn pits according to detailed guidance.

10.5 Energy Consumption

One of the basic needs of people living in refugee camps has been translated into electricity demand (Salehin et al. 2011). In crisis conditions, local commercial electrical power is usually not available, so a centralised camp electrical supply source is necessary. Diesel engine electrical generators are normally used and positioned around the camp. Priority for electrical power should be given to security lighting, access lighting and operating water pumps around the camp. When time and funds are sufficient, electrical power can be provided to individual living shelters (Department of Air Force 2000). Usually, electricity is installed at camp module level.

The electricity demand for a camp module can be estimated considering some fundamental factors such as lighting demand, water purification demand, cooling

Table 10.3 Total electricity requirements in a refugee camp module

Electrical needs	Source		
	Assessment of energy, water and waste reduction options for the proposed AMISOM HQ in Mogadishu, Somalia and the support base in Mombasa, Kenya (UNEP 2010) (data for the headquarter camp)	Assessment of energy, water and waste reduction options for the proposed AMISOM HQ in Mogadishu, Somalia and the support base in Mombasa, Kenya (UNEP 2010) (data for the support base camp)	Designing of an emergency energy module for relief and refugee camp situations: case study for a refugee camp in Chad-Sudan border (Salehin et al. 2011)
Lighting (kWh/day)			52.1
Lighting (external) (kWh/day)	273	273	
Lighting (internal) (kWh/day)	320	160	
Water purification (kWh/day)			63.8
Hot water (kWh/day)	497.3	248.7	
Cooling (kWh/day)	1,750.00	875	
Vaccine cooling (kWh/day)			18.8
Small power (accommodation) (kWh/day)	832.3	416.1	
Small power (office) (kWh/day)	536.8	273.7	
Catering (kWh/day)	42.6	21.8	
Telecommunications (kWh/day)			0.6

demand, catering and telecommunications demand. In general, the total electricity requested by a camp module, composed of 20,000 people, is around 135 kWh/day.

Table 10.3 (Salehin et al. 2011; UNEP 2010) shows in detail the electricity demand in a refugee camp module for different needs. Lighting is provided in the communal area of refugee camps, hospitals, toilet areas, and offices. The total number of staff and area of the office have been calculated based on UNHCR standards (UNHCR 2007). One important factor is to prevent the spread of preventable diseases through vaccination. The vaccines have to be stored in refrigerated tents that represent significant electricity consumption.

10.6 Conclusions and Further Research

The problem of refugees has taken on great significance because of the increasing immigration of people coming from developing countries to the developed part of the world, and because of the increasing number of natural and man-made disasters. For

a long time, the priority in the humanitarian context consisted of raising funds to face the effects of a natural disaster or of a man-made disaster. An approach to maximize efficient use of these resources is relatively recent (Chandes and Pachè 2010).

Efficient emergency management is certainly one of the primary issues in today's society, and developing effective methods and approaches for decision support is an extremely important and timely topic. In fact, when a disaster occurs, optimizing the use of scarce resources and efficiently managing the aids delivered by the different relief organizations is of primary importance.

The disparity between commercial and humanitarian approaches is evident. Of course, emergencies generated by natural or man-made disasters are unique: lives are at stake; the issue is not to bring a logistic quality service at the lowest cost to consumers. But the optimization of techniques usually used in the commercial companies can represent a valid tool for an efficient management of the emergency and of the humanitarian aid.

Transportation is the second largest overhead cost to humanitarian organizations after personnel (Pedraza et al. 2011). In general the supply chain management is a typical area in which the commercial approaches can help the humanitarian organizations. Also the efficient management of the energy or the life cycle assessment of the products can results in savings for the humanitarian sector. To face the energy problem for the rural off-grid areas in developing countries, a combination of the most appropriate technical practice models and social innovation can be adopted (Narima and Langendoen 2012). The marketing policies versus the donors, or the mood of refugees are, for example, other important aspects that require a professional approach.

In conclusion, the organisations for emergency and humanitarian aid have experienced an important growth, and efficiency in management becomes crucial. Improving the state of the art and practice of humanitarian sector has huge economic and social implications as there is evidence that the human and economic impacts of natural or man-made disasters are increasing. The main response of the international community to the increased scale of refugee movements has been humanitarian assistance. This is usually provided within the context of refugee camps while their exiled populations wait for several months, sometimes years, in the hope that they will be able to return home 'in dignity and security'.

Furthermore, the unpredictability of the disasters and the urgency in tackling them make the camp design a very difficult task. A significant number of refugee camps are built quickly with little regard for social aspects, provision of services, utilisation of local materials, quality control, post-construction oversight, or the potential amount of time spent in the camp. A preventive reference framework can be crucial in order to avoid errors. The general structure of the camp plays a fundamental role, in terms of infrastructures and camp modularisation. A simple optimised module, called community (80–100 people helped), can be considered the basic module to obtain a complex camp by replication. Based on this modularisation concept, the fundamental aspects to be considered when establishing a refugee camp are: shelter and accommodation, water consumption and distribution, sanitation and hygiene, energy consumption and food and nutrition.

Due to the importance of this theme, the authors have developed a complete refugee camp profile that can be used by humanitarian organisations, agencies and government authorities during the first phase of assessment and of development aid. Moreover, the authors have defined a set of key technical indicators such as surface area per person, tent area per person, water consumption per person, etc. to support a rapid, effective and solid camp design.

This approach is well known in the commercial and industrial field and is useful in the humanitarian field because of the speed of response required during a crisis. Waste management is a crucial issue in a refugee camp; waste has immediate and long-term negative effects if not managed properly. Refugee camp planning must be a deliberate process which requires the innovative application of scientific principles to provide better refugee camp management while striving to reach self-sustainability processes.

In waste management practices, for example, each waste component is not dealt with independently, but rather as part of an integrated and innovative process. This approach has been shown to provide significant cost savings. For example the Louisiana Department of Environmental Quality estimated that 50 million cubic yards of debris was generated by Hurricane Katrina in Louisiana and over $100 million worth of reusable materials could be diverted from this waste stream. Simple math reveals that transporting such debris in 40 cubic yard containers for a distance of 100 miles would burn 20 million gallons of diesel fuel producing 430,000 tons of CO_2 emissions. To burn the debris mass would have generated 22.5 million tons of CO_2, but burning the debris would simply be converting landfill into "air fill." (Dehhart 2010).

In a humanitarian context as a refugee or relief camp, the human waste can be used as a component in energy production. This reduces the amount of energy and water transported into the camp. Food waste can be used as a component in energy production or composted, which are both very useful processes. Compost and sludge are used as micronutrients to bioremediation or land-farm petroleum-contaminated soils, saving millions of dollars by not shipping the soil out of the country. In giving attention to the waste problem these are only a few of the practices that may help reach the goal of a self-sufficient refugee camp.

Many challenging issues on waste are discussed but in general the environmental sustainability of refugee camps is at stake. Nowadays, refugee camps are mainly based on traditional technologies (in terms of tents, electrical energy generation, packaging, waste management, etc.) usually ignoring the efficiency and environmental impact. Some new ideas appear interesting such as the low impact cogeneration of energy (also using renewable sources), the use of new materials for tents and for other equipment, the re-use of packaging materials and separate waste management. The main goal is the introduction of efficiency (and consequently cost reduction) in the camp design due to reduced environmental impact.

Annex1

Minimum daily requirement of water

Water needs	Source						
	Water manual for refugee situations (UNHCR 1992)	Communicable disease control in emergencies—a field manual (WHO 2005)	Handbook for emergency, United Nations High Commissioner for Refugees (UNHCR 2007)	Minimum requirements: immigrant connect (2010)	Assessment of energy, water and waste reduction options for the proposed AMISOM HQ in Mogadishu, Somalia and the support base in Mombasa, Kenya (UNEP 2010)	UNHCR (2011)	The sphere project. Humanitarian charter and minimum standards in disaster response (2013)
Minimum "survival" allocation (litres per person/day)	7		7	7		7	
Minimum allocation (litres per person/day)	15–20		20	20		20	
Hospital (litres per person/day)	220–300						
Health centre (litres per patient-in/day)	40–60	50	40–60	40–60		40–60	
Health centre (litres per patient-out/day)	5						5

(continued)

(continued)

Water needs	Source						
	Water manual for refugee situations (UNHCR 1992)	Communicable disease control in emergencies—a field manual (WHO 2005)	Handbook for emergency, United Nations High Commissioner for Refugees (UNHCR 2007)	Minimum requirements: immigrant connect (2010)	Assessment of energy, water and waste reduction options for the proposed AMISOM HQ in Mogadishu, Somalia and the support base in Mombasa, Kenya (UNEP 2010)	UNHCR (2011)	The sphere project. Humanitarian charter and minimum standards in disaster response (2013)
Cholera centre (litres per patient/day)							60–75
Feeding centre (litres per person/day)	20–30	20–30	20–30	20–30		20–30	
Kitchen (litres per person/day)		10			4		
Livestock (litres per animal/day)							20–30
Schools (litres per pupil/day)	2		3	3		3	3
Offices (litres per cubicle/day)			2–8	2–8		2–8	
Hand washing (litres per person/day)			1–2	1–2	8	1–2	1–2

(continued)

(continued)

Water needs	Source						
	Water manual for refugee situations (UNHCR 1992)	Communicable disease control in emergencies—a field manual (WHO 2005)	Handbook for emergency, United Nations High Commissioner for Refugees (UNHCR 2007)	Minimum requirements: immigrant connect (2010)	Assessment of energy, water and waste reduction options for the proposed AMISOM HQ in Mogadishu, Somalia and the support base in Mombasa, Kenya (UNEP 2010)	UNHCR (2011)	The sphere project. Humanitarian charter and minimum standards in disaster response (2013)
Shower (litres per person/day)					30		
Public toilet (water flushing) (litres per person/day)					28		20–40
Toilet cleaning (litres per person/day)					4.5		

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Chapter 11
A Sustainable Humanitarian Relief Network Study for the Wenchuan Earthquake

Xie Wei, Abbas Al-Refaie, Melissa Robles and Bernd Noche

Abstract Achieving sustainable societies is a common goal for governments, companies and societies around the world. This new approach has been implemented with success on supply chain sciences where knowledge, methods and tools are being developed to support the establishment of supply chains that meet the requirements of the social, economic and environmental dimensions of sustainability. Nevertheless, most of the efforts on Sustainable Supply Chain Management concentrate on commercial logistics. This work looks forward to sensitize on the need to make humanitarian networks responsible, and therefore sustainable, as well. With an exemplary study, it is analyzed a sustainable humanitarian relief network for the Wenchuan Earthquake.

11.1 Introduction

11.1.1 Sustainable Supply Chain Management

On its report in 1987, the World Commission on Environment and Development (Bruntland Commission) presented one of the most important approaches of critical importance for the future of the mankind, which is the concept of sustainable development. A strong relation between economic, social and environmental dimensions was born when sustainable development was defined by the commission as the "development which meets the needs of current generations without compromising the ability of future generations to meet their own needs" (WCED 1987).

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The new concept called for a new behavior. Thus, through the years, governments, companies and societies acknowledged increasingly their responsibilities on this common future. In the coming years, they will adapt their work agendas, policies and attitudes in order to deal with this challenge. Sustainability shapes all aspects of human live and all scientific and social sciences should develop knowledge, methods and tools to help mankind to achieve this goal through the management of supply chains.

The fact that the logistics sector is responsible for 13.1 % of the greenhouse gases worldwide (Deutsche Post 2010) stresses the relevance that the management of supply chains has over sustainability. A definition for this new sustainability approach in logistics triggers the development of the concept of Sustainable Supply Chain Management (SSCM). Carter and Rogers (2008) defined SSCM "as the strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of key interorganizational business processes for improving the long-term economic performance of the individual company and its supply chains." This definition is based on the triple bottom line denoting that SSCM should guarantee meeting the requirements of the social, economic and environmental dimensions.

The SSCM approach is valid not only for commercial logistics but for humanitarian logistics, a flourishing field for science generation, as well. The Fritz Institute defined humanitarian logistics as "the process of planning, implementing and controlling the efficient, cost-effective flow and storage of goods and materials, as well as related information, from the point of origin to the point of consumption for the purpose of alleviating the suffering of vulnerable people" (Thomas and Kopczak 2005). The incorporation of sustainability in humanitarian supply chains secures achieving a standard of living for the affected population (social dimension), using in an efficient and ethical way the resources of the donors (economy dimension), and reducing the environmental impact of relief operations; i.e., environmental dimension (Klumpp 2013) (Fig. 11.1).

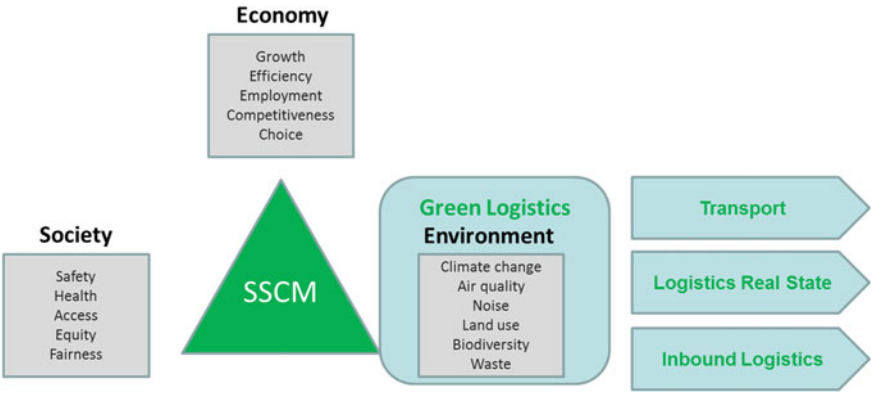

Fig. 11.1 The dimensions of sustainable supply chain management and delimitation of green logistics (Green Logistics 2012)

11.1.2 Green Transportation Management

Energy consumption of transport, emission of large quantities of harmful gases during transport, noise pollution, flammable, explosive, chemical and other hazardous raw materials or products may cause explosions, leaks and other accidents that will impact the environment. Building green logistics systems is, therefore, very important. This can be achieved with management methods as follows:

1. The rational allocation of distribution centers, development of distribution plans, and improving of transport efficiency in order to reduce damage of cargo and cargo traffic.
2. Carrying out of joint distribution to reduce pollution. Joint distribution is the collaborative distribution of the small and medium enterprises from the same industry or the same area. By unifying sets of goods and delivery can the efficiency of city goods transport significantly be improved, the load rate be increased, and the level of distribution services be enhanced, so that the inventories can be greatly reduced, or even achieve "zero" inventory what reduces logistics costs.
3. The implementation of the joint distribution makes systems of transportation more compact. A joint system of transportation is targeted to general cargo and unit load system for the effective combination of several transport means. The total amount of transport vehicles can be reduced through the conversion of the transport modes, including the steering of rail, sea and air transport.
4. Evaluation of the environmental performance of the transport.

11.1.3 Scope of the Study

In this article, the objective in the green logistics domain is to evaluate the CO_2 emissions resulting from the rational allocation of distribution centers, development of distribution points, carrying out joint distribution, and effectively combining various types of transport. All of these are the main focus of green logistics.

This work implements a sustainable humanitarian logistics for the relief network of the Wenchuan Earthquake and addresses the three dimensions of SSCM by assuring sustainable economic operations for the aid items distribution with an effective use of the financial resources of donors (economy dimension), evaluation of the resulting CO_2 emissions for the transportation (environmental dimension), and guaranteeing a timely distribution to the affected population in terms of credibility (social dimension).

A mathematical model is used to optimize the relief transportation process, which considers: the procurement allocation, procurement quantity, selection of transportation mean, and vehicle arrangement. This study enhances the knowledge on Sustainable Humanitarian Logistics by demonstrating with a real disaster case

the applicability of operation research techniques and carbon footprint analysis to perform more responsible relief operations. This example implements as well a methodology to model the satisfaction of the affected population by evaluating the effectiveness of the aid items distribution with a credibility factor. It also aims to tighten the cooperation links between academic institutions and practising humanitarian organizations by presenting the impact of academic research on the humanitarian projects.

11.2 Literature Review

Literature in Humanitarian Logistics (HL) is in the last years gaining in importance on the academic community. An important number of contributions have been prepared in the fields of personnel, equipment and communication, planning, policies and procedures as well as inventory and warehousing. From an analysis of 51 papers written between 1995 and 2009, the literature in HL is predominately in the area of planning (Overstreet et al. 2011). Nevertheless, scarce literature is available that addresses the sustainability dimension on the humanitarian scene. Literature in planning addresses mostly the economical dimension of humanitarian logistics by modeling disaster relief networks for optimizing the network distribution and transportation routing. As sustainability demands a compromise between economies, society and environment, the study began with a literature review about contributions for the design of distribution networks in the case of disaster. It is intended through this work to enrich this planning task with social and environmental issues. However, the economical dimension should be always kept in mind as a sustainable humanitarian network implies the efficient use of relief resources to guarantee the optimal use of financial or in-kind donations.

Nagurney et al. (2011) designed a model for a network that encompasses the outsourcing stages from the manufacturing plants, until distribution centers and demand points. The model searched for the minimal total cost that includes among others production, storage, and distribution calculating penalties due to unsatisfied demand as well as excessive supplies. Demand was modeled as uncertain with a known probability distribution and the model allowed for the investment of enhanced link capacities for manufacture, storage and distribution.

Blecken et al. (2010) considered as well penalty cost for non-satisfied demand using a rolling horizon approach to differentiate between uncertain demand and certain demand taking into account the possibility of future disruptions. The objective function minimized costs for a multi-period problem with a central warehouse and two distributions centers, considering transportation units capacities. Each period of the problem was once a time resolved for the current and remaining period. The information from each solving was considered for the next period solving. The model was tested by solving a problem of a vaccination program in east Burundi.

Important input for the present work is the contribution of Adivar and Mert (2010) who modeled an international disaster relief network with donor countries, collection points and points of delivery. Supply amount of items and procurement costs from donor countries were modeled as a fuzzy number. The satisfaction level was modeled with a fuzzy membership as credibility and the critical perception of items were defined by a tolerance level. For example, cloth has a bigger tolerance level than medicines because medicines are more critical for saving lives. The model had two objectives, minimizing the total cost of procurement plus transportation and maximizing credibility and was tested by using data of a real flood disaster at Tindouf province in Algeria.

Burcu et al. (2010) developed a linear mixed integer programming model for a single-product, single-period facility location and distribution model to minimize the total cost including purchasing, inbound, outbound, distribution, redistribution and mode of transfer costs between truck and rail considering the additional costs of unsuccessful delivery.

