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Humanitarian Aid Logistics: Response Strategies in the 2015 Refugee Crisis

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Response Strategies in the 2015 Refugee Crisis

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Abstract

Humanitarian aid logistics is an emerging field that applies principles of supply chain management and logistics to the humanitarian relief sector. This thesis explores humanitarian aid logistics strategies in the context of the 2015 Refugee Crisis. An unprecedented number of refugees sought asylum in Europe beginning in 2015, where European officials and humanitarian organizations were largely unprepared to provide for them. The 2015 Refugee Crisis offers a unique perspective on humanitarian aid logistics because it requires both short-term and long-term response strategies. Through the framework of management science, a subfield of supply chain management, and logistics, this thesis creates a model that addresses the lack of adequate shelter sites and capacity for refugees in Greece. This is still a relevant problem today as a number of refugees still reside there, and the model adjusts for fluctuating capacity and conditions of the shelters. Long-term issues are discussed as the effects of the Crisis continue. Through analysis of short-term and long-term relief strategies, this thesis provides a foundational understanding of humanitarian aid logistics in crises that involve a complex network of stakeholders and unpredictable timelines. It is also useful for discussions about future implications of humanitarian aid logistics and other crises occurring in other parts of the world.

Executive Summary

This thesis explores the emerging field of humanitarian aid logistics and discusses applications of supply chain management and management science strategies and tools to the 2015 Refugee Crisis in Europe. Humanitarian aid logistics can be defined as 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 end beneficiaries' requirements. Within humanitarian relief, crises are unpredictable and lives are at stake. Therefore, the logistics of humanitarian relief organizations are complex as they must respond quickly and effectively to any given crisis occurring around the world.

I chose to analyze the 2015 Refugee Crisis because there are multiple stakeholders involved in managing the crisis, from governments, to relief organizations, to suppliers, to the refugees themselves. The effects from 2015 are still ongoing, and countries like Greece are struggling to host the high number of refugees entering its borders. The impact of the EU-Turkey Deal from 2016 affected the ability of refugees to continue migrating to other European countries, effectively trapping them in Greece while they await to be relocated. This presented a unique dilemma in that Greece had to find capacity to host thousands of refugees in its various shelters.

In order to address the lack of capacity among Greece's shelters, this paper presents a linear programming model which seeks to optimize the number of refugees across shelter locations. Data from the United Nations High Commissioner for Refugees (UNHCR) was obtained to utilize realistic numbers of refugees and capacity levels at each shelter. While the data reflects a short time window, and refugee movements fluctuated on a daily basis, the model serves as a basis for

short-term decision-making and the numbers can be adjusted as needed. By minimizing the amount of travel time between shelters, an optimal solution could be found.

Beyond short-term strategies, this paper discusses the use of weighted criteria and a preference matrix that considers the quality of the shelters. Many refugees spend years living in these shelters, some of which are considered to be substandard and inhumane. The use of a preference matrix prioritizes quality of shelters as a long-term strategy. There is also a discussion of the tradeoffs between effectiveness and efficiency; minimizing travel time and the optimal number of refugees between shelters and the quality of shelters. The long-term strategies that are discussed involve shelter innovation, integrating refugees into urban housing, and the use of a centralized logistics information system that would facilitate faster communication between stakeholders.

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Humanitarian Aid Logistics

Introduction

In the commercial world, supply chain management is at the core of a company's operations. Supply chain management focuses on the optimization of activities involving sourcing, procurement, logistics, and the coordination between channel partners including suppliers, intermediaries, third-party service providers, and customers. Logistics is one part of the supply chain that entails the planning, implementation, and control of forward and reverse flow of goods, services, and information between the point of origin and the point of consumption. By optimizing their supply chains, companies can maximize output while remaining cost efficient. Outside of the commercial world, though, supply chain management is also a critical component of non-profit organizations, states, and non-governmental organizations. Efficiency is made more difficult in the face of uncertainties regarding demand, availability, timeliness, costs, and many other real-world factors. This paper will examine the application of supply chain principles to the realm of humanitarian relief and disaster response strategies through analysis of humanitarian logistics in relation to the 2015 Refugee Crisis.

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 end beneficiaries' requirements (Blecken). Outside of standard functions, humanitarian supply chains also include aspects of donor-relationship management, resource assessment, supplier management and monitoring and evaluating the effect of aid that has been delivered (Dubey and Gunasekaran). Humanitarian supply chains are considered to be possibly the most complex type of supply chain and are often described as a response to unforeseeable and unplanned events that

range from small localized natural disasters through to catastrophic events affecting large regions and populations (Hughes, K.) Prior to the mid-2000s, the field of humanitarian logistics received little attention. However, humanitarian organizations are increasingly realizing the importance of supply chain management and logistics (Vojvodic et al). Organizations are prioritizing their logistics function, as it impacts the entirety of their operations and in many cases the outcome of saving lives and reducing suffering. 80% of all disaster relief efforts revolve around logistics (Dubey and Gunasekaran).

Humanitarian operations range from short-term humanitarian relief in response to acute emergencies to medium and long-term assistance focusing on recovery and reconstruction in post-emergency contexts (Blecken). In the first ten days of a humanitarian crisis, immediate concerns center around saving lives and providing basic necessities. This is known as a "bed for the night strategy", which is considered the classical approach to humanitarian relief (Barnett and Snyder). In this strategy, aid agencies should limit themselves to the impartial, independent, and neutral provision of relief to victims of conflict and natural disasters. Impartiality requires that assistance be based on need and not on the basis of nationality, race, religion, gender, or political opinion. Neutrality demands that humanitarian organizations refrain from taking part in hostilities or from any action that either benefits or disadvantages the parties to the conflict. Independence demands that assistance should not be connected to any of the parties directly involved in armed conflicts or who have a stake in the outcome. This is especially critical for aid agencies who rely on government funding, especially if the donors have a stake in the outcome (Weiss and Barnett).

After the initial stages of a crisis, humanitarian organizations focus their attention on short-term priorities. Some examples of short-term priorities include food security and preventing the outbreak of disease among vulnerable populations by providing access to clean water and

sanitation. Once the situation has become more stabilized, organizations look at medium and long-term priorities. They must ensure a constant supply of necessities, adequate housing, and health services. Long-term priorities are mainly concerned with sustainability, education, and development.