Due to the difficulties in the local distribution, some authors focused on the transportation of relief items addressing vehicle routing problems. In this task, a last-mile delivery problem (LMDP) was developed to determine which vehicle visits which nodes in which sequence and the number of pallets to be delivered at each visit with a certain demand (Huang et al. 2012). Metrics were developed as objective functions of different models of the LMDP. These metrics were efficiency measured in terms of total travel costs, efficacy measured by the sum of each pallet′ s arrival time, and equity measured in terms of the disparity in efficacy among nodes.

For the relief transportation, Ortuño et al. (2011) developed a multi-criteria approach with a lexicographical goal programming formulation to deliver the planned quantity of goods while considering operation costs, time of response and reliability for a vehicle to complete successfully the route considering a ransack probability that the vehicle could suffer plundering. The decision support system was first validated with data from a real operation carried in Niger.

In a kinetic based methodology, Ben-Tal et al. (2011) studied flow and density on links of a disaster relief network. The traffic flow was modeled assuming a linear relationship between flow and density on the link with uncertain demand on the source node but the demand of each link origin—destination is assumed to be known at the beginning. Because of the human life hazarding factor, the coefficient of cost was assumed to be dependent on time horizon and demand what introduced a satisfaction level assessment with delivery time and delivery quantity. The dynamics of the scene was modeled in the way that the change of traffic level was determined by traffic flow and demand at each node and in each time period. This multi periodicity resembled very close the behavior of emergency logistics as the first hours were the critical ones to save more lives. On the latest periods of a disaster, the society achieved a more stable condition as the hazard was no longer stroking and help arrived. A penalty for unmet demand was introduced and the model considered uncertain multi-period demand.

11.3 Modeling an International Disaster Relief Network

When a major disaster takes place, local emergency services are overwhelmed and help from the rest of the country and/or international is requested. Therefore relief organizations must respond with the delivery of basic aid (food, medical supplies, and shelter). Relief operations include mainly resource gathering, warehousing and delivery to people in the affected area. The effectiveness and efficiency of the humanitarian logistics becomes a critical factor for the success in preparing for and managing these operations. In this scenario, building effective and efficient transportation models in humanitarian logistics, which determine the best way to deliver aid supplies to the affected areas rapidly and in a sustainable way, becomes one of the key success factors. The efficiency of a disaster relief can reduce the personnel continuous injury and death, calm down the victims, and reduce sufferings from the disaster. All those will help to a faster recovery of the region.

Humanitarian logistics can be divided into three stages: pre-disaster logistics (prevention and mitigation preparedness), disaster-response (warning, impact, emergency response) and post-disaster logistics (transition and rehabilitation, reconstruction and development, evaluation and learning). The pre-disaster logistics deals mainly with the activities of procurement, transportation and warehousing.

In the disaster-response of humanitarian logistics the activities of procurement and transport to regional distribution centers take place. Figure 11.2 depicts the network of a classic humanitarian logistics model.

Effective disaster relief efforts include the cooperation of many groups, organizations and agencies, but each of them has different functions. In case of a

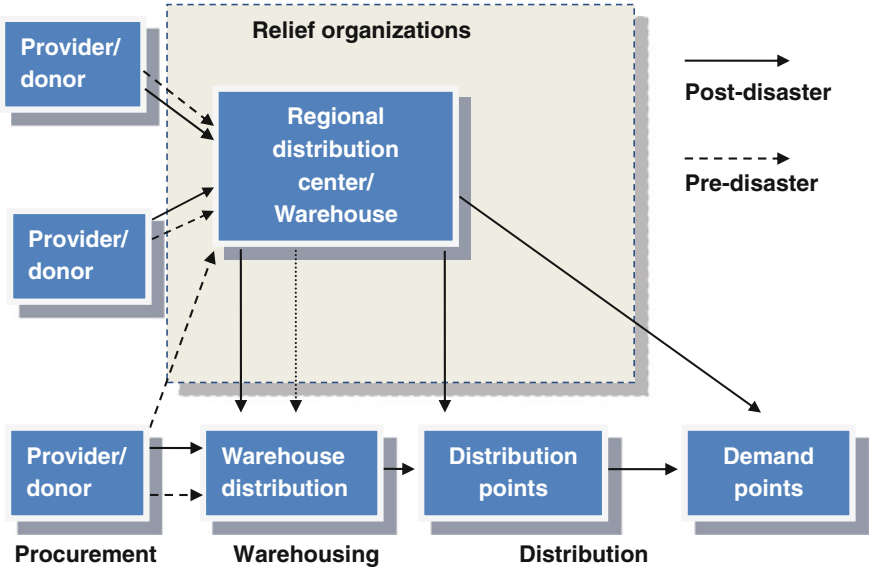

Fig. 11.2 Classic humanitarian logistics model (Guang-min et al. 2011)

disaster, the following processes should take place in order to secure survivors and supply them with aid commodities:

1. Collection of information related to the affected area and the disaster
2. Assessment of logistical, supply needs and local capacities
3. Organization and execution of rescue and disaster relief efforts
4. Identification of appropriate sites for beneficiary shelters, communication, distribution and medical installations
5. Determination of best delivery routes in terms of time and security

The structure of the relief distribution system is depicted in Fig. 11.3. Donor depots provide the relief items, which are considered as collection points *i*, so they have also the two jobs: items procurement and collection. And the relief transfer depots *l* are the bridge between the donor points *i* and relief point *j*. They collect the items from the donor cities, and then distribute those items to each relief city. The model is built up of *T* planning periods, *R* items of relief items, *I* donor points and *J* relief points. The purpose of the design is to resolve for each *L* candidate locations as the transfer depots, so that we can investigate the efficiency of the optimal distribution systems.

11.3.1 Model Assumptions

In the model it is assumed that the information, such as quantity of items demand, the number of people in each devastated area, situation of relief distribution, etc. is

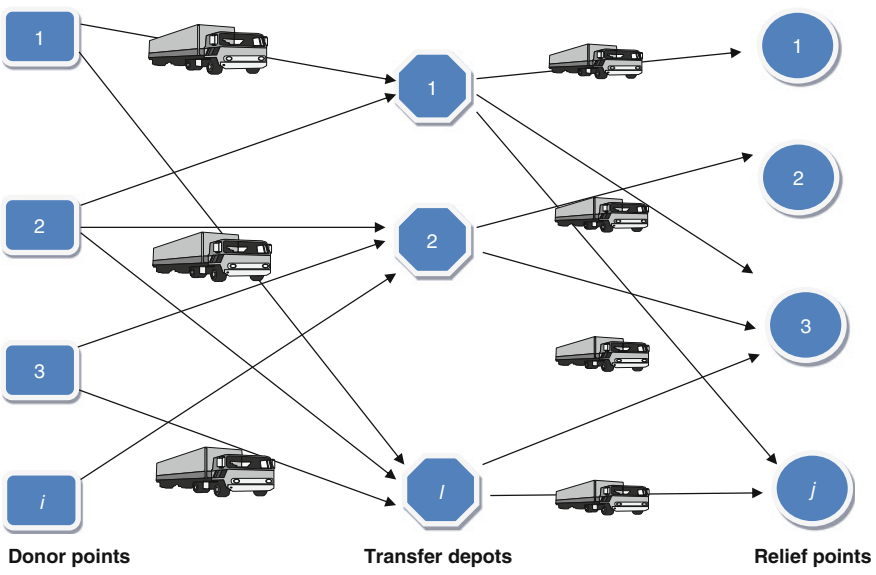

Fig. 11.3 Structure of the relief distribution systems

sufficient and correct. It is considered that the devastated areas are still accessible by the current road network. Only those regular daily items, such as water and food, are considered in the network. The needs of the affected people and the availability of roads are not changing through the time.

11.3.2 Description of Model Objective and Membership Functions

The objective of the mathematical model is to minimize the total cost of procurement plus transportation (11.1). Equations (11.2)–(11.5) are the costs which include procurements cost in donor cities i; transport costs from collection point i to transfer point l and from transfer point l to demand point j, and fixed costs of transportation vehicles.

By calculating the credibility, the aim is to test the satisfaction of the affected population. The constraint (11.6) ensures that relief items in donor cities i are not larger than the supply quantity. Equation (11.7) represents the flow conservation constraint for every item and transshipment point. The demand satisfaction constraint in Eq. (11.8) ensures that at each demand point is satisfied in the most credible way. The available number of vehicles to be used is considered in constraints (11.9) and (11.10). In inequality (11.11)–(11.14) the capacity and load limitations of the transportation vehicles are considered. In the disaster shipment, each type of vehicle is strictly limited, therefore, the weight and the volume of each relief item is multiplied by the number of items in order to check the available capacity. Inequality (11.15) denotes the non-negativity constrains. Equations (11.16) and (11.17) calculate the CO_2 emissions, while Eq. (11.18) calculates the total travel time. The CO_2 emission depends on the energy consumption, which is determined by the load level of the vehicle as full load has different energy consumption than empty load. The function helps to calculate the actual energy consumption, and multiply this value by the CO_2 factor. The calculations for the CO_2 emissions correspond to the principles of a published first draft for a CEN-Norm for the calculation of emissions in transport (Kranke 2010). Equation (11.18) calculates the total travel time. Equations (11.18) and (11.19) give the time period in which the relief item arrives to the corresponding point of delivery and credibility. For better reading, input parameters are listed on the Appendix. The resulting model extended the one of Adivar and Mert (2010) with environmental dimension:

$$\min f1 = \sum_{i,l,r,t} (p_{ir} + c_{il}) x_{ilrt} + \sum_{l,j,r,t} c_{lj} y_{ljrt} + \sum_{i,l,v,t} F_{ilv} n_{ilt} + \sum_{l,j,v,t} F_{ljv} n_{ljt} \qquad (11.1)$$

Subject to

$$c_{il} = k_r t_{il} \quad \forall i, l, r \tag{11.2}$$

$$c_{lj} = k_r g_{lj} \quad \forall l, j, r \tag{11.3}$$

$$F_{ilv} = f_v t_{il} \quad \forall i, l, v \tag{11.4}$$

$$F_{ljv} = f_v g_{lj} \quad \forall l, j, v \tag{11.5}$$

$$\sum_{i,t} x_{ilrt} \leq q_{irt} \quad \forall i, r, t \tag{11.6}$$

$$\sum_{i,t} x_{ilrt} = \sum_{j,t} y_{ljrt} \quad \forall l, r \tag{11.7}$$

$$\sum_{j,t} y_{ljrt} \geq d_{jr} \quad \forall j, r \tag{11.8}$$

$$\sum_{i,t} n_{ilvt} \leq N_{iv} \quad \forall i, v \tag{11.9}$$

$$\sum_{j,t} n_{ljvt} \leq \sum_{i,t} n_{ilvt} \quad \forall l, v \tag{11.10}$$

$$\sum_{r} \varpi_r x_{ilrt} \leq \sum_{v} C_v n_{ilvt} \quad \forall i, l, r, v, t \tag{11.11}$$

$$\sum_{r} \varepsilon_r x_{ilrt} \leq \sum_{v} L_v n_{ilvt} \quad \forall i, l, r, v, t \tag{11.12}$$

$$\sum_{r} \varpi_r y_{ljrt} \leq \sum_{v} C_v n_{ljvt} \quad \forall i, l, r, v, t \tag{11.13}$$

$$\sum_{r} \varepsilon_r y_{ljrt} \leq \sum_{v} L_v n_{ljvt} \quad \forall i, l, r, v, t \tag{11.14}$$

$$x_{ilrt}, y_{ljrt} \in R \quad \forall i, l, j, r, t \tag{11.15}$$

$$\mathrm{CO_2}{-}Emission_{PL} = EC_{PL} \bullet \mathrm{CO_2}\ Factor \left[\frac{\mathrm{kgCO_2}}{100\,\mathrm{km}}\right] \tag{11.16}$$

$$Energy\ consumption_{PL} = EC_{empty} + (EC_{full} - EC_{empty}) \bullet \frac{PL}{PL_{\max}} \left[\frac{Liter\ Fuel}{100\,\mathrm{km}}\right] \tag{11.17}$$

$$T = \sum_{i,l,t} T_{ilt} + \sum_{l,j,t} T_{ljt} \tag{11.18}$$

$$\mu_{d_{jr}}(a_{ijrt}) = \theta_{jr} \tag{11.19}$$

$$a_{ijrt} = (t_{il} + h + g_{lj}) z_{ljrt} \tag{11.20}$$

11.3.3 Credibility Membership Function

If the arrival time exceeds the threshold value, the credibility gradually decreases. For example, in an earthquake, the food requirements must arrive in 3 days, in order to save the victims who are extremely in need of food. If food takes more than 3 days to arrive, the victims will gradually die because of the lack of food, then the food will become more and more useless, the credibility of the relief supply is also deteriorating. In this model, the membership function denotes credibility of delivery of the item with respect to time, for every demand and for every point of delivery. In the membership function, there are two parameters t_{jr}^0 and t_{jr}^1 . In Fig. 11.4, the threshold value is shown. Between t_{jr}^0 and t_{jr}^1 the necessity of the item continues, and after t_{jr}^1 falls down, that means the delivery is no longer useful.

11.3.4 Membership Function for Supply Quantity

In the humanitarian logistics the relief items are usually durable and the requirement deadline is not strict, but the earlier the delivery arrives the more credible it is. Because the demand amounts are usually approximate amounts, we assume the supply amount of items r by relief collection points i and that it is a triangular number. It is denoted by $s_{ir} = \left(q_{ir}^0, q_{ir}^1, q_{ir}^2\right)$, these are the most possible intervals, most pessimistic, and most optimistic values of supply quantity (Fig. 11.5).

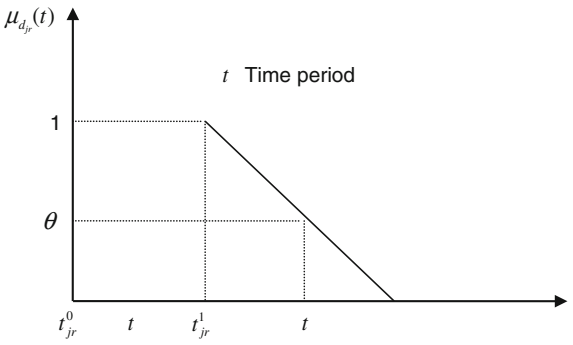

Fig. 11.4 Membership function for the credibility of the delivery of item r

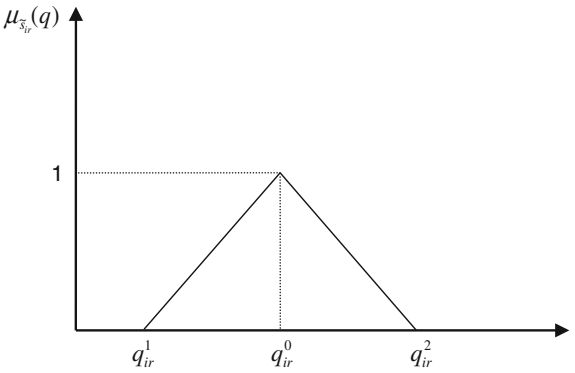

Fig. 11.5 Membership function for supply quantity

11.3.5 Membership Function for Demand Satisfaction

Due to the fuzziness in supply and delivery operations, the satisfaction of the requested demand quantity should be expressed by a soft equation whose membership function is given in Fig. 11.6 with δ_r being an acceptable tolerance level for the demand of each relief item r, we can define the membership function for the fuzzy demand satisfaction equation as follows. Note that tolerance level for health related items are considered to be lower than other items such as clothing.

11.4 Wenchuan Earthquake Case

On Monday, May 12, 2008, a devastating mega earthquake of magnitude 8.0 struck the Wenchuan area, northwestern Sichuan Province, China, which is named Wenchuan Earthquake. The earthquake hit Beichuan and Wenchuan of Sichuan province in China. It affected 47,789 villages, 4,656 towns in Sichuan, Gansu,

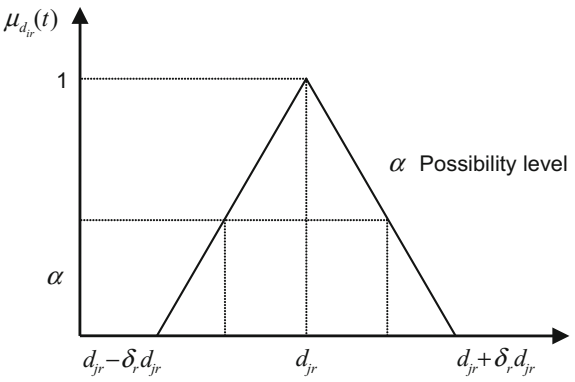

Fig. 11.6 Membership function for demand satisfaction

Shanxi and Chongqing provinces (UN Disaster Management Planning Hyogo Office 2012).

Up to June 23, 2008, it caused 69,181 deads, 18,498 missing, and 374,171 injuries. The focal mechanism of the earthquake was successive massive rock fracturing 15 km in depth at Yingxiu. The seismic analysis confirms that the major shock occurred on the Beichuan–Yingxiu Fault and that aftershocks rapidly extended in a straight northeast–southeast direction along the Longmenshan Fault zone. Fatalities approached a total of 15,000, with a significant number resulting from four types of seismically triggered geohazards rock avalanches and landslides, landslide-dammed lakes (“earthquake lakes”), and debris flows (UN Disaster Management Planning Hyogo Office 2012).

The six most severely affected areas are located in Sichuan province, which are Doujiangyan (DJY), Lixian (LX), Wenchuan (WC), Maoxian (MX), Beichuan (BC) and Qingchuan (QC). The number of dead and missing people in these six areas accounts for 96.6 % (UN Disaster Management Planning Hyogo Office 2012) of the total number of dead and missing people in this earthquake; and we choose the six areas’ emergency resources allocation problem as a simulation study.

From the electronic map, we assume that there are three donor collection centers: Chengdu (CD), Deyang (DY), and Mianyang (MY), four transfer points: Pengzhou (PZ), Shifang (SF), Mianzhu (MZ) and Jiangyou (JY), and six demands points: Doujiangyan (DJY), Lixian (LX), Wenchuan (WC), Maoxian (MX), Beichuan (BC) and Qingchuan (QC). Figure 11.7 illustrates the distribution of six most severely affected areas and four dispatching centers. The distance and the travel route are based on Google Maps results.

For the simplicity, we assume the transport cost of 1 t is 0.5¥ per min. This price is also the average price of the logistics company in peacetime. In practice, this data may be also used with little change (Table 11.1).