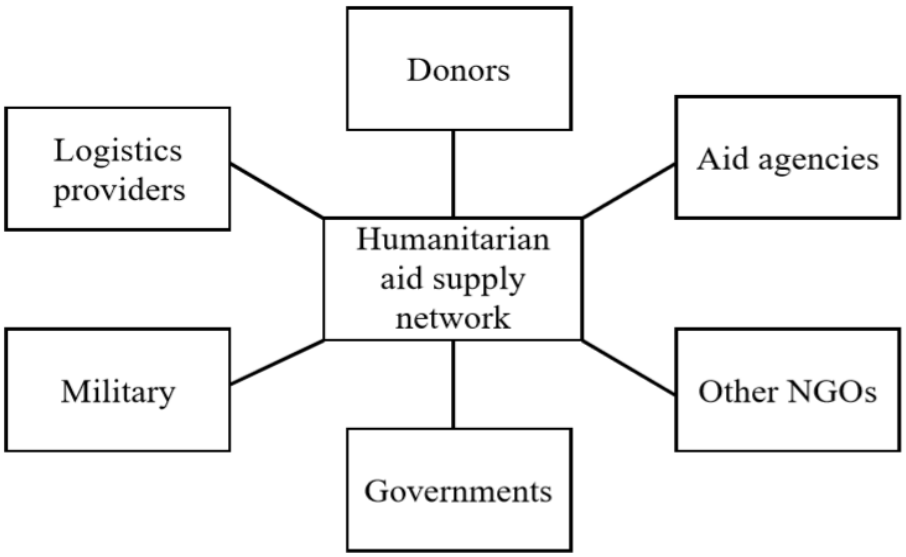
For most companies, optimizing their supply chain is usually aimed at maximizing profits. This often entails implementing the most cost-efficient measure while meeting quality or other performance goals. For humanitarian organizations, the focus is shifted to maximize the number of people who can be helped with the available funds. Due to the nature of urgency and quick response time, low cost is not always achievable. There is a tradeoff between time sensitivity and achieving low-cost solutions. Efficient supply chains can be implemented usually where demand is more certain. At the start of any crisis, speed overrides cost as a priority. The first 72 hours are crucial. At this stage goods may be flown in from abroad as quickly as possible despite being an expensive option. Later on, typically after the first 90 to 100 days, it becomes a mixture between being effective in helping people and doing this at a reasonable cost (Van Wassenhove, L. N.).

One of the most difficult aspects of humanitarian supply chains is what is known as the last mile effort. This describes the challenges surrounding the last leg of the supply chain, in getting critical supplies to the end user. Delays can arise due to unpredictable and rare disruptions and/or a lack of flexibility to respond to changes quickly. These can be attributed to abnormal risks, such as natural disasters, financial crises, terrorism, or disruption to a supplier's facility. Delays can also occur in the supply chain due to various reasons including compromised quality of the supplied goods, difficult border crossings, and in many cases, inadequate infrastructure (Jahre).

The greatest challenges faced by actors working in the field of humanitarian logistics are operating conditions, such as infrastructure, uncertainty in supply and demand, timeliness, high

staff turnover, and the many stakeholders involved. These stakeholders include humanitarian organizations, governments, militaries, media, donors, and victims of the disaster. Van Wassenhove notes that, "At any one time, there can be as many as several hundred humanitarian organizations at the scene of a disaster, not always acting in a coordinated fashion." This highlights the need for collaboration not just among humanitarian organizations, but all stakeholders at various levels. Coordination and collaboration efforts with partners in the supply chain occurs both horizontally and vertically (Blecken, Alexander). This can be visualized by Chart 1 below:

Chart 1 - Stakeholders in the humanitarian aid supply network



(Source: Kovaks and Spens)

When disaster strikes, the governments of host, neighboring and other countries within the international community are the catalysts of the humanitarian logistics stream since they have the power to authorize operations and mobilize resources. Host government authorization is

fundamental for the involvement of other countries. Without this, no other actor except national aid agencies and the military can operate (Dubey and Gunasekaran).

Commercial supply chains and humanitarian supply chains differ in the incentives offered to improve performance. Companies in the private sector are regulated by the supply and demand of the market, and are motivated to invest in continuous improvement by their bottom line and profit. Organizations in the humanitarian sector lack the incentive to learn from previous disasters and invest in continuous improvement. These organizations do not measure profit or see a rise in their stock price. Their "reward" is to minimize the amount of lives lost and suffering due to conflict and disasters; thus, the outcomes have much higher stakes than those faced by companies in the private sector (Van Wassenhove, L. N.).

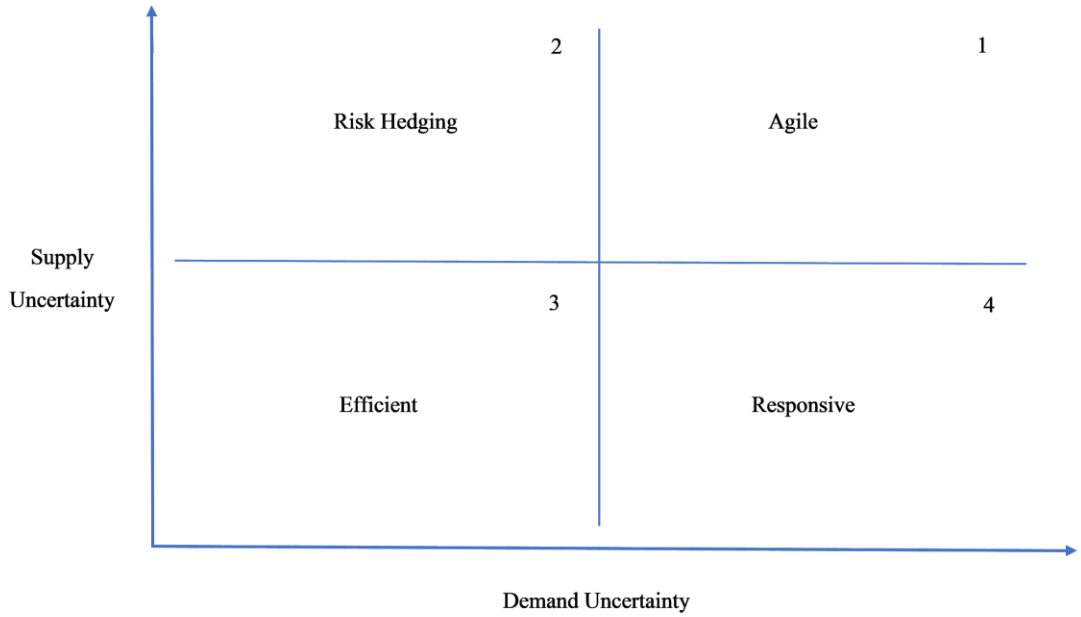
Logistics Strategies

The logistics involved in commercial supply chains can either be reactive or proactive, and depending on the organization, both. The logistics involved in commercial supply chains are guided by quality, cost, time, and risk. Humanitarian logistics on the other hand are mainly reactive and consist of three stages: preparedness, response, and collaboration (Dubey and Gunasekaran). Logistics in the private sector usually deals with a predetermined set of suppliers, manufacturing sites, and a stable or at least predictable demand, all of which are unknown in humanitarian logistics (Cassidy, W.B.). Like companies in the private sector, humanitarian organizations can gear their supply chains to be more effective and efficient by adopting three concepts: agility, adaptability, and alignment. In the private sector, agility corresponds to the responsiveness, efficiency, and flexibility of the supply chain. In humanitarian relief, agility translates to rapid deployment on demand. Adaptability emphasizes the need for dynamic supply chains, which corresponds to the creation of alliances and partnerships across suppliers. For example, UNHCR

and other humanitarian organizations secure supply in advance by forming partnerships with suppliers in different locations around the globe, typically by region. When or if a crisis arises, they can depend on this network of suppliers in the region closest to where the crisis is occurring. By establishing a large network of suppliers, humanitarian organizations can depend on getting the supply they need in the right place at the right time. Alignment focuses on reducing the differential interests of multiple parties, such as risk and resource planning among humanitarian organizations (Van Wassenhove, L. N.).

There are various supply chain strategies that can be applied to humanitarian logistics. Supply uncertainty and product uncertainty lead to different situations. Depending on the crisis at hand, humanitarian organizations will follow one of four strategies outlined in the strategy matrix (Chart 2). When both demand and supply uncertainty are low, an efficient supply chain design is the best fit. However, when demand uncertainty is high but supply uncertainty is low, then responsive supply chain design is regarded to be a best fit. This would entail contracting for additional supplies in the event they are needed. In the case when supply uncertainty is high but demand uncertainty is low, then a risk hedging strategy is the best fit. For example, organizations can work with a supplier to set aside amount of supply for an agreed cost ahead of time to reduce uncertainty. However, when both demand and supply uncertainty are high, then an agile supply chain strategy is the best fit. Agile involves responsiveness and flexibility as organizations respond to demand as it happens (Dubey and Gunasekaran).

Chart 2 - Supply chain strategy matrix



(Source: Dubey and Gunasekaran)

In the planning stage, one key decision that organizations must make is between postponement vs. speculation. A postponement strategy utilizes product or process design concepts such as standardization, commonality, modular design, and operations reversal to delay the point of differentiation in products, services, movement and other value-adding activities. Postponement activities in the field of humanitarian logistics most often take the form of prepositioning semi-finished goods, centralizing stock, and setting aside non-earmarked funding and goods. Postponement is more likely to be employed during the earlier stages of a crisis, when demand is uncertain or fluctuating. By delaying differentiation, there is less waste and organizations can wait to make more informed decisions. Speculation, on the other hand, allows forward placement of inventory, forward buying and early commitment to the form of a product. A speculation strategy is geared towards situations where demand can be more easily predicted. For instance, a speculation strategy would be useful for medium to long-term planning in a humanitarian crisis,

such as supplying vaccines to an established refugee camp or providing food to victims of natural disasters. These are instances where demand is stable and predictable as the event or crisis has already happened.

Flexibility is crucial in humanitarian logistics. Organizations work with a complex network of suppliers to ensure that needs are met in any crisis. A flexible supply base strategy involves multiple sourcing options, thus allowing for alternatives should one source be disrupted. One way of doing this is to develop a supply alliance network with suppliers in various countries. A flexible supply base can also include decentralized decisions which enable local adaptations. Related to this strategy is the concept of flexible transportation. A flexible supply chain will include multi-modality (plane, truck, rail, ocean carrier, pipeline, etc.), multiple carriers and/or multiple routes.

According to Jahre, strategic stock strategy is among one of the most commonly reported strategies that humanitarian organizations employ. Strategic stock strategy utilizes inventories at certain "strategic" locations (warehouses, logistics hubs, distribution centres) that can be deployed quickly in case of a disaster. UNHCR is one of the most prominent organizations in the field of humanitarian logistics that follows a strategic stock strategy. UNHCR operates in 123 countries with more than 9,300 staff working to provide protection and assistance to more than 46 million refugees, returnees, internally displaced, and stateless people. The organization's Supply Management System (SMS) has a network of seven distribution centers throughout the world located in Copenhagen, Jordan, Dubai, Nairobi, Tanzania, Cameroon, and Ghana. UNHCR can ship core relief items from these stockpiles to assist up to 600,000 people within 72 hours, if needed (Executive Committee of the High Commissioner's Programme). While strategic stock allows for flexibility and shorter lead times, it can also be expensive and risky. However, by pairing strategic stock strategy with others such as flexible supply base and postponement, some of these risks can