For the disaster relief, the operating units are generally national or international units, thus, we can call for more resources, and even military resources. Therefore, we have two kinds of vehicles for the relief distribution: military vehicles with a loading capacity of 26.25 m^2 and 10.5 t, and civilian trucks with 4.5 m^2 and 1.5 t of loading capacity. Further data is the availability amount of each vehicle type per city, the fix cost per hour, the energy consumption, and the CO_2 factor per liter energy. These details of the transportation means are given in Table 11.2.

The distribution route and time under normal condition was found by Google Maps, finding the shortest traveling routes between the two cities to ensure the shortest traveling time. But the actual distribution of relief is often an emergency. The government could enact stringent traffic-control measures. Unlike regular distribution, the traffic volume of relief is variable, and the speed could not be exactly determined, therefore, giving better estimates for travel times. Tables 11.3 and 11.4 show the shortest travel time between each donor point and transfer points, and shortest travel time between transfer points and relief points.

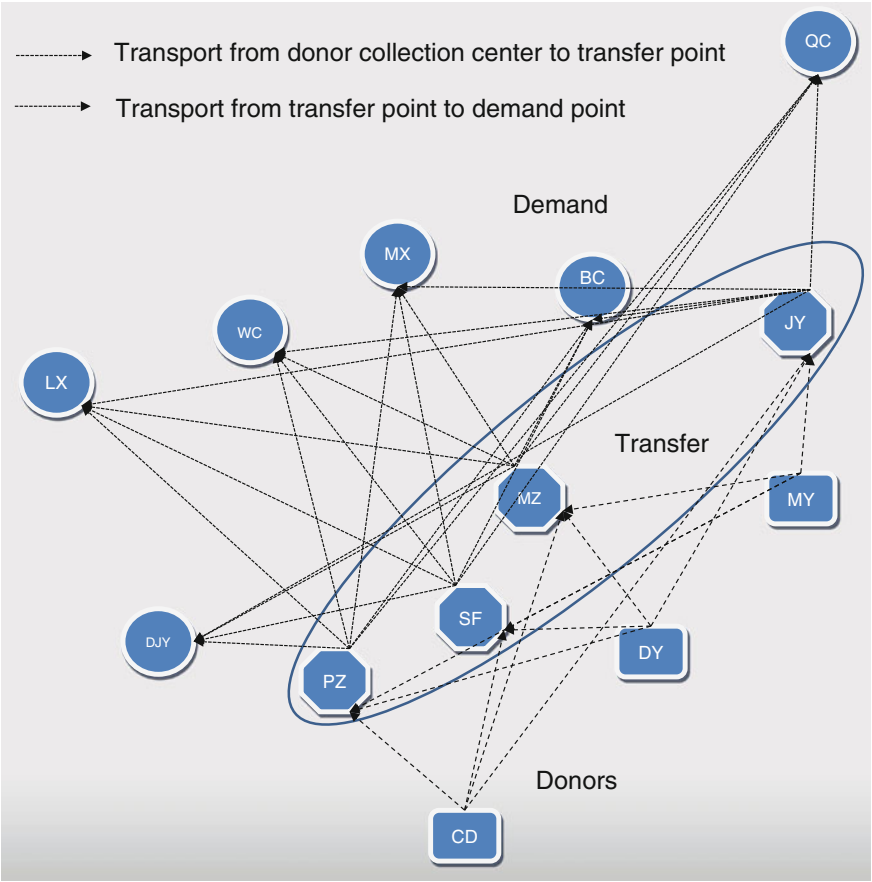

Fig. 11.7 The modeled distribution network for Wenchuan earthquake

Table 11.1 Data of relief items

Item	Calculation unit	Unit volume (cm^3)	Unit weight (ton)	Unit transport cost (¥/hour)
Mineral water	Box	13,200	0.0135	0.405
Dry food	Box	12,000	0.0112	0.336
Canned food	Box	3,500	0.0048	0.144
Tent (6–8 people)	Each	12,500	0.0033	0.099

Table 11.2 Data of transportation means

Vehicle type	Availability			Fix cost (¥/hour)	EC_{emp} (liter/km/min)	EC_{full} (liter/km/min)	CO_2 factor (kg/l)
	CD	DY	MY				
Military vehicle	50	30	25	12.6	0.157	0.196	3.138
Civilian truck	200	150	100	8.4	0.097	0.121	3.138

Table 11.3 Travel time from collection point to transfer point

Time (hour)	1.PZ	2.SF	3.MZ	4.JY
1.CD	0.75	1.42	1.92	2.33
2.DY	1.32	0.59	0.84	1.42
3.MY	1.97	1.45	1.47	0.92

Table 11.4 Travel time from transfer point to demand point

Time (hour)	1.DJY	2.LX	3.WC	4.MX	5.BC	6.QC
1.PZ	1	3.57	2.47	3.29	2.4	6.02
2.SF	1.49	4.15	3.05	3.85	1.7	5.4
3.MZ	1.9	4.57	3.46	3.85	1.12	5.58
4.JY	2.69	5.22	4.12	3.32	1.49	3.94

11.5 Results

For solving the model, the software LINGO was used. LINGO is a modeling language for optimization problems, including many common available functions for users to create an optimization model and other data files (txt, Excel spreadsheet files, database files, etc.). LINGO's main range of applications includes: production planning, transport, finance, investment allocation, capital budgeting, mixed scheduling, inventory management, allocation of resources among others.

One of LINGO's most powerful features is its mathematical modeling language. LINGO's modeling language allows expressing the problem in a natural manner that is very similar to standard mathematical notation. Rather than entering each term of each constraint explicitly, we can express a whole series of similar constraints in a single compact statement. Another convenient feature of LINGO's modeling language is the data section; this section allows isolating the model's data from the formulation.

With the model results on hand that minimize the total cost, it is appreciated for the first transport relations from donor cities to transfer cities. There are 6 routes of distribution selected, which are from Chengdu to Pengzhong, from Chengdu to Jiangyou, from Deyang to Shifang, from Deyang to Mianzhu, from Deyang to Jiangyou, and from Mianyang to Jiangyo (Fig. 11.8).

From the results, the transfer points that are going to receive the larger quantity of water items are Jiangyou receiving water mainly from the donor collection center

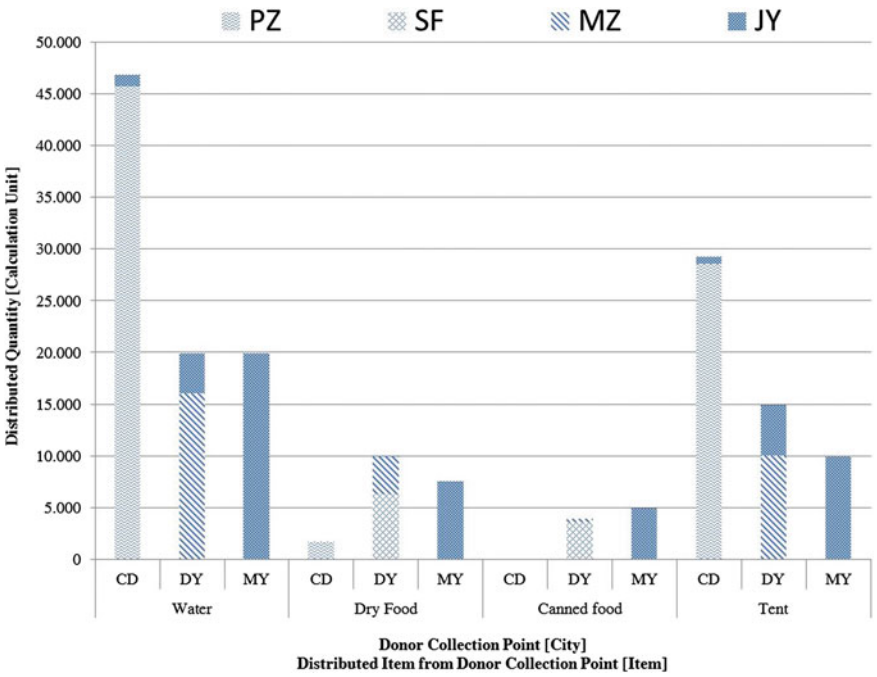

Fig. 11.8 Item distribution from donor collection points CD, DY and MY to transfer points PZ, SF, MZ, JY

Mianyang; and Pengzhou receiving this relief commodity mainly from the donor collection center in Chengdu. Shifang will not tranship water items at all.

On the other hand, Shifang will be an important transhipment point for dry and canned food as it will receive large amounts from Deyand. Jiangyou will be as well an important node for dry and canned food, the Mianyang donor collection point will be its unique provider for both items. Tents will be transported mostly to Pengzhou coming from Chengdu and in a less amount; tents will be as well transhipped to Mianzhu and Jiangyou. This concentration of the type of item transported to each transfer point allows the warehouses in these cities to better prepare areas for the receiving, storage and dispatching of items with same properties and specialize on their handling.

It is observed that Mianzhu will not be one of the most important transhipping points. In the transportation network, it is observed that Mianzhu has less favourable road connections to the disaster locations such as Wenchuan, Maoxian and Doujiangyan.

From transfer cities to donor cities there are 11 routes of distribution selected, which are from Pengzhou to Doujiangyan, from Pengzhou to Lixian, from Pengzhou to Wenchuan, from Pengzhou to Maoxian, from Shifang to Doujiangyan, from Shifang to Lixian, from Shifang to Wenchuan, from Mianzhu to Beichuan,

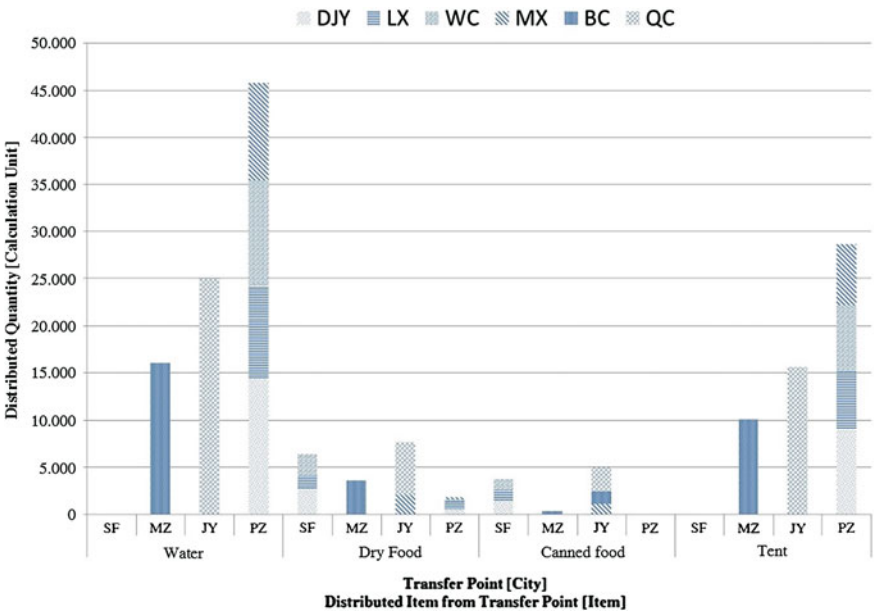

Fig. 11.9 Item distribution from transfer points SF, MZ, JY and PZ to demand points DJY, LX, WC, MX, BC and QC

from Jiangyou to Maoxian, from Jiangyou to Beichuan, from Jiangyou to Qingchuan (Fig. 11.9).

Water for the demand points of Doujiangyan, Lixian, Wenchuan and Maoxian will be supplied from transfer point Pengzhou to the demand point Beichuan from Mianzhu, and to the demand point Qingchuan from Jiangyou. Doujiangyan, Lixian, and Wenchuan will be supplied with dry and canned food from the transfer point of Shifang. Maoxian, Beichuan and Mianzhu will received these items from Jiangyou. The only exception is Beichuan, receiving dry food from Mianzhu. Doujiangyan, Lixian, Wenchuan and Maoxian will be supplied with tents from the transfer point of Pengzhou, Beichuan from Mianzhu, and Qingchuan from Jiangyou.

Due to the differences in travel time to each city; the credibility of each relief demand city is also different. From the results of credibility in each relief city, the value of credibility in Doujiangyan and Beichuan is 1, which means the distribution to those two cities is perfect, the items arrive in time, and the demands of victims in those cities are totally met (Fig. 11.10).

But the credibility in the other four cities Lixian, Wenchuan, Maoxian, Qingchuan is not so pleasant. This situation in the relief distribution is not unusual, because of the various situations when the disaster occurred; it is unrealistic to meet the requirements of each affected area. But this does not mean that the value of the data is meaningless, according to this result, we can find out, if we make the distribution to those four cities with normal driving, loading and unloading speed is

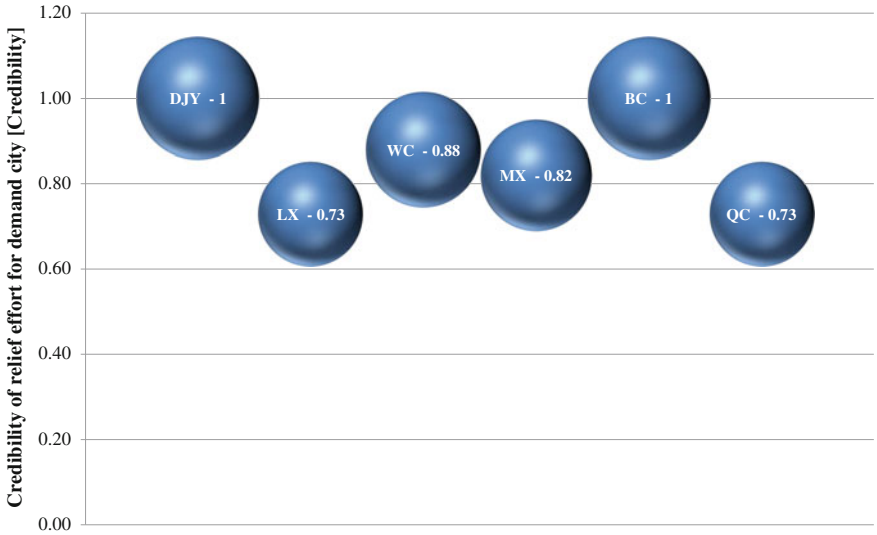

Fig. 11.10 Credibility at each demand point

unable to meet the perfect credibility. Therefore to those cities, we can accelerate the delivery speed; this would, for example, be a certain extent for improving the credibility by using the helicopter for aerial delivery.

For the transportation from the donor collection points to the transfer points 12 t of CO_2 emissions were released by transporting 1,613 t of relief items of all types. Due to the differences in distances between donor collection points and transfer points, and the different load utilization of the transport means, only an analysis of kg CO_2 per transported ton-km can give an objective measure for evaluating the network efficiency in terms of emission release. Figure 11.11 resumes these results.

From the graphic it could be concluded that the transports from Chengdu to Jiangyou released less kg CO_2 per ton-km of relief item transported than the other transport relations. For this transport relation, 4 military vehicles were deployed and none civilian vehicle. This allows moving more tons of relief items with fewer vehicles thanks to the big and well utilized capacity of the military vehicles on this relation. On average, 0.128 kg CO_2 were released per ton-km between donor collection points and transfer points and the most emission intensive transport relation was from Deyang to Mianzhu. For this connection, 21 civilian vehicles were deployed for every military vehicle.

For the transportation from the transfer points to the demand points 27 t of CO_2 emissions were released for transporting 1,654 t of relief items to the affected population. In Fig. 11.12 the analysis of kg CO_2 per ton-km is given.

On average 0.181 kg CO_2 were released per ton-km between transfer points to demand points. Thus, this part of the network was more emission intensive; this could be caused by the fine distribution. Here was the transport relation Shifang to Lixian the most efficient with the minimum of CO_2 per ton-km. On this route it was

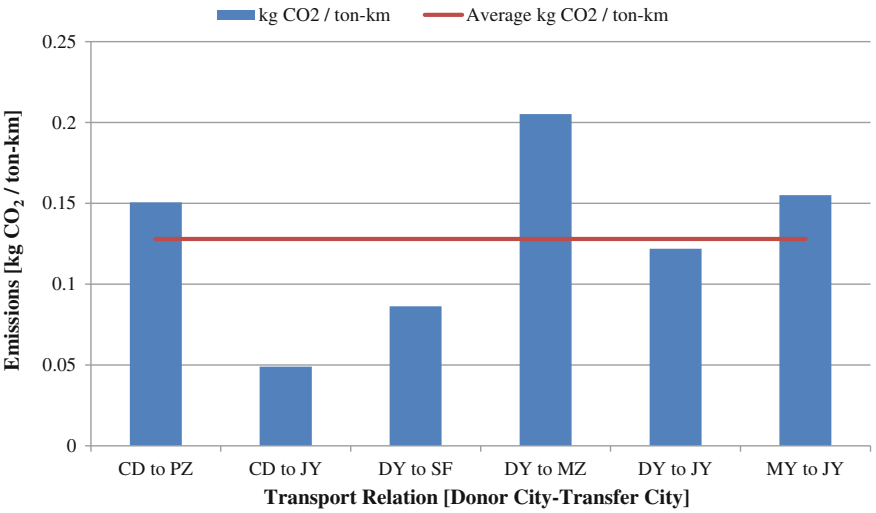

Fig. 11.11 Intensity of emissions per transported ton-km from donor collection point to transfer point

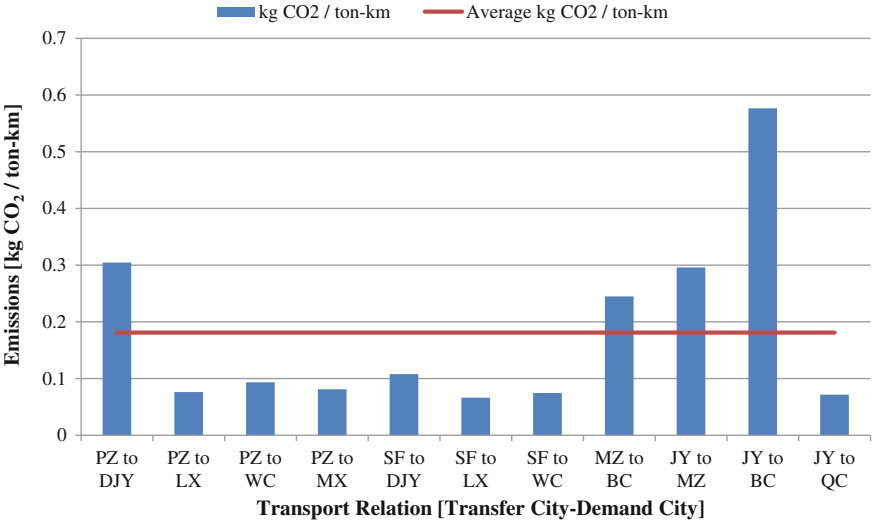

Fig. 11.12 Intensity of emissions per transported ton-km from transfer point to demand point

possible to reduce the use of small civilian vehicles and 2 military vehicles were deployed. The most emission intensive was the transport from Jiangyou to Beichuan as for this route only small vehicles were deployed.