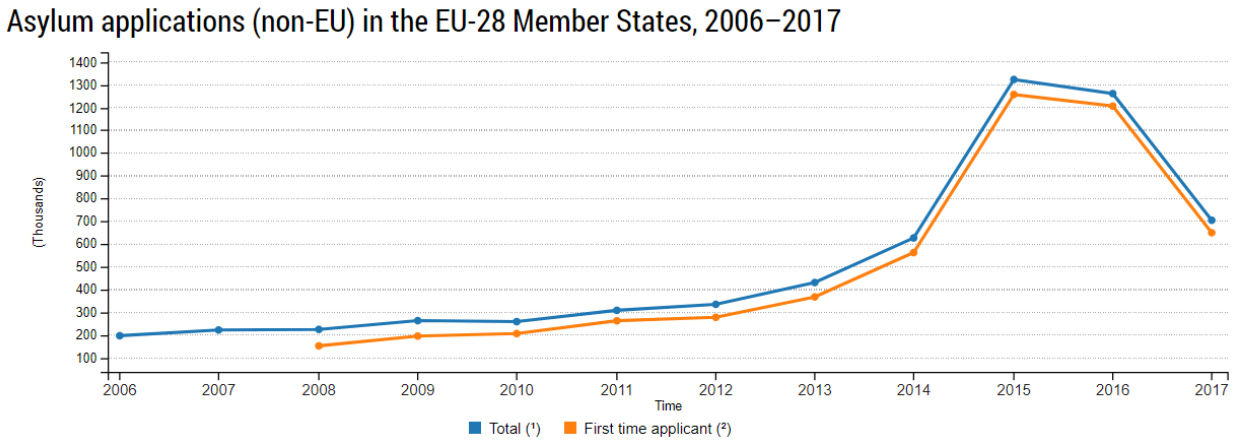
be mitigated. The combination of these strategies is shown to improve the speed, cost, and quality of an organization's response (Jahre).

The 2015 Refugee Crisis

Background

In 2015, the number of people applying for asylum in the EU peaked at 1.26 million ("EU Migrant Crisis"). Of these, Greece alone received 850,000. Only 292,540 cases were approved for asylum in that year out of the 1.26 million overall. Germany and Sweden accepted the highest number of asylum seekers, with Germany accepting over 140,000 applicants and Sweden accepting over 32,000 ("Migrant Crisis"). The International Organization for Migration estimated that over one million traveled to Europe by sea. Between 2015 and 2016, an estimated 8,793 refugees died trying to cross the Mediterranean Sea. By 2016, the total number of asylum applications in the EU reached 2.5 million people.

Figure 1 - Asylum Applications in the EU

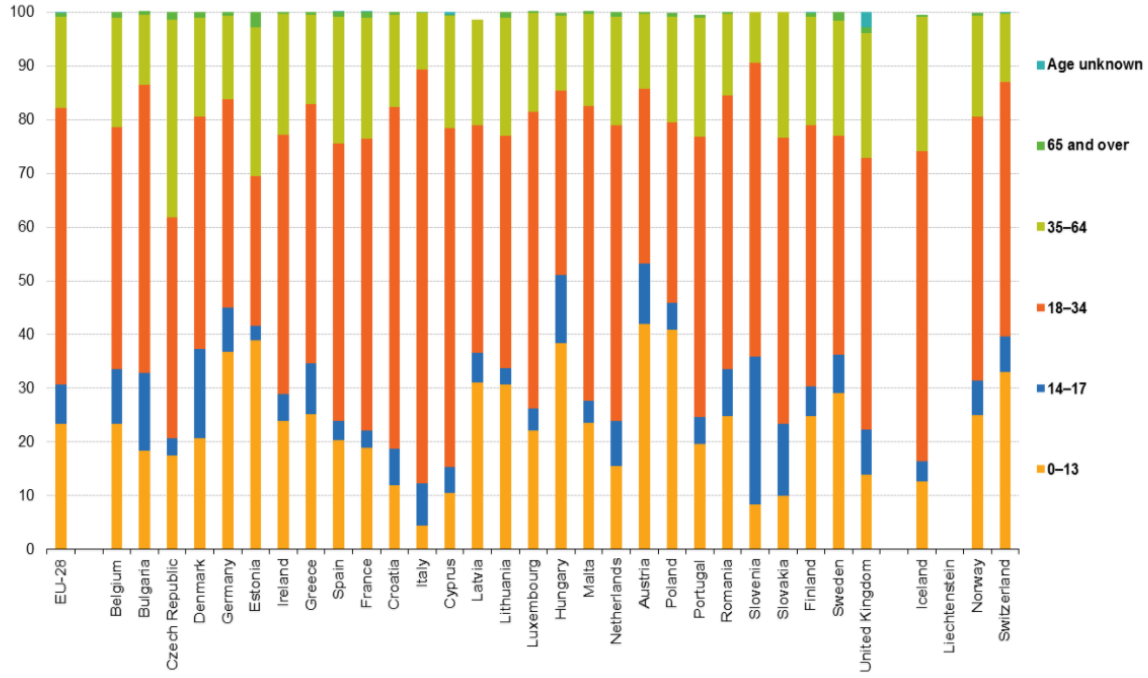


(Source: "Asylum Statistics")

The top three countries that refugees were fleeing from included Syria, Afghanistan, and Iraq. Syrians accounted for the largest number of applicants in 14 of the 28 EU Member States ("Asylum Statistics"). The demographics of asylum seekers are outlined in Figure 2. Across the EU as a whole, almost half of asylum seekers were aged 18-34. One third were minors under the age of 18, some of whom were unaccompanied. In certain countries, the proportion of younger

asylum seekers under the age of 18 was as high as 44 percent. These higher proportions were reported in Hungary, Austria, Germany and Poland ("Asylum Statistics").

Figure 2 - Age Distribution of Asylum Applicants



(Source: "Asylum Statistics")

Refugees vs. Asylum Seekers

Individuals traveling to Europe in 2015 and 2016 consisted of economic migrants, refugees, and asylum seekers. There are different definitions and legal implications for each group depending on their status and reasons for migrating to Europe. This section will attempt to define these differences and eligibility for remaining within Europe. An economic migrant is a person who leaves his or her country of origin purely for financial and/or economic reasons. They are choosing to leave in pursuit of a better life; not because they are fleeing persecution and have no

choice but to leave. “Economic migrants do not fall within the criteria for refugee status and are therefore not entitled to benefit from international protection as refugees” (UNHCR 2006).

According to the international convention and protocol on the status of refugees the definition of a refugee pertains to any individual who has:

> “a well-founded fear of being persecuted for reasons of race, religion, nationality, membership of a particular social group or political opinion, is outside the country of his nationality and is unable, or owing to such fear, unwilling to avail himself of the protection of that country; or who not having a nationality and being outside the country of his former habitual residence as a result of such events, is unable or, owing to such fear, is unwilling to return to it” (UN General Assembly).

Before refugee status is granted, vulnerable individuals fleeing persecution are referred to as asylum seekers. An asylum seeker is the term given to a person who has applied for refugee status and has not yet received a final decision on his or her claim (UN General Assembly). Without refugee status, they are offered less legal protection and do not have the same rights under international law. In Greece, asylum seekers make up the majority of people who are living in reception centers and shelter sites as they wait for their case to be processed. Sadly, not every asylum-seeker will ultimately be recognized as a refugee. However, an asylum-seeker should not be sent back to his or her country of origin until the asylum claim has been examined in a fair procedure.

Refugees are protected under the 1951 Geneva Convention, known as the Convention relating to the status of refugees. One key principle outlined in the convention is non-refoulement, which is binding on all states. Under non-refoulement, “No Contracting State shall expel or return

('refouler') a refugee in any manner whatsoever to the frontiers of territories where his life or freedom would be threatened on account of his race, religion, nationality, membership of a particular social group or political opinion" (UN General Assembly). This would include refusal of entry at the border as well as removal from within the territory. The principle of non-refoulement applies wherever a state exercises its authority, including beyond its borders, for example when intercepting ships on the high seas (UN General Assembly). For these reasons, the EU cannot turn away refugees and asylum seekers.

EU Asylum System

EU member states have a shared responsibility to welcome asylum seekers. The Common European Asylum System (CEAS) sets out to establish common asylum policy throughout the EU ("Common European Asylum System"). The creation of a common procedure across all EU countries aims to increase speed and efficiency while promoting fairness in decision-making. In addition to a common procedure, CEAS promotes solidarity and cooperation to alleviate pressure on any one member state. Cases should be examined in a uniform standard across member states to ensure asylum seekers are granted similar outcome no matter the country they apply in. In the 2015 Refugee Crisis, this was not the case as Italy and Greece's reception and processing capabilities were overwhelmed. Under CEAS, the Reception Conditions Directive aims to harmonize reception standards across the EU. "It ensures that applicants have access to housing, food, clothing, health care, education for minors and access to employment under certain conditions" ("Reception Conditions"). However, the Reception Conditions Directive leaves discretion to individual member states. They are able to determine what constitutes adequate living standards for refugees and how it should be undertaken, which creates variability in the process depending on the member state.

In the EU, the Dublin System regulates which country processes asylum applications. Under the Dublin Convention first enforced in 1997, the country of first arrival is typically the one to take responsibility for examining and processing asylum applications. One example of an exception to the Dublin Convention is family reunions, in which case the country of first arrival would not take on this responsibility. The Dublin Convention was replaced by Dublin II in 2003 which set out hierarchical criteria to determine which state is responsible for processing the application. Dublin III comes into force in 2013, which further defines rights of asylum seekers and allows appeal of decisions (Cellini). The 2015 refugee crisis highlighted the Dublin System's limitations and failures. Countries like Greece and Italy that were disproportionately receiving refugees did not have the capacity or resources available to process the vast amount of applications being filed. A lack of political unity and cooperation among EU member states has also led to increasing difficulty in enforcing the shared asylum policy. For example, non-EU members that participate in the Dublin System can opt out of some of the minimum standards set forth by the EU (Bank and Milner).

Relocation vs. Resettlement

Once refugee status has been approved, refugees can wait months or years to be relocated within Greece or to a different EU country. Relocation, "is the transfer of persons who are in need of or already benefit from a form of international protection in one EU member state to another EU member state where they would be granted similar protection" ("Resettlement and Relocation" n.d.). Relocation is an applicable option for asylum seekers and refugees currently residing in Greece. As of September 2017, only 19,244 people have been relocated from Greece and 8,451 from Italy ("Relocation and Resettlement" 2017). Relocation is often used interchangeably with resettlement, but they are very different. Resettlement, "is the transfer of non-EU national or

stateless persons who have been identified as in need of international protection to an EU state where they are admitted either on humanitarian grounds or with the status of refugee" ("Resettlement and Relocation" n.d.). Resettlement applies to recognized refugees living outside of the EU. Most resettlement cases have taken refugees from Turkey, Jordan, and Lebanon ("Tenth Report on Relocation and Resettlement"). The EU budget supports Member States with €6,000 - €10,000 per resettled refugee ("Relocation and Resettlement" 2017).

EU-Turkey Deal

On March 18, 2016, the EU and Turkey released a joint statement known as the EU-Turkey Deal. The goal of the EU-Turkey Agreement was set out, "to replace disorganized, chaotic, irregular and dangerous migratory flows by organized, safe, and legal pathways to Europe for those entitled to international protection in line with EU and international law ("EU-Turkey Statement"). A secondary goal of the agreement was to further deepen EU-Turkey relations (Borges). This agreement outlined nine key actions that would foster bilateral cooperation between the two actors to combat major issues of the 2015 refugee crisis. The first action point states that all new irregular migrants entering the EU through the Greek islands would be returned to Turkey beginning on March 20, 2016. At that time, the number of migrants entering Greece from Turkey had already significantly decreased from the peak months of 2015. After the EU-Turkey was put into place, there was an uptick in the number of refugees attempting dangerous routes, including through Libya and the Mediterranean Sea (Rygiel et al).

The second action point states that for every irregular migrant returned to Turkey, another Syrian refugee will be resettled from Turkey to the EU. Other action points address Turkey's role to prevent new sea and land routes from Turkey to the EU, the creation of a Voluntary Humanitarian Admission Scheme, acceleration towards visa liberalization for Turkish citizens, six

billion euros in funding and aid to be used on Syrian refugees residing in Turkey, upgrading the Customs Union, re-opening negotiations on the Turkey's accession to the EU, and a joint effort to improve humanitarian conditions in Syria ("EU-Turkey Statement").

Some Syrian asylum-seekers have been forcibly returned to Turkey without having access to asylum and without being able to appeal against their return, in breach of international law. Others have 'voluntarily' returned to Turkey because of the misery on the Greek islands. In Turkey, Syrian refugees receive temporary protection, but are left to fend for themselves. Greek asylum appeals authorities have consistently ruled that Turkey is not a safe country. The response to the EU-Turkey Deal was a widespread criticism from various international parties. In response to the EU-Turkey Deal, Elisabeth Ingres, the head of Medecins San Frontieres's (MSF) mission in Greece stated that the general sentiment is that, "they would not allow their assistance to be instrumentalized for a mass expulsion operation and refuse to take part in a system that has no regard for the humanitarian or protection needs of asylum seekers and migrants" (Borges).