11.6 Conclusions and Remarks

Distribution models are applied on several fields like procurement, distribution, transport of persons through different types of organizations such as, producers, handle, and public transportation and the several ramifications. Applying this knowledge and tools to the humanitarian scene requests the understanding and modelling of the disaster's specific conditions and its environments changing nature. Moreover, new models should be developed to extend the common economical approach of commercial networks to address the unique challenges of sustainable humanitarian relief networks.

This paper provided an exemplary study presented to illustrate how methods and tools could be implemented to perform relief distributions in a sustainable way. The model addresses the three dimensions of SSCM by assuring sustainable economic operations for the aid items distribution with an effective use of the financial resources of donors (economy dimension), evaluation of the resulting CO_2 emissions for transportation (environmental dimension) guaranteeing a timely distribution to the affected population measured in terms of credibility (social dimension).

The model used to analyze the relief network in the event of the Wenchuan Earthquake can be implemented for international disaster relief distribution planning. The underlying assumptions, parameters and process descriptions made throughout the development of the model apply for many organizations and cases. Hence, the output model of this work would help international organizations and decision makers coordinating relief supply and distribution in establishing accountability and more credible status in the eyes of communities while reducing the transport emissions of the relief network to ensure responsible operations. Due to the formulas for the calculation of the emissions, the model here presented can be applied only for land transport. However, with the incorporation of corresponding formulas, calculations of emissions for other transport modes like sea, air, river and train are feasible. Incorporating new transportation modes would as well require the adaptation of formulas to model the different cost structures of each mode. Further, as this model considers only a direct transport from donor to transfer city, the indirect transportation can be modeled by adding a new index level between the two nodes. This issue can be considered in future research due to modeling complexity. That is, a new index i-j-k-l model should be developed.

With this work, it is intended to sensitize the international community that even on disaster situations green logistics concepts and other sustainable operations should not be neglected. The damage on the affected area should not be increased with unsustainable and not responsible decisions neither from the local actors nor from the international community. Thus, actors in a disaster relief network are encouraged to implement methods and tools like the model and analysis here presented to optimize their operations and turning them sustainable.

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Appendix

Definition of parameters

Input	Parameters
x_{ilrt}	Amount of item r from the donor point i to transfer point l at time t
y_{ljrt}	Amount of item r transport from l to delivery point j at time t
p_{ir}	Procurement cost of relief item r at donor city i
c_{il}	Unit transportation cost from donor point i to delivery point l
c_{lj}	Unit transportation cost from donor point l to delivery point j
F_{ilv}	Fixed cost of allocating transportation vehicle v from donor point i to delivery point l
F_{ljv}	Fixed cost of allocating transportation vehicle v from delivery point l to relief point j
n_{ilvt}	Number of vehicles v required between donor point i and transfer point l at time t
n_{ljvt}	Number of vehicles v required between transfer point l and relief point j at time t
k_r	Unit transport cost of item r per hour
t_{il}	Travel time from donor point i to transfer point j
g_{lj}	Travel time from transfer point i to demand point j
f_v	Units fix cost of vehicle v per minute
q_{irt}	Supply quantity of item r available at donor city i at time t
d_{jr}	Demand for item r at delivery point j
N_{ivt}	Total number of available transportation vehicle v in donor city i at time t
ϖ_r	Package volume of each relief item r
ε_r	Package weight of each relief item r
C_v	Transportation capacity of vehicle v
L_v	Transportation load of vehicle v
$T_{il}(t)$	Travel time from the donor point i to transfer point l
$T_{il}(t)$	Travel time from the transfer point l to delivery point j
θ_{jr}	Credibility level about the satisfaction of the demand for item r at point of delivery j
$\mu_{d_{jr}}(t)$	Membership function for the credibility of the delivery of item between t_{jr}^0, t_{jr}^1 the necessity of the item falls down and after t_{jr}^1, equal to zero
a_{ljrt}	$\in Z$ arrival time of item r to delivery point j leaving transfer point l in time t
z_{ljrt}	$\in\{0,1\} = 1$ if item r with destination j arrives transfer point l in time t
EC	Energy consumptions
PL	Actual truck load in tons (t)
$PL_{\max}$	Maximum payload capacity in tons (t)

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Chapter 12
Enhancing Sustainability in Managing Inventory Prepositioning Networks for Disaster Relief Through a Simulation Game

Julian Harke and Sander de Leeuw

Abstract Sustainability questions are often connected to preparedness in a logistics, storage and also qualification and organizational dimension. These concepts are addressed in this chapter, offering a simulation game concept as a method of choice for enhancing preparedness and therefore sustainability in humanitarian supply chains.

12.1 Introduction

Every year millions of people are affected by disasters. In order to respond effectively and efficiently to disasters, humanitarian aid organizations need to be prepared. An important form to improve disaster response by preparedness is inventory prepositioning (IPP), the positioning of inventory for relief purposes. Recently IPP has received increasing attention (see e.g. Balcik and Beamon 2008; Duran et al. 2011; de Leeuw et al. 2010; Richardson et al. 2010). However, a prepositioning network is a complex system where the decision maker faces highly uncertain demand in terms of quantity, timing, location and types of relief items needed (Balcik and Beamon 2008). The complexity of the network makes the development of sustainable solutions difficult. Humanitarian aid organizations furthermore have to deal with the dynamics of this complex system with time delays, feedback loops,

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and multiple actors. On top of that, disasters are characterized by extremely low frequency of occurrence yet a very high impact. Such low frequencies of events as well as the dynamics of IPP systems are impediments to sustainable learning and subsequently to effective preparedness of humanitarian aid organizations. With such low frequencies it is difficult to develop sustainable IPP strategies. In this paper we present the design of the Disaster Preparedness Game, a simulation game for the humanitarian sector using input from the generic stock management system by Sterman (1989), and identify how we can support learning about IPP systems.

Scholars as well as practitioners call for research on sustainable education and training for humanitarian logistics to overcome impediments to learning (see Bölsche et al. 2013; Kovács and Spens 2011a; Thomas and Mizushima 2005; Thomas and Kopczak 2005). Especially in operations management (OM) contexts, simulation games have proven to be effective tools to support learning about complex systems (see e.g. Holweg and Bicheno 2002; Pal and Busing 2008; Pasin and Giroux 2011; Sterman 1992). However, present simulation games do not reflect the dynamic decision-making environment of the humanitarian sector very well. Due to the unique characteristics of this sector appropriate approaches are essential (Richardson et al. 2010). For instance, the well-known Beer Game is characterized by ongoing demand throughout the game (see Senge 1990). In contrast, demand structures of humanitarian aid are characterized by considerable periods without beneficiary needs and a very short period of time with extremely high beneficiary needs. Hence, a game for the humanitarian sector needs to address its unique characteristics.

In this paper, we describe the design and testing of the Disaster Preparedness Game, which involved the activities of conceptual design, instrumental design, and testing and calibration. In the conceptual design we use the game architecture framework by Klabbers (2009) to link the characteristics of IPP systems to the content, the form, and the function of the game. In the instrumental design we use a system dynamics model as a starting point to develop the actual simulation game. Finally during testing and calibration, we iteratively adjusted the balance between level of reality and level of complexity to provide a simulated environment in which participants can learn quickly while characteristics of IPP systems are retained.

The Disaster Preparedness Game focuses on factors regarding inventory decisions in IPP to highlight the impact of those decisions. Focusing on those decisions keeps the game simple but effective, as addressing too many factors could be overwhelming for participants and increases the risk of confounding variables. Our objective is to provide an effective tool to demonstrate challenges in decision-making in the face of low frequency high impact events, as well as provide an environment for experimentation for decision makers, and develop avenues for further research. With the Disaster Preparedness Game we intend to provide a simulation game for training and education for the humanitarian sector.

In the next section, we review the relevant literature for humanitarian logistics and IPP. We discuss the characteristics of the humanitarian logistics, IPP as an important form of preparedness, and finally impediments to preparedness. In the section thereafter we discuss how games can be used for learning purposes. In the consecutive section, we describe the design of the Disaster Preparedness Game.

First we describe the conceptual design, and second the instrumental design by discussing the system dynamics model and presenting the game itself. We then describe our experiences of the testing and calibration phase. In the last section, we conclude with implication for training and education, limitations, and further research. Next to implications for training and education, we will also discuss avenues for further research, including behavioral research, using the Disaster Preparedness Game.

12.2 Preparedness and Inventory Prepositioning in Humanitarian Aid

The purpose of humanitarian aid is to meet the needs of vulnerable people affected by disaster (Thomas and Kopczak 2005; Van Wassenhove 2006). Humanitarian aid organizations respond to various types of disasters, such as slow onset or fast onset disasters, human or man-made disasters (cf. Van Wassenhove 2006). Humanitarian aid organizations need to be prepared for disasters in order to cope with high levels of uncertainty as well as respond effectively and efficiently. Inventory availability is crucial for disasters preparedness, in particular IPP (see Balcik and Beamon 2008; Duran et al. 2011; de Leeuw et al. 2010; Richardson et al. 2010). In this paper, we therefore focus on IPP in relation to disaster relief operations. In this section we will briefly discuss key characteristics of humanitarian logistics, the importance of preparedness for disasters, and IPP as an important way to increase preparedness.

12.2.1 Preparedness in Humanitarian Logistics

In the past logistics, has not received proper attention in the humanitarian sector. In more recent years, scholars and practitioners have begun to recognize the importance of logistics in the humanitarian sector (see e.g. Kovács and Spens 2007, 2011b; Thomas and Kopczak 2005; Van Wassenhove 2006). It is widely acknowledged these days that logistics play an important role in disaster relief operations in order to alleviate suffering of vulnerable people (Thomas and Kopczak 2005). Disaster relief operations are especially challenging due to uncertainty in demand regarding quantity, timing, location and types of relief items needed (Balcik and Beamon 2008).

We use the definition of humanitarian logistics from Thomas and Mizushima (2005, p. 60), which is widely used: “The process of planning, implementing and controlling the efficient, cost-effective flow of and storage of goods and materials as well as related information, from point of origin to point of consumption for the purpose of meeting the end beneficiary’s requirements”.

The importance of preparedness of humanitarian aid organizations is widely discussed in the humanitarian logistics literature (see e.g. Balcik and Beamon 2008; Duran et al. 2011; Kovács and Spens 2009; Tomasini and Van Wassenhove 2009; Van Wassenhove 2006). Better preparedness leads to a more efficient and effective response, despite the uncertainty of quantity, timing, location and types of items in disaster relief operations (Balcik and Beamon 2008). Van Wassenhove (2006) identifies five key elements of preparedness for humanitarian aid organizations: human resources for selection and training of people, knowledge management to learn from previous disasters and to transfer knowledge, operations and process management to move resources quickly, financial resources to prepare and initiate operations, and the community for collaboration.

One of the major impediments for preparedness is the high staff turnover which humanitarian aid organizations face. For instance, Thomas and Kopczak (2005) found that the turnover of field logistics personnel is annually as high as 80 %. Due to the high staff turnover the organizations often face a lack of institutional knowledge and learning (Thomas and Kopczak 2005). The staff of humanitarian aid organizations faces rough circumstances. They have to deal with uncertainty, time pressure, emotional and physical demanding tasks, politically volatile climate, destroyed infrastructure, armed conflicts, etc. (Van Wassenhove 2006).

It is generally acknowledged that there is a need for more research on training and education for humanitarian logistics to cope with staff turnover (see Kovács and Spens 2011b; Thomas and Kopczak 2005; Thomas and Mizushima 2005). Standardized training and certification leads to increased efficiency, improved communication and cooperation, increased career mobility of trained logisticians, and greater hiring flexibility and options (Kovács et al. 2012; Thomas and Mizushima 2005). The low frequency of the events together with the high staff turnover could slow or even prevent so-called learning by doing from disaster relief operations. With the Disaster Preparedness Game we provide an environment that compresses time and space, and induce learning by doing. We focus on inventory management in the Disaster Preparedness Game, as it is identified as one of the most requested skills in humanitarian logistician's job specifications (Kovács et al. 2012) and as IPP is an important way to increase disaster preparedness.

12.2.2 Preparedness Through Inventory Prepositioning

Richardson et al. (2010) define IPP as "the strategic positioning of inventory in the relief network in preparation for disasters, through the integration of facility location, inventory management and transportation decisions, while taking into account the key factors affecting it, to improve the response and efficiency of the relief network". Through IPP humanitarian aid organizations improve the ability to respond to disasters: The organizations can respond more effectively and efficiently (Tomasini and Van Wassenhove 2009), can respond faster due to strategic placement of inventory, transport arrangements and less time spend on procurement

(Balcik and Beamon 2008; Duran et al. 2011), and improve the cost effectiveness (Balcik and Beamon 2008). Unavailability of relief items may lead to not meeting the basic needs of people, and therefore in loss of life and further human suffering (Duran et al. 2011; Richardson et al. 2010).

Despite the advantages of IPP, prepositioning of inventory is in its infancy. According to Balcik and Beamon (2008) this is mainly due to the high cost associated with a prepositioning network. Due to this many organizations have to set up the supply chain to support the relief operations after the disaster onset (Balcik and Beamon 2008). Also, the nature of funding is a further drawback to set up a prepositioning network, since it is easier to obtain funding after a disaster strikes than for preparedness. Due to the donations that are earmarked for a particular disaster, financial resources to set up prepositioned stockpiles are missing between disasters (Besiou et al. 2012).

Inventory prepositioning has received considerable attention in the OR domain. Several OR-based decision-making models for IPP were developed (see e.g. Balcik and Beamon 2008; Campbell and Jones 2011; Rawls and Turnquist 2010, 2012). In general the modeling approaches address the decisions of facility location, inventory management and transportation decisions with regards to inventory, transportation and other costs (Barbarosoğlu and Arda 2004; Richardson et al. 2010). For a design of an effective and efficient relief network is it important to consider factors that affect IPP decisions (cf. Richardson and de Leeuw 2013). For example, some countries have facilitated customs clearance processes for relief items during disaster situations, while other countries do not have such pre-defined rules (Froberg 2010; Haiti Logistics Cluster 2010). This influences IPP decisions, for example, when keeping prepositioned items on a global level, organizations might face severe delays in customs in certain countries. Another example is the reallocation of relief items to other warehouses in the IPP network to be able to response quick (Rottkemper et al. 2011). It is crucial for decision makers to understand the implications of such factors in IPP systems.

In conclusion, IPP networks are complex systems with time delays, feedback loops, and multiple actors. There are few chances to practice and gain experience in inventory prepositioning decision-making due to the low frequency of disaster events but also due to issues such as high staff turnover. We have therefore developed a simulation game that can aid in understanding and practicing with IPP decision-making.

12.3 Learning Through Games

Games provide an environment, which may help to overcome impediments of so called learning-by-doing from the real world. Impediments slow or even prevent learning from the feedback process in real world situation. Sterman (1994) identifies several impediments, which slow or even prevent learning. For instance, misperception of feedback as own actions are often not perceived to create

dynamics, limited information received through the feedback structure of the system, and confounding variables when judging the effects of our own decisions are such impediments to learning.

Games allow us to create learning environments where the feedback is received quicker and allow us to observe the influence of certain variables. Sterman (1992) uses the term "management flight simulators" (pp. 40–41) to emphasize that in such games time and space are compressed in order to provide a learning environment where participants can experience the long-term consequences of their decisions. Many decisions are irreversible or risky in the real world, thus in many situations experimentation in the real world can be infeasible or unethical. For example, for pilots flight simulators are considered the only way to experience catastrophes, such as engine failures, in advance. Thus, how to cope with high impact low frequency events can be learned from games.

Including games in the learning process creates an additional feedback loop embedded in the already existing feedback loop of the real world (Sterman 1994). For simulated environments a good balance between level of reality and level of complexity is essential (Senge 1990) as in the real world complexity impedes learning. On the one hand people should learn in the simulated environment, but should not be overwhelmed by the simulation itself. On the other hand, participants need to trust in the external validity of the game to relate experiences made in game sessions to other settings that as well apply in the real world.

A common approach to support the reflection of experiences made during a game session is a debriefing session following the game (Kriz 2003). Furthermore, participants need sufficient time during the game session to reflect on their decisions and develop strategies otherwise only incremental adjustments to previous strategies are made, as it happens with the "trial and trial again" behavior observed by Sterman (1994). The desired outcome of the reflection of experiences is that participants apply acquired and transferred knowledge to real-life situations (Klabbers 2009).

12.3.1 Design of the Disaster Preparedness Game

In general, simulation games aim to simulate the environment of supply chains in which professionals normally operate. Many existing approaches focus on common issues encountered in real world supply chains and aim to provide participants with a better understanding of these situations (Corsi et al. 2006). The high prevalence of the Beer Game since five decades shows that a simple approach to simulate a complex system is perceived as effective and preferred to many other approaches. Croson et al. (2014) highlight that due to the simplicity of the Beer Game people learn quickly while the game retains key features of real supply chains. In the following we describe the design of the Disaster Preparedness Game. We iteratively adjusted the balance between level of reality and level of complexity to provide a simulated environment in which participants can learn quickly while characteristics of IPP systems are retained. We

present our initial experiences with playing the game and discuss how the Disaster Preparedness Game can be used to demonstrate the dynamics of IPP systems.

The game design approach we follow includes the activities of conceptual design, instrumental design, and testing and calibration (Klabbers 2009). The conceptual design, based on the game architecture framework by Klabbers (2009), guided the instrumental design process. For the instrumental design we used a system dynamics model adapted from the generic stock-management system model by Sterman (1989) as a starting point (see Sect. 12.3.2). During the testing and calibration phase we played the game with Supply Chain Management students, academics focused on humanitarian logistics, and practitioners from a large globally operating humanitarian organization.

The game architecture framework by Klabbers (2009) was used to keep track of the game elements and whether its form, content, and usage were appropriate for its purpose. We defined the Disaster Preparedness Game as a simulation game, which incorporates characteristics of IPP systems to support learning for the humanitarian sector. The form, content, and its usage will be in line with this definition. The form of the game includes 4 players acting in the role of a decision maker responsible for in- and outbound of relief items. These players have to follow rigid rules every round. Each player can make use of the same warehouse locations. The content allows different game settings, such as allowing or forbidding collaboration. The usage of the game takes place in game sessions which consist of the first half of playing the game, followed by an intermediate assessment to avoid "trial-and-trial again" behavior, and the second half, followed by a final discussion to reflect on decisions taken.