Conditions in Greece

A report from UNHCR in the November of 2015 noted conditions in Greece in particular were not sufficient. Many Greek reception centers lacked adequate shelter, sanitation, and site management. Furthermore, refugees were left without access to accommodation, healthcare or education. The quality and scope of services offered varied significantly by site and location ("Greece"). "The Council of Europe has deemed refugee facilities in the camps to be substandard and able to provide no more than the most basic needs such as food, hygiene, products and blankets while Save the Children has described the conditions in some of the new camps as inhumane" ("Service Delivery in the Refugee Camps of Greece"). Lesvos, one of the main reception centers located near Turkey, received 3,300 people on average per day in November 2015. The center only

had a total capacity for 2,800. UNHCR provided transportation from the northern shores to other sites in eastern Greece through eight buses and three minivans on a 24/7 basis. From the beginning of the Refugee Crisis to the end of 2015, UNHCR increased its staff from 54 to 216 in Greece ("Greece").

Since the implementation of the EU-Turkey agreement, Greek authorities have initiated a policy to automatically detain those who arrive by sea. The closure of the border between North Macedonia and Greece, commonly referred to as the Balkan route, left thousands of refugees and migrants stranded in Greece. Out of all EU member states, Greece is arguably the least equipped to host refugees and asylum-seekers. The country is still recovering from the economic crisis and unemployment is one of the highest in the EU. Austerity measures led to major cuts in public spending, and the state is behind in addressing long-term responses for hosting refugees ("Service Delivery in the Refugee Camps of Greece"). Asylum seekers await their case to be processed in Greece for months on end, unable to leave, and living conditions are poor and they are subject to violence. Current estimates place this number at 60,000 people ("EU Policies Put Refugees at Risk"). Many of the asylum seekers arrive that arrive in Greece are already in a vulnerable state. However, even those who turn up at Greek reception sites in good condition soon find themselves suffering from health problems. A single doctor per shift provides medical care to the entire camp population and often only the most urgent cases get seen. Doctors at the local hospital are also overwhelmed (Yaxley).

In 2018, the number of arrivals to the Greek islands stood at 23,000 (Kingsley). New arrivals stay at camps like Moria, a designated hotspot, until their case is settled. It can take as long as two years before asylum seekers are given their decision (Kingsley). Conditions in Moria are dire. The camp currently hosts around 9,000 people in a space designed for just 3,100. The

overcrowding is so extreme that asylum seekers spend as much as 12 hours a day waiting in line for food that is sometimes moldy. There are about 80 people for each shower and around 70 per toilet (Kingsley). Some aid workers have complained about raw sewage leaking into tents where children are living. Reports of sexual assaults, knife attacks and suicide attempts are common (Kingsley). Mental health is a rising concern, as asylum seekers are subjected substandard living conditions for long periods of time. "The conditions [at Moria] have fueled accusations that the camp has been left to fester in order to deter migration and that European Union funds provided to help Greece deal with asylum seekers are being misused" (Kingsley). As of September 2018, an investigation by the EU anti-fraud agency into Greece had been announced.

Recently, conditions at the Vathy reception and identification center on the island Samos has been worsening. As of November 2018, the center is currently hosting around 4,000 people, which is six times more than its intended capacity. It was designed to host no more than 650 people (Yaxley). Supplies are short, and new arrivals must resort to buy flimsy tents from local stores. The tents that they pitch are located on a steep slope in adjacent fields to the center, offering little protection from the cold weather, without electricity, running water or toilets (Yaxley). UNHCR has reported that there are snakes in the area and rats that are thriving in the uncollected waste.

The centers on the Greek islands of Lesvos and Samos represent the worst of the sites in Greece. Others, such as Skaramagas, are leading examples of what sites should be. Skaramagas is one of the largest camps in mainland Greece, hosting 3,200 people. It is also considered one of the highest quality camps. Refugees have been able to establish small businesses and community groups. Some of the "luxuries" at the camp include refrigerators, convection ovens, and plumbing. The camp also has a common area with a community center, a playground, and offices for non-governmental organizations (NGOs) (Alesevich).

Short-Term Strategies

Linear Programming Model

There are an infinite amount of short-term and long-term considerations and complex decisions that must be made in relation to the refugee crisis. One example of a short-term problem is the lack of shelter available in Greece for refugees and asylum seekers, particularly in 2015 and 2016. On any given day, many refugee centers and shelters were at maximum capacity and often exceeded their capacities in order to accommodate as many people as possible. In some cases, capacity levels soared upwards of 200 percent, as seen in Table 1. This strain on resources made it increasingly difficult for organizations like UNHCR to provide adequate care for refugees, many of whom are women and children. Unsurprisingly, the shelters that most often exceeded capacity could be found on the eastern islands of Greece which bordered Turkey. During 2015 and early 2016, the route that most refugees took to eventually reach Europe was through Turkey. In other cases, refugees made treacherous journeys across the Mediterranean Sea to reach Europe. Both routes led to the massive amount of people overcrowding shelters in Greece.

Table 1 shows an array of shelters in Greece and the current capacity and occupancy level for each. Those shelters at or below 100 percent capacity are highlighted green and are not under consideration for this problem. Shelters highlighted in yellow fall between 100 and 120 percent capacity, and shelters in orange are above 120 percent capacity. The problem will focus on the eight shelters exceeding 120 percent capacity. Table 1 also shows the physical number of spots available at shelters, and negative numbers indicate the number of individuals over capacity. Since Greece was not a final destination for most refugees, these numbers did not remain constant. Many moved on to other European countries such as Germany after filing for asylum in Greece. Therefore, the data in Table 2 only represents a snapshot from May 13, 2016 (see Appendix,

Exhibit A). However, the data still represents an accurate measure and scale of the problem. Optimizing shelter capacity seeks to minimize suffering and poor conditions for refugees. While this paper solely focuses on an optimal solution based on the number of refugees present in Greece on May 13, 2016, the model serves as a flexible baseline. Data could be updated continuously as numbers fluctuate over time, leading to new optimal solutions.

Table 1 - Capacity Levels of Refugee Sites in Greece

Site	Capacity	Occupants	% Full	# Available
Agios Andreas	120	191	159%	-71
Alexandreia	1200	816	68%	384
Andravidas	300	321	107%	-21
Chalkero	350	286	82%	64
Cherso	2500	3987	159%	-1487
Chios	1100	2419	220%	-1319
Diavata	2500	2320	93%	180
Doliana	400	226	57%	174
Drama	500	510	102%	-10
Eleonas	1500	2270	151%	-770
Elliniko I	1400	1259	90%	141
Elliniko II	1300	1365	105%	-65
Elliniko III	1300	972	75%	328
Filipiada	700	562	80%	138
Giannitsa	900	751	83%	149
Katsika	1500	997	66%	503
Konitsa	150	167	111%	-17
Kos	1000	167	17%	833
Larisa (Koutsochero)	1500	769	51%	731
Lavrio	400	385	96%	15
Lavrio Accomodation Facility	250	508	203%	-258
Leros	1000	530	53%	470
Lesvos	3500	4287	122%	-787
Malakasa	1500	1311	87%	189
Nea Kavala	2500	3980	159%	-1480
Oinofyta	300	42	14%	258
Oreokastro	1500	485	32%	1015
Pieria (Camping Nireas)	400	393	98%	7
Pieria (Ktima Iraklis)	200	198	99%	2
Pieria (Orpheas Hotel)	500	206	41%	294
Pieria (Petra Olympou)	1100	957	87%	143
Pieria (Stadium)	400	319	80%	81
Ritsona	1000	717	72%	283
Samos	850	1114	131%	-264
Schisto	2000	1850	93%	150
Skaramagas dock	2880	2880	100%	0
Thermopiles	400	420	105%	-20
Thessaloniki Port	400	382	96%	18
Tsepelovo	200	143	72%	57
Veria	400	400	100%	0
Volos	200	88	44%	112

The objective of this short-term problem is to minimize the total amount of travel time between shelters. In setting this objective, the hope is to transport refugees as quickly and effectively to the nearest shelter that has the ability to take them. It is not always the case that shelters with leftover capacity will necessarily be the closest. In this case, Greece poses a complex problem because many of the refugees seeking temporary shelter there are concentrated in southern and eastern regions. It would then make sense that shelters with the most leftover capacity would be located in the northern and western regions of the country.

In order to find an optimal solution for the lack of shelters in Greece in May of 2016, management science principles and a linear programming model can be used. Management science is the application of the scientific method to managerial decision-making. Linear programming is a mathematical tool a mathematical technique for maximizing or minimizing a linear function of several variables, based off of linear algebra and optimization theory within calculus. The solution will be found using a type of "what-if analysis" found in Microsoft Excel's Solver tool. It is a common type of model utilized to solve management science problems. A linear programming model consists of various inputs, including decision variables, an objective function, and model constraints.

Table 2 is a template of all of the inputs that will be entered in the solver tool. It displays the time it takes to travel, in minutes, between shelters. Those shelters labeled A-H are currently exceeding their maximum capacity. Demand represents the number of refugees that would have to be transported elsewhere to lower capacity level to 100 percent. The shelters labeled 1-22 are currently under capacity. Supply represents the number of empty spots remaining, or the number of refugees that they could accept without exceeding their maximum capacity. The cells that are

highlighted show the shortest amount of time between shelters exceeding capacity and the next closest shelter.

Table 2 - Travel Time in Minutes Between Origin and Destination Sites

		Origin								
		A	B	C	D	E	F	G	H	
	Destination	Agios Andreas	Cherso	Chios	Eleonas	Lavrio Accomodation Facility	Lesvos	Nea Kavala	Samos	**Supply**
1	Malakasa	47	328	646	40	61	815	288	1065	189
2	Oinofyta	58	320	657	50	73	825	280	1075	258
3	Ritsona	64	313	666	56	78	834	274	899	283
4	Elliniko	42	375	635	22	47	803	328	869	469
5	Oreokastro	325	43	749	309	334	625	47	977	1015
6	Diavata	316	46	752	301	326	613	39	978	180
7	Doliana	332	242	906	295	327	790	188	1313	174
8	Chalkero	409	134	659	395	427	528	130	889	64
9	Thessaloniki	312	58	757	301	327	635	43	985	18
10	Schisto	48	371	616	17	63	783	418	849	150
11	Giannitsa	326	61	783	313	339	667	40	1009	149
12	Alexandreia	304	68	775	292	318	655	47	1003	384
13	Kos	1003	892	645	977	1023	501	877	610	833
14	Larisa (Koutsochero)	239	133	834	232	259	730	126	1079	731
15	Leros	790	1112	635	763	810	717	1064	403	470
16	Pieria (Orpheas Hotel)	257	102	850	248	276	680	75	1038	294
17	Pieria (Petra Olympou)	301	117	893	291	319	699	95	1047	143
18	Pieria (Stadium)	257	85	873	261	299	670	66	1018	81
19	Katsika	270	197	867	253	287	772	170	1117	500
20	Tsepelovo	330	262	928	313	346	838	235	1182	57
21	Filipiada	236	232	834	220	252	805	204	1064	138
22	Volos	211	172	809	204	229	750	148	1098	112
	Demand	71	1487	1319	770	258	787	1480	264	

The decision variables, objective function, and model constraints can be found in Table 3. The decision variable representing the number of refugees traveling between shelters is denoted as "X_{ij}", where "i" represents the shelter under capacity and "j" represents the shelter over capacity. For example, the first decision variable is X_{1A}, where "1" represents the location Malakasa, and "A" represents the shelter at Agios Andrea. The value we set for X_{ij} represents the number of refugees we plan to move between these points. Within the objective function shown in Table 3, the goal is to minimize the total travel time and so, for example, the number of people moved from site 1 to A (X_{1A}) is multiplied by *47*, the amount of time in minutes between these two locations as

noted in Table 2. Because there are 176 decision variables representing the various combinations between shelter sites, the display of the objective function is shortened.