The game is primarily designed for decision makers in humanitarian aid organizations and is focused on managing natural disasters. Often humanitarian aid organizations provide new staff with on-the-job introduction and training when disasters strike (McEntire 1999). The Fritz Institute (2005) found, as a result of a survey undertaken after the 2004 Indian Ocean Tsunami, that the number people with relevant training was the lowest on the local level and highest on the international level. Therefore we designed the Disaster Preparedness Game in such a way that it can be used as a board game as well as a computerized version. The advantage of a computerized version is that the participants do not need to pay attention to apply the rules and steps correctly, as the computer dictates them. Therefore the participants can focus on the simulated environment. Furthermore, the use computers could enable a higher level of reality and complexity (Lewis and Maylor 2007). However, the advantage of a board game is that it can be easily used in the field and without much equipment. Despite advances in technology, the board game version of the Beer Game is still preferred to many other approaches in today's OM education. Elgood (1997) discusses further advantages of board games: (1) computer-based games may limit interaction between the individual participants or teams while playing the game, (2) a board game can create more interest in the state of the game, for instance the position of the other players, than when all participants just interact through a computer, and (3) for participants it is more obvious that they are all provided with common information when the information is announced publicly in the game session rather than just provided on the computers screen.

12.3.2 System Dynamics Model Disaster Preparedness Game

As part of the instrumental design, system dynamics is used to develop a model in which the characteristics of the humanitarian sector and the factors affecting IPP are addressed. System dynamics is an experimental and quantitative approach to model the structures of complex systems (see Forrester 1958). Klabbers (2009) argues that system dynamics models provide a suitable base for games. Gonçalves (2011) and Besiou et al. (2011) show that system dynamics is an appropriate method to study complex systems in humanitarian logistics. We base the Disaster Preparedness Game on a system dynamics model adapted from the commonly applied generic stock-management system model by Sterman (1989). We added custom clearance and the possibility of item reallocation between warehouses. Figure 12.1 depicts the system dynamics model of one warehouse. The model can be extended to a warehouse network consisting of several warehouses, as it holds for any number of warehouses as the sum of all reallocation in- and outflows is always zero.

The system dynamics model in Fig. 12.1 consists of stock, rates, item flow, information flow, and feedback loops (cf. Sterman 2000). Inflows in a network of warehouses only enter the system after an order is placed. These inflows enter the supply line of one of the warehouses according to the orders placed. Each warehouse can also receive reallocated items from another warehouse, which skip the supply line as they are not ordered at the supplier. Outflows are all losses, which include demand fulfillment, reallocation to other warehouses and other inventory losses such as theft.

The reader is referred to Sterman (1989) for details on the rates and the order decisions, as they are adapted from the model of a generic stock management system. When responding to a disaster, we introduce a binary variable to distinguish between customs clearance time lags during disaster and non-disaster situations. The acquisition rate depends on this binary variable.

12.4 Description of the Disaster Preparedness Game

In the Disaster Preparedness Game, the players take the role of logisticians in one of the competing humanitarian aid organizations. The different organizations have all the same six warehouse locations to preposition relief items. For the sake of simplicity, we assume that relief items are suitable for all disasters and non-perishable. Each player has to manage the prepositioned inventory of their organization in the different warehouses by ordering relief items, reallocating inventory, and respond to disasters by dispatching relief items. Through these in- and out flows players can control their desired inventory levels.

Figure 12.2 shows the board of the Disaster Preparedness Game. On the board, the location of possible warehouse locations, supply lead times for the different warehouse locations, and disaster prone regions are presented. The warehouse

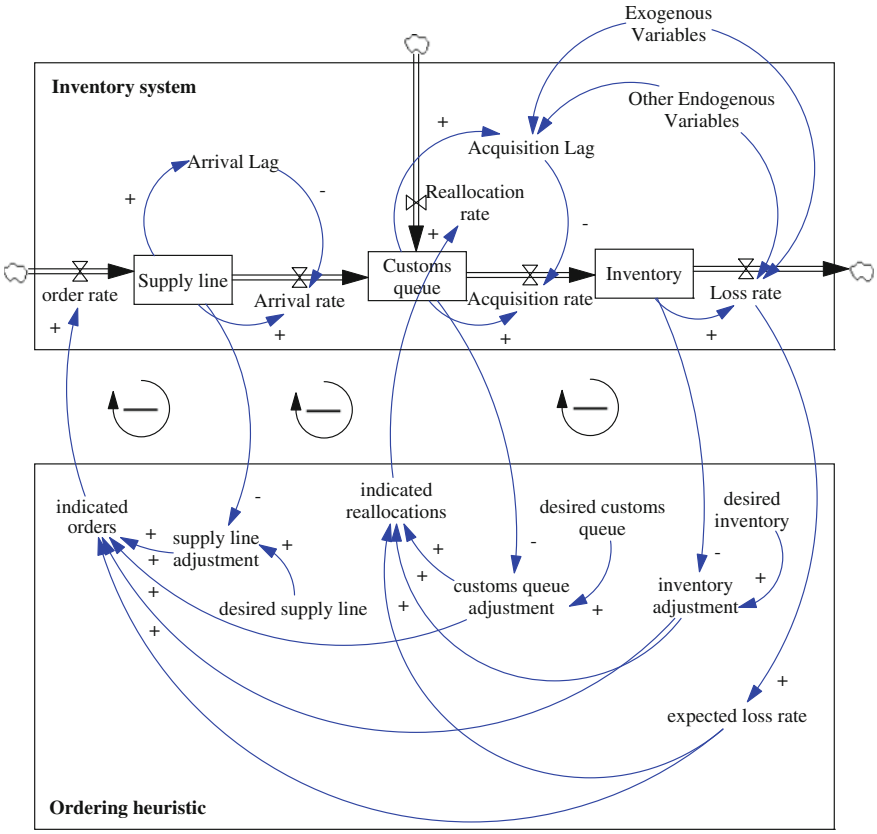

Fig. 12.1 IPP system dynamics model

location in each country is similar to the country entry point. Players also get additional information about warehouse locations, such as theft rate, political stability, customs clearance, and distances to the other countries. The total supply lead time in the game consists of shipping delay and country specific customs clearance delay, which can vary in disaster situations. In the game earthquakes represent disasters without forecasts, as they are the least predictable natural disasters, while storms represent disasters with existing forecast methods (Guha-Sapir et al. 2004).

The game session begins with an introduction explaining the game elements and rules. The scenarios in the game sessions are derived from real data of EM-DAT (2013), the OFDA/CRED International Disaster Database. However, without letting the players know the years and region of the data used for the game session to prevent prior knowledge about certain disasters influencing their decisions. In order to create trust in external validity an example of historic data of affected people from EM-DAT is presented in the introduction. It is also announced in which rounds the storm season starts and ends. However, the total number of rounds is not

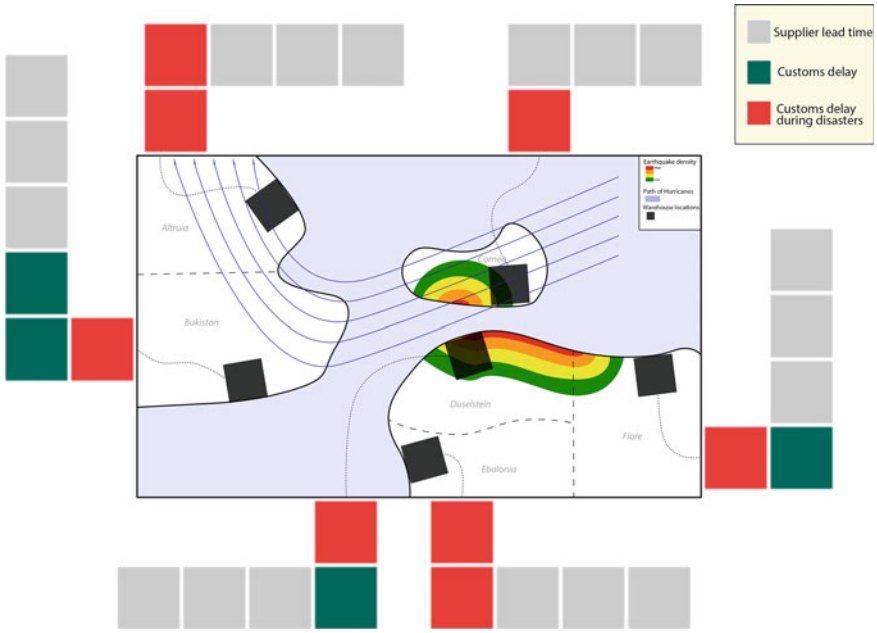

Fig. 12.2 Board of the disaster preparedness game

announced to avoid the horizon effect (see Sterman 1992). Also, the accuracy and scale of storm forecasts are discussed, as the players will receive storm forecast information in the game. Before the actual game starts some trial rounds are played that the participants get familiar with the rules and elements of the game. In this phase players make sense of the environment (Lewis and Maylor 2007), therefore has the facilitator to makes sure that the game is understood clearly by all players.

Initially each player has a certain number of items available to place on the board. Limiting the number of items to place on the board reflects the limited funding for IPP in humanitarian aid organizations. In disaster response operations, humanitarian aid organizations try to attract high media attention in order to attract more donors. Therefore, players can gain access to more funding in the game, if their response is more successful in terms of response time and number of people helped than the response of others.

After the initial step players make each round simultaneous decisions in an iterative play. Figure 12.3 depicts the iterative play, which continues for several rounds to give the players the opportunity to experience the dynamics of IPP systems, and to experiment with their strategies. At the beginning of each round, the items that were ordered a couple of rounds ago arrive in the warehouses. Following the item arrival, all players get common information of an event. The information provided can include disasters, forecasts, other political instability, theft, and so on. However, in contrast to many existing OM games, players might face rounds without any event occurring as it is common in the humanitarian sector that

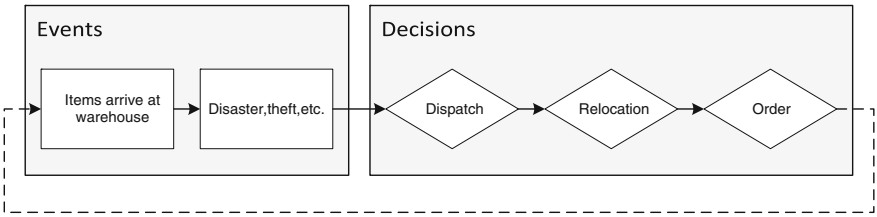

Fig. 12.3 Iterative play of the disaster preparedness game

humanitarian aid organizations face considerable periods without beneficiary needs. If a disaster occurs the information contains affected area and estimates about severity of the disaster. All players respond simultaneously to the same disaster. The disaster response was successful if the sum of people helped by all players together is equal to the total number of people affected. Hence, some players might be able to contribute more to a disaster response than others. For the storm forecasts the scale discussed in the introduction is provided that the players can prepare. Theft leads to inventory loss, while political instability leads inaccessible inventory, which cannot be used for some rounds. Based on this information players need to take dispatch, reallocation, and/or order decisions.

Despite the competition for funding, all organizations share the common goal of meeting the needs of vulnerable people. However, to date no common performance measurement for relief operations exists (Kovács and Spens 2011b). Even though the estimates for the number of people affected differ between humanitarian aid organizations (see USAID/OFDA 2008), we assume in the Disaster Preparedness Game that all decision makers in the humanitarian sector use a common estimate for the number of people affected. Based on this estimate, players aim to maximize the number of people helped. In the Disaster Preparedness Game players can gain access to more inventory chips when responding first and to a higher number of affected people than others.

Next to the goal of maximizing the number of people helped decision makers need to take into account financial resources. A simple performance measurement is used in the Disaster Preparedness Game, where all player aim to maximize the number of affected people helped while keeping their inventory holding cost low. This performance measurement can be translated in the goal of an efficient and effective response by alleviating suffering when maximizing the percentage of people helped at a low cost.

After several rounds the game pauses for an intermediate assessment in order to avoid the so-called “trial and trial again” behavior. Discussion during this intermediate assessment is not allowed to avoid groupthink. To reflect on their experiences the participants have to reflect on following questions:

1. What challenges in taking decisions did you identify?
2. What was your strategy?
3. Do you want to change your strategy? If yes how? If no, why not?

After the game ends the participants have to answer another questionnaire to reflect on the experiences made during the game. To avoid groupthink the players need to fill out the questionnaire before the experiences are discussed in the group:

1. Did your new strategy help?
2. Where do you see still improvements of your strategy?

After the individual reflection the participants share their experiences made before the facilitator leads an open discussion.

12.5 Experiences with Playing a Disaster Preparedness Game

In this section discuss our experiences made with playing the disaster preparedness game by assessing qualitatively the game design based on observations and focus group discussions. During the game sessions we acted as a facilitator, presenting the introduction and making sure that the game is understood clearly by all players. This allowed us to observe the players actions, the difficulties they were facing, and the outcomes when using a scenario derived from EM-DAT. After playing the game we conducted a focus group discussion of around 30 minutes with the players.

In a focus group discussion, in contrast to an individual interview, the participants spontaneously raise questions to be discussed by the group. Hence this leads to dynamics that are not reach by face-to-face interviews (see Krueger and Casey 2009). For instance, participants reflect on what they have heard and therefore can take different directions then independently conducted interviews; different views may emerge and the group can respond to these views.

During the testing and calibration phase we ran five sessions with students, one with academics, and one with practitioners. For all sessions we used the board game version involving four players, which we described in Sect. 12.4. The sessions with students included one session with recent graduates from a Supply Chain Management master program, two sessions with students randomly assigned from different master and bachelor programs, and two sessions with current master students from a Supply Chain Management master program. During these sessions we mainly focused on the level of complexity, as the students were not familiar with the concept of IPP before. To assess the level of reality we first played the game with academics and second with practitioners of a large international humanitarian organization operating in Pakistan, which we will refer to as HumOrg. All the academics as well as all the practitioners are familiar with the concept of IPP.

Observations and feedback of the first three sessions with students showed that the level of complexity needed to be adjusted. We reduced the complexity by focusing only on inventory decisions and removed decisions on transport mode, warehouse location, and financial constraints.

After playing the game, four academics discussed the extent to which the Disaster Preparedness Game mirrors IPP systems of humanitarian aid organizations in a small focus group. We also took the opportunity to play the game with staff managing IPP at HumOrg in Pakistan: the manager responsible for disaster response, the commodity coordinator, the procurement manager, and the logistics coordinator. We also conducted a focus group discussion with them similar to the one with the academics. Next to that we conducted an additional 30 minutes interview with the manager responsible for disaster response. We audio recorded and transcribed these focus group discussions and the interview.

The focus groups identified the Disaster Preparedness Game as more than just an introduction to inventory prepositioning for disaster preparedness:

> That would be very good actually. Even for strategy making also. You can just see the strategy.

In HumOrg they mentioned how they are planning to use the game:

> […] my first focus will be on the [national response team]. In [the national response team] we have permanent members. But in the [area response team] a project coordinator is a member of the [area response team] but then when the project ends so that person is no longer with HumOrg […]. Because everyone knows the people who are in the [area response team] are basically in the field and they normally deal with the warehouse and commodity and logistics.

When discussing IPP the limited budget is a key issue. In the game the relationship between budget and supply becomes apparent, as the following quote illustrates:

> The main thing is the budget, if we have budget at hand we can preposition, if we have budget we can order new things. […] who is not involved in these [disaster response] activities, it will be good for those ones to understand how the things are moving […].

Strategies how to cope with the low frequency high impact events were discussed. First, many players identified the strategy of having a central warehouse as beneficial. This is summarized in the following statement:

> [It] is much smarter to actually have one central stock […] from a lead-time perspective, because the lead time to go somewhere is much shorter, […] than ordering supplies for every single location.

When choosing a central inventory location the characteristics of that location were considered; security seemed a core consideration (several players asked themselves where inventory would be safest). Relying on just one warehouse also comes with risks as one of the practitioners illustrated with the following real-life example:

> […] we dumped all our commodities in the warehouse and then when the flood warning was released for [the area where the warehouse is located] then I was very worried. Because I thought, if for example all access to the warehouse would be closed by the flood, so then how could we move our commodities from the warehouse to the field when the warehouse is surrounded by water? Or if we lost our commodities in the flood, so then what would be the situation?

However, during a storm season inventory is preferably stocked up in locations close to the storm-affected area:

> You have to have your products there in that country, […] your supply chain needs to be geared up to deal with it right before, so if there is a big issue, you can actually respond fast.

The possibility to gain access to higher levels of inventory was related to attracting donors by higher media attention:

> You go somewhere, you put your flag there […] so that the cameras see that you are there, so that you get additional funds […].

Players experienced that stocking up for disasters that are considered more predictable (represented by storms in the Disaster Preparedness Game) is better possible than for unpredictable disasters, which are represented by earthquakes. Before and during a storm season the players stocked up at a local level by ordering new items or reallocating items. As one player identified in case of one country in the Disaster Preparedness Game, which we called Bukistan:

> […] everything we were moving was only dependent on the forecasts. For example, the forecast says that the situation will be worse in Bukistan, we should ship the items there.

As a result, none of the players solely relied on a central warehouse nor solely on local inventory. Local inventory enables the players to react quicker to disasters. As one player mentions:

> […] initially when I was starting this so I was thinking that I will only manage two warehouses and then from there I will manage if there is any response. But then I started with four warehouses in the region. And I think it is, in time of emergency, it is very good.

The custom clearance delay was an issue identified by all players. One player brings the example of Iran as a neighboring country of Pakistan:

> It will take time, especially the customs clearance […] it will take time. […] For example if the emergency is a larger emergency and then the Iranian government calls for international assistance, then maybe things will be easier.

The fact that many examples were used throughout playing and discussing the game shows that the game adheres to problems encountered in real life. In the next section we further discuss our game, draw conclusions and identify avenues for future research.

12.6 Discussion and Conclusion

Humanitarian aid organizations face a complex and highly dynamic environment where high-impact disaster events occur with low frequency. The characteristics of this environment impede learning. Also the high staff turnover leads to a further impediment of learning in decision-making processes. To support learning in this environment we developed the Disaster Preparedness Game, a simple but effective

OM game for the humanitarian sector. This game demonstrates challenges in decision-making in the face of low frequency high impact events, as well as provides an environment for experimentation for decision makers that are confronted with such events.

As discussed in Sect. 12.3, a good balance between level of reality and level of complexity is essential for a good learning environment. The Disaster Preparedness Game is a relatively short game with little complexity. Lewis and Maylor (2007) identify a trend to more complex OM games, but they also question the value of more complexity in games, as many instructors prefer simpler games which can played in "2 or 3-h lecture slot". The use of the Beer Game has shown the power of relatively short games with limited complexity, both in the area of education on supply chain dynamics and in research.

In education the Disaster Preparedness Game can be used as an introduction to humanitarian logistics and IPP as the game focuses on characteristics specific to the humanitarian sector. In the game sessions participants experience the difficulties how to cope with low frequency high impact events. Addressing this topic in education can increase awareness of dynamics in similar systems and low frequency high impact situations in general, in the humanitarian as well as the commercial sector. As the practitioners identified, in humanitarian aid organizations the Disaster Preparedness Game is useful for people who normally do not have to deal with disaster as they focus on for example ongoing programs, but after a disaster strikes are often involved in disaster response operations. However, just playing the game is not sufficient for effective learning. Participants need to have enough time to reflect on the outcomes of the game (Sterman 1994). Therefore, the debriefing phase is an essential part of every game session to support learning (Klabbers 2009; Kriz 2003).

For decision makers in humanitarian aid organizations the Disaster Preparedness Game provides a safe environment for experimentation with their strategies and decisions. Experimentation, especially during the disaster response phase, is not possible and would be unethical in real disaster situations. Sterman (1994) highlights the importance of experimentation in order to improve decision-making processes. Due to the compression of time and space in the simulated environment the Disaster Preparedness Game supports learning in an effective manner, which was confirmed in the focus groups with practitioners. Learning experiences of the Disaster Preparedness Game might help participants to cope with similar situations when they are encountered later in practice (Klabbers 2009). The game sessions in the testing and calibration phase show that playing the game results in fruitful discussions about experiences.

The test with HumOrg showed that the game is practice oriented and a good instrument to show participants the complexities of inventory prepositioning in relation to response to a disaster, particularly to groups of people with not just logistics backgrounds but with rather mixed backgrounds. HumOrg identified that this game is particularly interesting for education of teams that are normally not operating in humanitarian response activities but rather in ongoing programs for

example. At HumOrg these response teams consist of people from finance, admin, procurement, operations, and programs. As one person identified:

> […] if we start a response, most of the people will be there in the field, like sector leads, admin, procurement, they will be there in the field and they will be helping the area [where they are situated] or if it is a new area, then they will be working on the warehouses, to place the commodities, transport it to the field, like they will be managing logistics. So that's why I was thinking I would use this game with them as to give them this idea that in a different situation or in a changing environment how they will manage their warehouses.

We played the game with a limited number of people, which limits our conclusions. Despite the valuable insights that the qualitative assessment of the Disaster Preparedness Game provides, further empirical evidence on the effectiveness of the game will be gained through further using the game with humanitarian organizations. Especially using the game with practitioners who are involved or have been involved in disaster response would provide more insights of the effectiveness, including the desired outcomes, of the Disaster Preparedness Game. HumOrg already identified that they are particularly interested in continuing this successful initiative. However, playing the game with practitioners from different humanitarian aid organizations might provide us with additional insights.

Following the tradition of conducting experiments based on simulation games (see e.g. Croson and Donohue 2003, 2006; Croson et al. 2014; Steckel et al. 2004; Sterman 1989), we expect valuable results conducting behavioral experiments using the Disaster Preparedness Game. Experiments in real disaster situations are unethical and due to an often chaotic situation problematic to conduct. The Disaster Preparedness Game can serve as a base to conduct experiments to examine both, policies that improve system performance, such as IPP strategies, and behavioral issues. The terrain of behavioral OM is gaining quite some traction, but so far has received little attention in the humanitarian domain. Due to the focus on inventory management variables in IPP systems, the game provides a highly controllable simulated environment and therefore is well suited for behavioral experiments.

The observations during the testing and calibration phase indicate that players adjust their own inventory levels based on information they have about inventory levels of others. Similar to experiments based on the Beer Game (see e.g. Croson and Donohue 2003; Croson et al. 2014; Steckel et al. 2004), it is important to study the impact of inventory visibility and of further collaboration to the system performance in the humanitarian sector. Even when collaboration is encouraged players still compete, so why should they share information? These are problems that might hinder a better collaboration between humanitarian aid organizations.

In addition, research about pooling demands for different disasters can be conducted. Important is when and why participants decide to reallocated inventory. Which role do local vs. global inventory levels play? In real disaster situations it may mean a late arrival in the disaster area when relying global stock only, and hence on flying in everything.

To conclude, the Disaster Preparedness Game can be used for education and training, but as well for behavioral research [with behavioral experiments similar

to how the Beer Game has been used (cf. Sterman 1989; Steckel et al. 2004)]. Nevertheless, further research on how to be better prepared for the next disaster needs to be conducted. Following the research presented here, focusing on training and education using games in the humanitarian setting and behavioral research is a valuable research area.

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Chapter 13
Applicability of Performance Measurement Systems to Humanitarian Supply Chains

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Abstract Recently performance measurement in humanitarian supply chains has become a key driver to ensure efficiency and effectiveness of operations and overall sustainability. The purpose of this paper is to evaluate current performance measurement systems from the commercial sector for their applicability to the specificities of the humanitarian supply chain sector. In doing so, we adapt the evaluation criteria for an 'appropriate' performance measurement system from Caplice and Sheffi (1995) to the humanitarian supply chain context and apply them to well-known performance measurement framework from the commercial sector (Balanced Score Card, SCOR Model and Performance Prism). Findings indicate that the analyzed performance measurement frameworks have some potential to enable effective and efficient performance measurement of supply chains in the humanitarian aid sector in light of the established criteria.

13.1 Introduction

Non-profit organizations are under extreme pressure to demonstrate their achievements (Moxham 2009; Moxham and Boaden 2007) to numerous stakeholders to ensure continuity of funding. Owing to the central role of logistics in any kind of operation (Van Wassenhove 2006), especially the effectiveness and efficiency of the supply chain are important indicators of performance (Beamon and Balcik 2008) in the humanitarian aid context. Even though the attention to the role of logistics in the

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humanitarian sector has increased significantly, to date, only 20 % of humanitarian organizations measure performance consistently; 25 % declare to control a limited amount of indicators and 55 % do not monitor or report any performance measurement indicators (Blecken 2010). There are multiple reasons for this including non-existence of data, a chaotic and complex environment, contradicting goals of long-term versus short-term disaster response as well as limited information technology capacity and infrastructure (Van der Laan et al. 2009; Blecken et al. 2009; Davidson 2006; Widera and Hellingrath 2011; Tatham and Hughes 2011; Jahre and Heigh 2008). However, to achieve sustainable business success an organization has to use relevant performance measures (Neely et al. 2000). Furthermore, to be able to measure effectiveness and efficiency of logistics a suitable financial and non-financial performance measurement system is needed that can inform the numerous stakeholders at the strategic, tactical and operational level (Long 1997) ensuring simplified communication among supply chain actors and increased transparency of supply chain and logistics processes (Gunasekaran and Kobu 2007). A performance measurement system is a central part of performance measurement guiding management towards better decision making (Caplice and Sheffi 1995), as either measurement or management separately lead to incomplete conclusions (Srimai et al. 2011).

As no such system exists for the humanitarian aid sector, the aim of this chapter is to (1) explore and develop criteria of a good performance measurement system applicable to the humanitarian supply chain context and (2) evaluate the suitability —in terms of the developed criteria—of well-known systems from the commercial setting (Balanced Score Card, SCOR Model and Performance Prism) in monitoring supply chain management (SCM) performance and achieving sustainable results. This chapter is structured as follows: the first section will set the scene by outlining the specificities of the humanitarian sector that need to be considered when creating evaluation criteria for a humanitarian performance measurement system. Next, drawing on Caplice and Sheffi (1995) an overview of what is considered to be a good performance measurement system in the commercial sector for adaption to the humanitarian setting will be outlined. Following, we evaluate existing commercial performance measurement systems applying the criteria developed for the humanitarian supply chain context. The final section concludes with recommendations for future developments in the area of supply chain performance measurement and management.

13.2 Theoretical Background

The centrality of SCM to any relief operation was established by the seminal work of Long and Wood (1995), defining humanitarian SCM as an umbrella term for providing disaster relief and long term support for developing regions. Broadly speaking, foreign aid-assisted projects can be categorised as development aid and emergency aid. Whereas development aid is constantly given to a country over

longer periods of time in the form of education, roads, goods etc. in order to develop, emergency aid is provided to countries over a shorter period after e.g. a disaster in order to provide basic needs to the people experiencing difficulties in these situations.

The overall aim of humanitarian aid is to rapidly provide relief (often a matter of life or death) and alleviate suffering with the intention to firstly safe and sustain lives and then (re)create self-sufficiency (Thévenaz and Resodihardjo 2010). While both, development and emergency aid are aimed at reducing vulnerability (McEntire 2004), reducing the risks from disasters is central to the success of development itself (International Federation of Red Cross and Red Crescent Societies 2002). However, Oloruntoba and Gray (2009) point out that there appears to be an inadequate link between emergency and development aid coordination in many organizations even though there is a complex relationship between the two: losses from natural disaster can arise due to unsustainable development initiatives, while disaster can wipe out years of development in a matter of seconds.

Humanitarian supply chains may be partially commercial as for-profit companies undertake production and some of the transport and logistics activities (Jahre et al. 2009). Furthermore, Ernst (2003) suggests that commercial and non-profit logistics have a lot in common since both are managing the flow of goods, information and finances. Specific logistical activities and functions during humanitarian operations include inventory management, transport and capacity planning, information management and technology utilization, procurement, human resource management and collaboration with chain partners (Pettit and Beresford 2009; Blecken et al. 2009). Specifically development supply chains are often compared to 'regular' commercial supply chains as they are predictable and stable in terms of structure and activities. The management of emergency chains on the other hand differs on various levels (Beamon and Balcik 2008) due to the unique and very complex nature of disasters (Long and Wood 1995). While 'regular' SCM usually deals with a predetermined set of suppliers, manufacturing sites, business partners and stable or at least predictable demand, disaster SCM is characterized by large scale operations, irregular demand, unusual constraints in large scale emergencies and unreliable, or non-existent supply and transportation information—primarily unknown factors (Kovács and Spens 2007). Due to the nature of the unknown (locations, type and size of events, politics and culture, organizations involved) the configuration of a distribution network and relationships within is challenging (Beamon 2004). Furthermore, disaster management organizations deal with (almost) zero lead time in their supply chain as there may be no advance warning of a crisis, which in turn affects inventory availability, procurement and distribution. Often information is very limited at the beginning of a disaster (Tomasini and Van Wassenhove 2009) requiring organizations to make trade-offs between speed, cost and accuracy regarding the type and quantity of goods (Maon et al. 2009).

Further complicating humanitarian SCM is the nature of funding and conflicting interests of donors, benefit providers and recipients (Beamon and Balcik 2008). Investments in research, information systems, infrastructure and other long-term projects are restricted (Blecken 2010) leading to inadequate use of technology or

even non-existence of IT (Thomas and Kopczak 2005) that is crucial for effective and efficient supply chain operations. Additionally, there is a shortage of qualified logisticians in humanitarian organizations. A survey conducted by Oloruntoba and Gray (2003 in Oloruntoba and Gray 2006) shows that 80 % of 45 international aid organizations have a specific staff member for logistics and transport of which only 45 % have a formal qualification in logistics, transport or related areas. This can partially be explained with the high turnover of staff in the area (up to 80 %) leading to many workers with limited supply chain experience and training (Stephenson Jr, 2005). The unique and complex setting for disaster supply chains and these problems stand in contrast to the pressure from the numerous and very diverse stakeholders to show outcome driven results (Beamon and Balcik 2008) largely influenced by effective and efficient SCM.

13.3 Evaluation Framework

13.3.1 Literature Based Criteria

Modern SCM revolves around supporting business strategy (effectiveness) at minimum cost (efficiency), while being prepared for disruptions and geared towards quickly restoring operations (resilience) (Gatignon et al. 2010). The process of quantifying efficiency and effectiveness of actions is called performance measurement (Neely et al. 1995) and involves the identification, tracking and communication of performance results using performance indicators.

Moxham (2009) points out that in designing performance measurement systems, private and public sector literature promotes the consideration of relevance, integration, balance, strategy and improvement (Bititci et al. 2005; de Bruijn and van Helden 2006). A performance measurement system monitors business progress, the effect of strategies, plans, supports diagnoses and decision making, guides operations and facilitates motivation and communication (Chan et al. 2006; Beamon 1999) so that sustainability can be ensured.

To assess the actual strengths and weaknesses of an organization's logistics performance measurement system Caplice and Sheffi (1995) develop six evaluation criteria (Table 13.1). Accordingly, a performance measurement system "should be comprehensive, causally oriented, vertically integrated, horizontally integrated, internally comparable and useful" (Caplice and Sheffi 1995, p. 63). Similarly, Weidinger and Platts (2012) identify criteria such as clear structure, content, responsibility and purpose, accountability, result-orientation, action-orientation and communication to evaluate a performance measurement system. In this chapter we will draw on the evaluation criteria of Caplice and Sheffi (1995) as they are well-established and were empirically tested by the authors in two worldwide well-known companies achieving successful results.

Table 13.1 Evaluation criteria (Caplice and Sheffi 1995)

Criterion	Description
Comprehensiveness	The measurement system captures all relevant constituencies and stakeholders for the process
Causally oriented	The measurement system tracks those activities and indicators that influence future as well as current performance
Vertically integrated	The measurement system translates the overall firm strategy to all decision makers within the organization and is connected to the proper reward system
Horizontally integrated	The measurement system includes all pertinent activities, functions, and departments along the process
Internally comparable	The measurement system recognizes and allows for trade-offs between the different dimensions of performance
Useful	The measurement system is readily understandable by the decision makers and provides a guide for action to be taken

For any organization (for-profit and non-profit) effective operations require continual assessment of strategy to maintain consistency between efforts and the operating world (Hatten 1982). However, although the area of performance measurement is known to be crucial for performance improvement, research to date provides little insight into how effective performance indicators can be selected in the humanitarian context (Van der Laan et al. 2009). Additionally, the development of relevant performance measurement systems would help to guide humanitarian aid actors in their decision making, help improve the effectiveness and efficiency of relief operations while increasing transparency and accountability of operations (Beamon and Balcik 2008). By reflecting on the performance of humanitarian aid supply chains improvement needs could be identified easier that can be translated into concrete action steps as well as monitoring and standardization procedures (Schulz and Heigh 2009).

Research from 2013 identifies ten journal articles, one master thesis and one book chapter (Abidi and Klumpp 2013) dealing with the topic of performance measurement in supply chains (see Table 13.2); only two of these studies (Schulz and Heigh 2009; de Leeuw 2010) explicitly discuss performance measurement in the context of a performance measurement system—the balanced scorecard (BSC). However, as performance measurement and management in the humanitarian setting is particularly difficult due to the intangibility of services, immeasurability of the mission, unknown outcomes and the variety, interests and standards of stakeholders (Beamon and Balcik 2008) it is necessary to explore the applicability of such a commercial performance measurement system to the humanitarian setting first. Therefore, following, we adapt the criteria established by Caplice and Sheffi (1995) to the specificities of humanitarian supply chains. Table 13.3 displays the six criteria of an 'appropriate' performance measurement system for the humanitarian aid setting distinguishing between emergency and development aid based on our analysis of literature. The next sections will further elaborate on the criteria.

Table 13.2 Sources related to humanitarian performance measurement (Abidi and Klumpp 2013)

Year	Sources	Title	Author
2001	Transportation research: part A: policy and practice	Measuring post-disaster transportation system performance: the 1995 Kobe earthquake in comparative perspective	Chang and Nojima
2006	Master thesis (MIT)	Key performance indicators in humanitarian logistics	Davidson
2007	Journal of the operational research society	Large-scale data envelopment analysis (DEA) implementation: a strategic performance management approach	Medina-Borja et al.
2007	Disaster prevention and management	Balanced scorecard for natural disaster management	Moe et al.
2008	International journal of public sector management	Performance measurement in humanitarian relief chains	Beamon and Balcik
2009	International journal of services technology and management	A humanitarian supply chain process reference model	Blecken et al.
2009	Management research news	Logistics performance management in action within a humanitarian organization	Schulz and Heigh
2009	International journal of risk assessment and management	Performance measurement in humanitarian supply chains	Van Der Laan et al.
2009	Management research news	Not-for-profit supply chains in interrupted environments. The case of a faith-based humanitarian relief organization	McLachlin et al.
2010	IFIP advanced in information and communication technology	Towards a reference mission map for performance measurement in humanitarian supply chains	de Leeuw
2011	Book chapter	Humanitarian logistics metrics	Tatham and Hughes
2011	International journal of public administration	Measuring the immeasurable? The effects-based approach in comprehensive peace operations	Rietjens et al.

13.3.1.1 Comprehensiveness

For a performance measurement system to be ‘comprehensive’ in the humanitarian aid setting it needs to be able to consider not only the needs of beneficiaries in terms of specific economical, religious and traditional beliefs, social practices, political and security factors and coping mechanisms (The Sphere Project), but also the demands of various other stakeholders such as donors, staff and volunteers,

Table 13.3 Evaluation criteria for the humanitarian supply chain sector (based on literature review)

Criterion	Emergency	Development
Comprehensiveness	Beneficiaries, donors, governments, NGOs/INGOs, suppliers (including 3PLs), staff/volunteers, media, governments, military (Oloruntoba and Gray 2009; IFRC 2014)	Beneficiaries, donors, governments, NGOs/INGOs, suppliers (including 3PLs), staff/volunteers, media, governments, military (Oloruntoba and Gray 2009; IFRC 2014)
Causally oriented	Following indicators and activities influence future as well as current performance: Considerations of resources and output (efficiency), outcome and impact (effectiveness) as well as adaptability (flexibility) (Beamon 1999; Buckmaster 1999; Hofmann et al. 2004; Tatham and Hughes 2011) in *temporary networks* (Jahre et al. 2009)	Following indicators and activities influence future as well as current performance: Considerations of resources and output (efficiency), outcome and impact (effectiveness) as well as adaptability (flexibility) (Beamon 1999; Buckmaster 1999; Hofmann et al. 2004; Tatham and Hughes 2011) in permanent networks (Jahre et al. 2009)
Vertically integrated	• Translation of the overall firm strategy (Van der Laan 2009; Van Wassenhove 2006; Kovács and Spens 2011b; Jensen 2012) – Internally Strategic: mission effectiveness and financial sustainability Tactical: SCM Operational: project – Externally: collaboration	• Translation of the overall firm strategy (Van der Laan 2009; Van Wassenhove 2006; Kovács and Spens 2011b; Jensen 2012) – Internally Strategic: mission effectiveness and financial sustainability Tactical: SCM Operational: program – Externally: collaboration
	• Reward system	• Reward system
Horizontally integrated	All pertinent activities, functions and departments along the process during preparedness, immediate response and recovery including: inventory management; transport and capacity planning; information management and technology utilization; procurement; human resource management; collaboration (Pettit and Beresford 2009; Blecken et al. 2009) as well as continuous improvement	All pertinent activities, functions and departments along the process during *mitigation*: minimizing the negative impacts on human, social and economic environments (Moe et al. 2007); transport and capacity planning; information management and technology utilization; procurement; human resource management; continuous improvement; collaboration (Pettit and Beresford 2009; Blecken et al. 2009) as well as continuous improvement

(continued)

Table 13.3 (continued)

Criterion	Emergency	Development
Internally comparable	• Recognizes and allows for trade-offs between – Conflicting interests of donors, benefit providers and recipients (Beamon and Balcik 2008) – Speed-cost-accuracy	• Recognizes and allows for trade-offs between conflicting interests of donors, benefit providers and recipients (Beamon and Balcik 2008)
	• Customized to each country's specification (Van der Laan 2009)	• Customized to each country's project specification (Van der Laan 2009)
	• Accounts for cultural nuances impacting activities (Tatham and Hughes 2011)	• Accounts for cultural nuances impacting activities (Tatham and Hughes 2011)
Useful	Provide action oriented information (McLachlin et al. 2009)	Measuring success of a project by its contribution (McLachlin et al. 2009)

the media, the military, suppliers and governments (Oloruntoba and Gray 2006; IFRC 2014; Logistics Cluster 2014). A system applicable to both development and disaster aid should therefore be able to consider multi-dimensional performance measurements covering e.g. beneficiaries and donors satisfaction, efficient processes between humanitarian agencies, suppliers and employees as well as key performance indicators that show budget and costs results.

13.3.1.2 Causally Oriented

The criterion 'causally oriented' explores and determines whether a system allows for the evaluation of a process in terms of its results e.g. order fulfillment rates, on time delivery or beneficiaries' satisfaction. Therefore, for both, development and emergency aid, the system needs to be able to consider key performance indicators in relation to resources allocation and output (efficiency), outcome and impact (effectiveness) as well as adaptability (flexibility) (Beamon 1999; Buckmaster 1999; Hofmann et al. 2004; Tatham and Hughes 2011). Furthermore, the performance measurement system should not only be able to allow for indicators in relation to temporary networks (Jahre et al. 2009) during the response phase of an emergency, and permanent network covering long-term goals in terms of development, but also the interrelation of disaster and development aid goals as these need to be linked.

13.3.1.3 Vertically Oriented

For a performance measurement system to be 'vertically integrated' it needs to facilitate the translation of strategy to all decision makers within an organization at

each level of an organization, linked to a proper reward system (Caplice and Sheffi 1995). For both development and emergency aid this criterion has to be divided into an internal and external perspective: while the internal perspective covers the vision of humanitarian agencies at strategic level (mission effectiveness and financial sustainability), tactical level (management of the whole supply chain) and operational level (disaster aid: measurement at project level, development aid measurement at program level) (Van der Laan 2009; Van Wassenhove 2006; Kovács and Spens 2011a; Jensen 2012), the external perspective makes sure that the measurement framework allows for the set-up of key performance indicators in relation to the network of a humanitarian organization i.e. collaborative partners (e.g. Van der Laan 2009; Van Wassenhove 2006; Kovács and Spens 2011a; Jensen 2012).

13.3.1.4 Horizontally Integrated

The criterion 'horizontally integrated' evaluates whether a performance measurement system is able to incorporate all activities and processes in the value and supply chain. For the humanitarian setting this implies that a system needs to be able to cover all supply chain activities, functions as well as department i.e. inventory management, transport and capacity planning, information management and technology utilization; procurement, human resource management, collaboration (Pettit and Beresford 2009, Blecken et al. 2009). Furthermore, for development aid the system needs to allow for key performance indicators that measure mitigation activities such as reducing the risks from natural disasters and minimizing the negative impacts on human, social and economic environments (Moe et al. 2007). In addition continuous improvement and lessons learnt should be considered.

13.3.1.5 Internally Comparable

A performance system can be considered 'internally comparable' if it ensures that decision takers are supported in the choice they make. For a performance measurement system to be internally comparable within the humanitarian aid setting it needs to allow for visibility in the whole supply chain considering each country´s specification (Van der Laan 2009) during emergencies as well as on-going development initiatives. Furthermore, the system should allow decision makers to account for cultural nuances that might impact activities (Tatham and Hughes 2011). Allowing to make trade-offs between (1) conflicting interests of donors, benefit providers and recipients (Beamon and Balcik 2008) and (2) speed, cost and accuracy is essential.

13.3.1.6 Useful

The criterion 'useful' evaluates whether the system is readily understandable by decision makers and able to provide a guide for actions to be taken. Hence, for disaster

aid the system needs to provide action oriented information and for development aid success of a project by its contribution i.e. to the promotion of peace in the area need to be includable (McLachlin et al. 2009). An improved understanding of how to design, implement and use humanitarian chain performance measurement is a key lever for improving performance (de Leeuw 2010).

13.3.2 Empirical Based Criteria

To develop an evaluation framework for performance measurement systems in the humanitarian supply chain context that is theory-driven as well as managerial relevant we also sent out 20 questionnaires to academics and practitioners active in the sector. The questionnaire was split into two parts: (1) general questions including organization, position, experience in (humanitarian) supply chain sector and (2) an overview of the Sheffi and Caplice (1995) criteria that we asked participants to apply to the humanitarian SCM setting i.e. asking what specific elements have to be taken into account for emergency and development supply chains so that a system can be considered comprehensive, causally oriented, vertically integrated, horizontally integrated, internally comparable and useful.

Table 13.4 gives an overview of respondents included in our study. Additionally, we had a respondent (not included in the Table 13.4) who highlighted that he/she did not consider a performance measurement system to be useful for her/his organization. While the number of questionnaires incorporated here seems to be limited they support the evaluation criteria for the humanitarian sector derived from literature (Table 13.3). At the same time, we were able to supplement the criteria with additional practitioner insights. Table 13.5 below displays our adapted criteria, depicting previously from literature not identified subjects in italic.

Table 13.4 Overview of the respondents

Respondent	Job	Organization	Experience in years in the supply chain sector
1	Researcher	University in the Netherlands	1
2	Researcher	University in Germany	11
3	Director	University in Germany	20
4	Head of corporate communication and responsibility	Logistics Service Provider (private and humanitarian operations sector)	20
5	Operations management and logistics unit	Humanitarian organization	11
6	Field officer	Humanitarian organization	2

Table 13.5 Performance measurement evaluation framework for humanitarian supply chain sector

Criterion	Emergency	Development
Comprehensiveness	Beneficiaries, donors, governments, NGOs/INGOs, suppliers (including 3PLs), staff/ volunteers, media, governments, military (Oloruntoba and Gray 2009; IFRC 2014; Logistics Cluster 2014)	Beneficiaries, donors, governments, NGOs/INGOs, suppliers (including 3PLs), staff/ volunteers, media, governments, military (Oloruntoba and Gray 2009; IFRC 2014)
Causally oriented	Following indicators and activities influence future as well as current performance: considerations of resources and output (efficiency), outcome and impact (effectiveness) as well as adaptability (flexibility) (Beamon 1999; Buckmaster 1999; Hofmann et al. 2004; Tatham and Hughes 2011) in *temporary networks* (Jahre et al. 2009)	Following indicators and activities influence future as well as current performance: considerations of resources and output (efficiency), outcome and impact (effectiveness) as well as adaptability (flexibility) (Beamon 1999; Buckmaster 1999; Hofmann et al. 2004; Tatham and Hughes 2011) in *permanent networks* (Jahre et al. 2009)
Vertically integrated	• Translation of the overall firm strategy (Van der Laan 2009; Van Wassenhove 2006; Kovács and Spens 2011b; Jensen 2012) – Internally − Strategic: mission effectiveness and financial sustainability Tactical: SCM Operational: project – Externally: collaboration	• Translation of the overall firm strategy (Van der Laan 2009; Van Wassenhove 2006; Kovács and Spens 2011b; Jensen 2012) – Internally Strategic: mission effectiveness and financial sustainability Tactical: SCM Operational: program – Externally: collaboration
	• Reward system	• Reward system
		• *Sanction measures: effectiveness of sanctions, follow up actions for sustainability, focus on strategy*
Horizontally integrated	All pertinent activities, functions and departments along the process during preparedness, immediate response and recovery including: inventory management; transport and capacity planning; information management and technology utilization; procurement; human resource management; collaboration (Pettit and Beresford 2009; Blecken et al. 2009) as well as continuous improvement	All pertinent activities, functions and departments along the process during *mitigation*: minimizing the negative impacts on human, social and economic environments (Moe et al. 2007); transport and capacity planning; information management and technology utilization; procurement; human resource management; continuous improvement; collaboration (Pettit and Beresford 2009; Blecken et al. 2009) as well as continuous improvement

(continued)

Table 13.5 (continued)

Criterion	Emergency	Development
Internally comparable	• Recognizes and allows for trade-offs between – Conflicting interests of donors, benefit providers and recipients (Beamon and Balcik 2008) – Speed-cost-accuracy including: *the burn rate, turnover, documentation/transparency vs immediate response in disasters* • Customized to each country's specification (Van der Laan 2009) • Account for cultural nuances impacting activities (Tatham and Hughes 2011)	• Recognizes and allows for trade-offs between – Conflicting interests of donors, benefit providers and recipients (Beamon and Balcik 2008) – *Cost-accuracy including: the burn rate* • Customized to each country's project specification (Van der Laan 2009) • Accounts for cultural nuances impacting activities (Tatham and Hughes 2011)
Useful	Provide action oriented information (McLachlin et al. 2009)	Measuring success of a project by its contribution (McLachlin et al. 2009)

13.4 Evaluation of Performance Measurement Systems

Performance measurement systems have been developed to support businesses in the assessment of their effectiveness and efficiency in order to be sustainable. In academia as well as practice an excess of performance measurement frameworks exist (Kennerly and Neely 2002). The most common performance systems that are used in SCM practice are the BSC (Kaplan and Norton 1992; Kaplan and Norton 2001; Manville and Broad 2013) and the SCOR model (Supply Chain Council 2007; Theeranuphattana and Tang 2008). While the former assists decision makers to evaluate their business activities from a financial, customer, learning and growth as well as internal processes perspective (Kaplan and Norton 1992), the SCOR model allows for the decomposition of performance on four levels identifying processes that need to be studied further (Supply Chain Council 2007). Both frameworks are second generation performance measurement systems moving beyond the pure financial perspective of previous frameworks (Bourne et al. 2003) such as the DuPont system that links financial indicators from different organizational levels to return on investment in a hierarchical structure (Kennerly and Neely 2002). Other second generation frameworks are the performance prism by Neely and Adams (2000), which takes a stakeholder centric view of performance measurement, the performance measurement matrix integrating financial and non-financial as well as internal and external aspects (Keegan et al. 1989) and the Strategic Measurement and Reporting Technique (SMART) pyramid which includes internal and external indicators to measure the overall business operating system (Lynch and Cross 1991).

The balanced scorecard and the performance prism have been explicitly linked to voluntary organizations. Therefore, these two framework together with the SCOR model, which has been designed specifically for the SCM context, will be reviewed in the next paragraphs in relation to the previously established criteria for a good performance measurement system for humanitarian SCM.

13.4.1 Performance Prism

The performance prism developed by Neely and Adams (2000) allows for a balanced picture of an organization highlighting external and internal measures while considering financial and non-financial performance results (Neely et al. 2001; Purbey et al. 2007). More specifically it consists of five distinct but interrelated facets (as displayed in Fig. 13.1) with the following questions for an organization to address when defining performance measures:

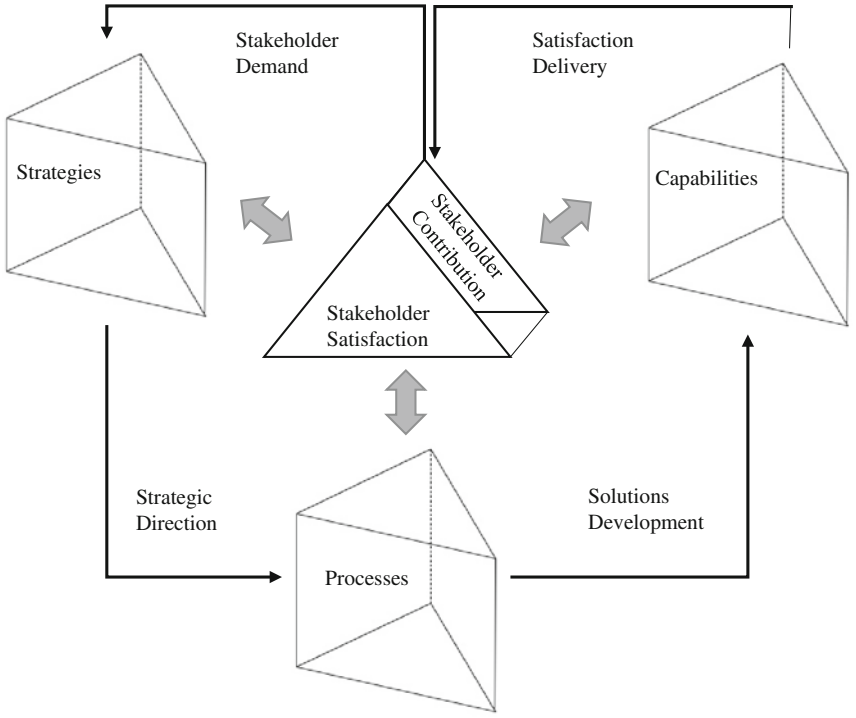

Fig. 13.1 Performance prism framework (Kennerley and Neely 2002)

- Stakeholder Satisfaction: Who are our stakeholders and what do they want and need?
- Strategies: What strategies do we need to put in place to satisfy these sets of wants and needs?
- Processes: What processes do we need to put in place to satisfy these sets of wants and needs?
- Capabilities: What capabilities—bundles of people, practices, technology and infrastructure—do we need to put in place to allow us to operate our processes more effectively and efficiently?
- Stakeholder Contribution: What do we want and need from our stakeholders?

The first facet of the performance prism is related to stakeholder needs as after all the only reason an organization has a strategy in the first place is to deliver value to them (Neely et al. 2001). Only after the wants and needs of stakeholders, which can all have a substantial impact on the performance and success of an organization, have been considered specific strategies can be formulated in the second step (Tangen 2004; Neely et al. 2001). Next, processes which are the engine of value enhancement as well as capabilities regarded as combinations of people, practices, technologies and infrastructure necessary for an organization's ability to compete (Adams and Neely 2000) are defined and put into place. In the final facet the prism considers possible contributions of stakeholders. The prism deliberately separates stakeholder satisfaction from stakeholder contribution as the two sides of the relationship have completely different requirements (Powell 2004) yet a healthy performing organization requires both the organization and the stakeholders to benefit and contribute. Considerations of each of the five facets warrants that the framework can be used at any organizational level, integrating both the organization's functions and its hierarchy (Kennerley and Neely 2002).

In the non-profit setting in general there is a necessity to identify key stakeholders as there is a danger of producing a multitude of performance measures that satisfy no one (Wisniewski and Stewart 2004). Here lies one of the strengths of the performance prism as it takes a stakeholders centric view (Tangen 2004; Striteska and Spickova 2012). This is particularly important for humanitarian aid SCM in view of the multitude of stakeholders that need to be considered to make a measurement framework comprehensive in line with the criteria set out in Table 13.6.

Previous research highlighted that it can be challenging to measure impact of humanitarian operations due to difficulties in identifying a causal relationship between a particular activity and a particular outcome (Moxham and Boaden 2007; Wainwright 2003). Furthermore, there is a danger of losing sight of efficiency while considering multitude of goals of the various stakeholders e.g. beneficiary vs. donor. However, the performance prism explicitly makes managers think through the links between measures in a way that other frameworks do not intuitively suggest (Neely et al. 2001). As the organization is seen as a set of processes (horizontal integration of activities and functions) for which specific capabilities are needed (these can be customized to specific locations) different sets of goals can be considered. It remains however unclear if and how it can be used for continuous improvement

Table 13.6 Evaluation of the performance measurement systems: performance prism

Criterion	Prism
Comprehensiveness	Takes a stakeholders centric view
Causally oriented	Creates a balanced picture of the organization by considering different resources inputs (capabilities and stakeholder contribution), while ensuring outcomes (goals and strategies) are met to achieve a certain impact (stakeholder needs)
Vertically integrated	Starts with stakeholder needs which might be different and/or conflicting when compared to the mission and strategy of the organization
Horizontally integrated	The organization and its functions are seen as set of processes. Furthermore no considerations of continuous improvement and lessons learnt
Internally comparable	All stakeholders are considered = goals are the same for everyone in the organization
Useful	There is no link between the performance prism facets and implementation of measures in the field; limited applicability to date. It remains unclear if it supports decision makers in their decision

and/or lessons learnt. Nevertheless, the framework enables a balanced picture of an organization highlighting external (stakeholders) and internal (strategies, processes and capabilities) measures (Kennerley and Neely 2002). This helps to map out and establish the interrelations between the different performance dimensions (set out in step 2 as strategies and in step 3 assigned to specific processes) and establish cause and effect relationships including stakeholder needs versus contribution (Wisniewski and Stewart 2004). Moullin (2002) shows how the performance prism can be used to develop a 'success map', considering the main stakeholders and needs of each group, based upon which measures can be established following an integrative strategy (McAdam et al. 2005). Hence, the framework is very much suitable to fulfil the criteria causally oriented, horizontally integrated and internally comparable in the humanitarian SCM setting.

However, while generally positive and congruent with our criteria, there are some concerns in relation to vertical integration. As the prism starts with considerations of stakeholders rather than strategy it is easy to lose track of mission effectiveness (the reason for the existence of humanitarian aid organizations) as well as financial sustainability. At the same time, it is unclear how collaboration with other NGOs, which is of paramount importance as no single organization has sufficient resources to respond to a disaster situation on its own (Balcik et al. 2010), can be incorporated as these cannot be considered main stakeholders and change from event to event. Furthermore, it has to be pointed out that the usefulness of the framework is questionable as overall application of the performance prism in practice is limited (Micheli and Kennerley 2005). While Neely et al. (2000) describe different implementation processes of performance measurement in the practice, there seems to be no link between the described facets of the performance

prism framework and how to implement specific measures of performance in the field. Finally, there is no evidence how the prism supports decision makers in their action.

13.4.2 Balanced Scorecard

In the early 90s Kaplan and Norton designed and developed the BSC. This performance measurement system allows decision makers of organizations to get a comprehensive and transparent overview about the vision and strategy from a financial, customer, internal business as well as innovation and learning (growth) perspective (Kaplan and Norton 1992)—see Fig. 13.2:

- the customer perspective deals with questions in relation to how customers see the organization;
- the internal perspective of the BSC provides an answer to the question of what the organization has to excel at;
- the learning and growth perspective looks for answers to the question of how an organization can continue to improve and create value; and
- the financial perspective deals with improving the bottom-line of an organisation.

The BSC balances internal and external measures, hence, highlights specific internal organizational processes and external outcomes that support an organization in continuously improving results and as a consequence overall performance. The systems indicators "are grounded in an organizations strategic objectives and competitive demands" (Kaplan and Norton 1998, p. 318) while facilitating their translation into action. Decision makers have the ability to select critical and

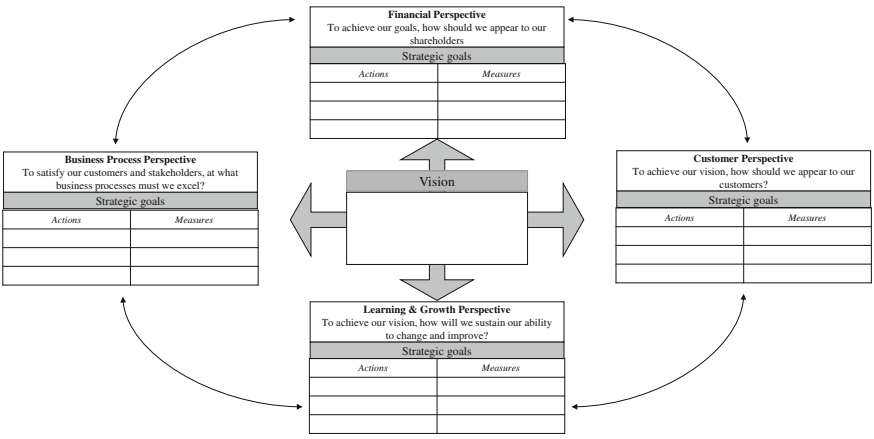

Fig. 13.2 Balanced scorecard (Kaplan and Norton 1996)

necessary performance indicators within each of the four perspectives in line with their organizational strategy. Kaplan and Norton recommend determining four to five indicators at each perspective.

Humanitarian organizations have to coordinate and provide services to multiple stakeholders, each with different objectives at different levels (see e.g. Norrekit 2000; Jensen 2012). Therefore, as highlighted previously, considerations of different stakeholders are immensely important in the non-profit sector. By only considering shareholders and customers the BSC cannot directly be considered comprehensive in light of our established criteria. However, as the term customers can be interpreted as donors or beneficiaries in the humanitarian setting other stakeholders can possibly be included. Therefore, the BSC can be considered somewhat comprehensive.

The BSC reports about current and future successes; priorities can be defined and communicated to employees, customers, decision makers and shareholders (Kaplan and Norton 1992, 1998). Furthermore, the BSC provides cause and effect assumptions, ensures transparency among included stakeholders and enables measurement of the efficiency of a supply chain network (Erdmann 2003). Hence, the system can be considered causally oriented, even though it remains unclear how to include the complete impact of humanitarian operations due to the lack of comprehensiveness that does not allow for all stakeholders to be included.

As the BSC facilitates the selection of measurement based on strategic objectives within each of the four perspectives, mission effectiveness and financial sustainability, both important in the humanitarian setting, can be accounted for. At the same time, these strategic objectives can be translated into specific SCM goals on a project and program level basis internally. Externally, however, it is necessary for collaborative supply chain parties to integrate a BSC as well. Taking into account that there are numerous stakeholders involved in the humanitarian supply chain sector this can be difficult. Hence, overall, the BSC can be considered somewhat vertically integrated in terms of the humanitarian SCM criteria. A key part of the BSC is the feedback and learning which allows for continuous improvement highlighting an important part of the criteria horizontal integration. At the same time however, failure of the BSC to involve human resources and not facilitating the measurement of operational activities that are executed in alliances or cooperation within the supply network bounds its horizontal integration (Kennerly and Neely 2002).

The BSC allows to consider trade-offs between the different dimensions of performance, which can be in relation to cultural nuances, language or specific country specifications, which is needed to be considered internally comparable in the humanitarian SCM setting. However, William and Lewis (2008) highlight that the implementation of the BSC in non-profit organization has the potential to be more damaging than helpful. Moreover, Neely and Bourne (2000) show that 70 % of balanced scorecard implementations fail due to poor design and implementation. Therefore, the usefulness of the BSC has to be assessed with care. An overview of all the established criteria in relation to the BSC is given in Table 13.7.

Table 13.7 Evaluation of the performance measurement systems: BSC

Criterion	BSC
Comprehensiveness	Only considers two stakeholders: shareholders and customers
Causally oriented	Reports current and future successes providing causes and effects based on assumptions. Is not an appropriate tool that considers collaboration or supplier relationship management because it requires different actors of a supply chain to implement a BSC
Vertically integrated	Provides information to decision makers at strategic, tactical and operational level about how well their business is running and whether its products and services match customer requirements at the strategic level
Horizontally integrated	Does not translate the overall strategy of the organization to all decision makers among the organization and it is not connected to an appropriate reward system. Taking into account that it does not consider all pertinent activities and it focusses on the four perspective (customer, internal, learning and growth as well as financial). Furthermore considerations of continuous improvement and lessons learnt is given if the actors along the supply chain have integrated the BSC
Internally comparable	Recognizes trade-offs between the different dimensions
Useful	• Does not allow transparency at a process level
	• Causalities have not been empirically tested
	• Supports the user in their decision makings and actions

13.4.3 SCOR Model

Traditional performance measurement systems have become less appropriate to measure and manage supply chains because they are too narrow in scope to address the broad range of activities across supply chains. The existing SCM performance measurement systems are difficult to use for practitioners due to the high number of indicators, definition of indicators and lack of clarity (Theeranuphattana and Tang 2008). To address these difficulties the Supply Chain Operations Reference Modell (SCOR) model as a business process reference model that enables users to address, improve and communicate SCM practices within and between all interested parties was presented in 1996 (Supply Chain Council 2007).

The SCOR model is applicable on four levels—see Fig. 13.3. Level 1 defines the scope and content of the supply chain by considering the five process types plan, source, make, deliver, return (traditional) and enable (extended model). Established metrics at Level 1 are known as strategic metrics or key performance indicators (KPIs) as they diagnose the overall health of the supply chain (Supply Chain Council 2007). Level 2 configures the process types from Level 1 into process categories, which determine the supply chain strategy or supply chain type (i.e. make-to-stock, make-to-order etc.) based on either the process categories in Level 2 themselves or the position within the supply chain (Supply Chain Council 2007). Level 3 processes describe the steps performed to put level 2 process categories into action

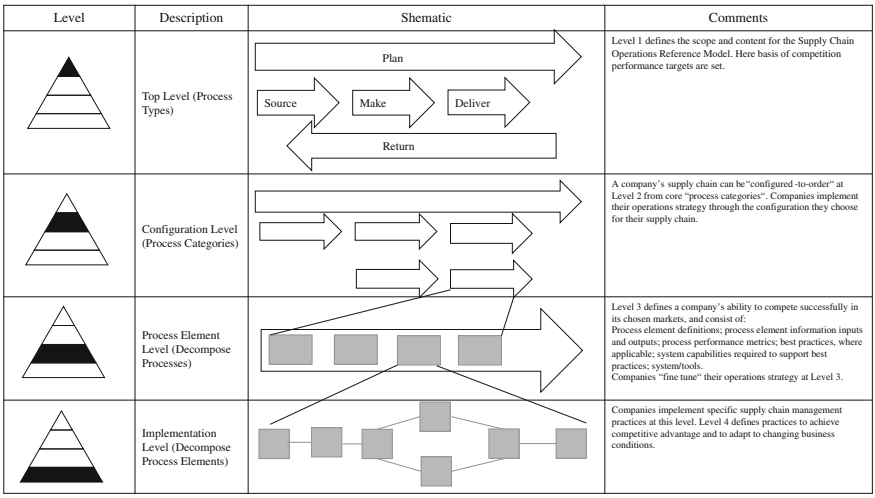

Fig. 13.3 SCOR model (Supply Chain Council 2007)

(Supply Chain Council 2007)—see also Fig. 13.3—while showing specific activities for each category defined in Level 2. Hence, level 1–3 of the SCOR model enable collaborative and effective SCM via benchmarking and efficient processes across the supply chain (Theeranuphattana and Tang 2008). Level 4 allows to achieve competitive advantages due to implementation of specific SCM practices.

The SCOR model illustrates management practices that produce best-in-class performance and provides a common language to facilitate horizontal process integration across different organizational units and actors in the supply chain. The system includes standard metrics to measure process performance including service levels. It is used in different industries across the globe.

The SCOR model has potential to be considered comprehensive in the humanitarian sector under the established criteria. As the system is only set-up to include supply chain members, indicators have to be re-defined to include other stakeholders i.e. donor, beneficiaries, military or government, that cannot be considered direct members of the process flows within a chain. While this is possible it will affect the usefulness of the system: a major strength of the system is that standard indicators which would require adjustment for additional stakeholders. Table 13.8 below gives an overview of all considerations of the BSC in relation to the established criteria.

Although the SCOR model can be rendered causally oriented due to its consideration possibilities in relation to future oriented financial indicators as well as outcome, adaptability, accountability and impact considerations, it has been criticized by academia for its process rather than strategic orientation (Gammelgaard and Vesth 2004). This effects the vertical integration capabilities of the framework in the humanitarian setting. At the same time it highlights a major strength of the framework:

Table 13.8 Evaluation of the performance measurement systems: SCOR model

Criterion	SCOR model
Comprehensiveness	Holds potential to include all necessary stakeholders
Causally oriented	Provides future oriented financial indicators and considers outcome, adaptability, accountability and impact
Vertically integrated	Provide the link between mission and strategy supporting strategic decision making. At the same time rather process oriented
Horizontally integrated	Specific supply chain processes can be measured at all levels: activities, functions and departments. Continuous improvement and lessons learnt are possible
Internally comparable	Provides a standard description of management processes and a common language across different organizational units and actors in the supply chain
Useful	Indicators have to be reduced, selected and re-defined for the humanitarian setting, taking away from the standardized approach

specifically set up for the supply chain context, the framework can be considered very horizontally integrated as it allows for all activities, functions and departments along the processes in a humanitarian supply chain to be integrated. Additionally, continuous improvement as well as lessons learnt are considered. Furthermore, SCOR provides a standard description of management processes and a common language to facilitate horizontal process integration across different organizational units and actors in the humanitarian supply chain, which allows for internal comparability.

A crucial issue with regards to the SCOR model is its usefulness. For applicability to humanitarian supply chains standard indicators need to be adjusted to allow for other crucial stakeholders to be included as well. Therefore, indicators have to be reduced, selected and re-defined for the specificities of the humanitarian context. While the flexibility of the system regarding measures can facilitate humanitarian SCM specific measures it takes away from one of the major strengths of SCOR: it provides standardized measures that can be used by all supply chain partners.

13.5 Discussion

The aim of this chapter is to (1) explore and develop criteria for a good performance measurement system in the humanitarian SCM context that can support the monitoring and ultimately achievement of sustainable results and (2) apply the established criteria to existing well known systems from the commercial setting. We have chosen the Balanced Scorecard, SCOR Model and Performance Prism for evaluation in light of our established criteria. All three systems show some potential for the adaption to the humanitarian SCM context, however with differing degrees and different considerations that need to be taken. Table 13.9 gives an overview and compares the systems across the established criteria in light of our analysis above.

Table 13.9 Evaluation of performance measurement systems

Criterion	Prism	Balanced score card (BSC)	SCOR model
Comprehensiveness	++	−	±
Causally oriented	++	−	+
Vertically integrated	±	±	−
Horizontally integrated	++	−	++
Internally comparable	+	+	+
Useful	−	−	±

++ fully congruent; + congruent; ± neutral; − partly incongruent; −− incongruent

As stressed in previous research (e.g. Wisniewski and Stewart 2004) the humanitarian supply chain sector needs to fully consider the diversity of stakeholders that can be interested in differing and possible conflicting performance measures (McAdam et al. 2005). Based on our analysis only the performance prism can be considered comprehensive by taking a stakeholder centric view. While the performance prism allows for any necessary stakeholder to be included BSC is limited to two stakeholders (shareholders and customers). However, considerations of the different stakeholders beyond shareholders and customers is of immense importance as highlighted by previous literature as well as the respondents of our questionnaire. Comprehensiveness in relation to the SCOR model can be considered neutral: while the system has the potential to include different stakeholders indicators it would have to be re-defined to include other relevant parties such as governments, beneficiaries or donors specific to humanitarian supply chains not considered in the original model that was designed for commercial supply chains. While this is possible the needed changes take away from the strength of the BSC in terms of established standardized measurements.

Among the three evaluated systems the Prism fulfills the causality criteria the most as it creates a balanced picture of the organization by considering different resource inputs (capabilities and stakeholder contribution), while ensuring outcomes are met (goals and strategies). The SCOR Model and BSC provide future oriented financial indicators and consider outcome, adaptability, accountability and impact. Hence, both systems can be considered causally oriented, even though it remains unclear how to include impact of operations due to the lack of comprehensiveness (only limited stakeholders are included).

The SCM humanitarian supply chain sector prefers a practitioner-oriented performance measurement system. That allows planning and controling supply chain by quantifying the efficiency and the effectiveness of past action (Neely et al. 2002). Nevertheless, the alignment of strategy and practice with vision and mission has to be ensured internally and externally with collaborative partners to allow for a long term orientation that leads to sustainable and successful operations. The BSC provides relevant and comprehensive information about the business at the strategic level from a customer, financial, learning and growth as well as internal business process perspective that can be translated into specific SCM goals e.g. customer (donors and beneficiaries) requirements. At the same time, this is difficult externally as the BSC

requires the numerous stakeholders involved in the humanitarian supply chain sector to implement the same system. Similar concerns in terms of vertical integration can be found when evaluating the performance prism. As the system is focused on meeting stakeholder satisfaction it can only be considered vertically integrated if the strategy of the organization is aligned with the need of all stakeholders. Again, due to the number of stakeholders involved in the sector this can be difficult. While BSC and prism can be considered neutral in terms of vertical integration, the SCOR model, scores negatively on this criterion: there are limited linkages between the defined humanitarian supply chain strategy with the overall humanitarian organizational strategy due to the process rather than strategic orientation of the system. Hence, in all three performance measurement systems vertical integration has to be evaluated with care.

While highlighting a weakness of the SCOR model in terms of vertical integration, the process orientation renders the system particularly horizontally integrated as all activities, functions and departments during preparedness, immediate response and recovery (emergency) as well as mitigation are included via plan, source, make, deliver and enable. Similarly, the Prism identifies the organization and its functions as a set of processes where inventory management, transport and capacity planning, information management and technology utilization, procurement, human resource management and collaboration can be considered. Therefore, the SCOR as well as the Prism are horizontally integrated providing decision making information at different levels including all activities along a supply chain. The BSC on the other hand can only be considered horizontally integrated to a limited extent: human resources are not involved and information exchange about operational activities performed in cooperation within the supply network cannot be displayed.

All three systems are internally comparable. They recognize and allow for trade-offs between the different dimensions of performance such as conflicting interests of donors, benefit providers and recipients (Beamon and Balcik 2008) as well as speed, cost and accuracy. Furthermore, they provide visibility as well as accountability to the organizations and support decision makers in their activities and actions considering cultural nuances and individual country specifications.

For any performance measurement framework to be of practical value (useful), the process of populating the framework has to be understood (Neely et al. 2000) and worked out with the employees at each level, in different countries as well as in the response phase or recovery phase. Furthermore, the performance measurement system should assist decision maker during operations and in the translation of their supply chain strategy into results. The usefulness of all three systems remains somewhat unclear as neither of them has received much attention in theory or practice.

13.6 Conclusion and Outlook

This chapter set out to (1) establish criteria for a good performance measurement system in the humanitarian SCM setting (2) use the established criteria to evaluate the suitability of commercial performance measurement system in the humanitarian

SCM context. Performance measurement and management are important for any kind of operation. However, particularly in the humanitarian aid sector, where limited resources have to be used in the most effective and efficient way, the measurement of performance is of paramount importance.

Due to the fact that humanitarian organizations are in need of a performance measurement system to e.g. plan and to control their overall supply chain or to monitor and evaluate their processes or to get support in their decision making, this research aimed to investigate the applicability of performance measurement systems in the humanitarian setting. We explored three performance measurement frameworks (Prism, BSC and SCOR Model) and come to the conclusion that all of them hold potential for implementation in the humanitarian setting, both in relation to emergency and development operations. However, particularly the Prism shows great opportunities as it not only allows for all stakeholders to be included, but also links mission, vision and strategy to operations and resources.

At the same time we have to take into account that there are other performance measurement systems (e.g. Results and Determinant framework which is developed by Fitzgerald et al. 1991), which we did no investigate, that might also hold potential for implementation in the humanitarian SCM context. Therefore, we suggest to explore other frameworks in future research. Additionally, these frameworks need to be empirically tested and implement in humanitarian organizations. This might prove to be difficult as our questionnaire pointed towards a limited awareness of respondants about the necessary criteria of a performance measurement system for humanitarian supply chains. We attribute this to the fact that the topic performance measurement in humanitarian supply chains is still in its infancy. As one respondent stated: "measuring performance is complicated by multiple competing objectives, and the fact that everything happens so fast and current events/actions are affected by previous ones". This strongly underlines the importance for future research on performance measurement systems and measures in the humanitarian aid supply chain context. Our study provides a much needed initial step supporting the increased interested of humanitarian organizations about performance management and measurement.

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