Table 3 - Objective Function and Constraints

Objective Function

$$\text{Min } Z = 47x_{1A} + 328x_{1B} \ldots + 148x_{22G} + 1098x_{22H}$$

Subject to constraints:

$X_{1A} + \ldots + X_{1H} \leq 189$	(supply from Malakasa)
$X_{2A} + \ldots + X_{2H} \leq 258$	(supply from Oinofyta)
$X_{3A} + \ldots + X_{3H} \leq 283$	(supply from Ritsona)
$X_{4A} + \ldots + X_{4H} \leq 469$	(supply from Elliniko)
$X_{5A} + \ldots + X_{5H} \leq 1015$	(supply from Oreokastro)
$X_{6A} + \ldots + X_{6H} \leq 180$	(supply from Diavata)
$X_{7A} + \ldots + X_{7H} \leq 174$	(supply from Doliana)
$X_{8A} + \ldots + X_{8H} \leq 64$	(supply from Chalkero)
$X_{9A} + \ldots + X_{9H} \leq 18$	(supply from Thessaloniki)
$X_{10A} + \ldots + X_{10H} \leq 150$	(supply from Schisto)
$X_{11A} + \ldots + X_{11H} \leq 149$	(supply from Giannitsa)
$X_{12A} + \ldots + X_{12H} \leq 384$	(supply from Alexandreia)
$X_{13A} + \ldots + X_{13H} \leq 833$	(supply from Kos)
$X_{14A} + \ldots + X_{14H} \leq 731$	(supply from Larisa)
$X_{15A} + \ldots + X_{15H} \leq 470$	(supply from Leros)
$X_{16A} + \ldots + X_{16H} \leq 294$	(supply from Orpheas Hotel)
$X_{17A} + \ldots + X_{17H} \leq 143$	(supply from Petra Olympou)
$X_{18A} + \ldots + X_{18H} \leq 81$	(supply from Pieria Stadium)
$X_{19A} + \ldots + X_{19H} \leq 500$	(supply from Katsika)
$X_{20A} + \ldots + X_{19H} \leq 57$	(supply from Tsepelovo)
$X_{21A} + \ldots + X_{21H} \leq 138$	(supply from Filippiada)
$X_{22A} + \ldots + X_{22H} \leq 112$	(supply from Volos)
$X_{1A} + \ldots + X_{22A} = 71$	(demand from Agios Andreas)
$X_{1B} + \ldots + X_{22B} = 1487$	(demand from Cherso)
$X_{1C} + \ldots + X_{22C} = 1319$	(demand from Chios)
$X_{1D} + \ldots + X_{22C} = 770$	(demand from Eleonas)
$X_{1E} + \ldots + X_{22E} = 258$	(demand from Lavrio)
$X_{1F} + \ldots + X_{22F} = 787$	(demand from Lesvos)
$X_{1G} + \ldots + X_{22G} = 1480$	(demand from Nea Kavala)
$X_{1H} + \ldots + X_{22H} = 264$	(demand from Samos)
$X_{ij} > 0,$	(solution cannot be negative)

where X_{ij}= travel time between shelter under capacity (i) and shelter over capacity (j), i=1,2,3 and j=A,B,C.

After determining the decision variables and the objective function, constraints were added to the problem. There are three major considerations for the constraints. First, the number of

refugees being sent from the original shelter to the receiving shelter could not exceed the capacity of the receiving shelter. Therefore, the sum of the refugees sent from all shelters labeled A-H cannot exceed the supply at a shelter 1, Malakasa. Since Malakasa can take up to 189 refugees, the constraint limits the amount of refugees to be received up to 189. This does not mean that Malakasa will take all 189 if there are other shelters that would minimize the total time traveled. The second constraint category addresses demand, or the number of refugees being sent from overcrowded shelters. The demand is set exactly equal to the number of refugees that are considered over the maximum capacity of a shelter.The last constraint ensures that all decision variables are non-negative numbers, since the number of people traveling between shelters cannot be negative.

Table 4 shows the optimal solution calculated by solver. The far right column lists the number of refugees received at each shelter compared to the available supply. Due to the tight margin, most shelters took in the maximum number of refugees that they had capacity for. Only 3 of the 22 destination shelters were not filled to maximum capacity. These sites are Doliana, Katsika, and Tsepelovo, which are the westernmost locations and the farthest from the ports of entry for most refugees. On the horizontal axis, the number of refugees sent from each shelter exactly matches demand. With the constraints and parameters of this problem, solver found that the minimum total time traveled between shelters amounts to 1,755,746 minutes or 29,262 hours. Even though most of the shelters are full, this problem is optimizing the way people are transported in a time efficient manner. In this problem, refugees are not simply reshuffled to random shelters throughout Greece. Without setting an objective to minimize travel time, the maximum total travel time could amount to 4,398,853 minutes, which is roughly 2.5 times more than the optimal solution. This would place a strain on resources and refugees could be traveling the farthest possible distances between shelters, which is not efficient.

Table 4 - Excel Solver: Optimal Solution

	Destination	Agios Andreas	Cherso	Chios	Eleonas	Lavrio Accom	Lesvos	Nea Kavala	Samos	Supply	# received
1	Malakasa	0	0	189	0	0	0	0	0	189	189
2	Oinofyta	0	0	258	0	0	0	0	0	258	258
3	Ritsona	71	0	0	0	212	0	0	0	283	283
4	Elliniko	0	0	266	157	46	0	0	0	469	469
5	Oreokastro	0	1015	0	0	0	0	0	0	1015	1015
6	Diavata	0	0	0	0	0	0	180	0	180	180
7	Doliana	0	0	0	0	0	0	0	0	174	0
8	Chalkero	0	0	64	0	0	0	0	0	64	64
9	Thessaloniki	0	0	0	0	0	0	18	0	18	18
10	Schisto	0	0	150	0	0	0	0	0	150	150
11	Giannitsa	0	0	0	0	0	0	149	0	149	149
12	Alexandreia	0	0	0	0	0	0	384	0	384	384
13	Kos	0	0	46	0	0	787	0	0	833	833
14	Larisa (Koutsochero)	0	472	28	0	0	0	231	0	731	731
15	Leros	0	0	206	0	0	0	0	264	470	470
16	Pieria (Orpheas Hotel)	0	0	0	0	0	0	294	0	294	294
17	Pieria (Petra Olympou)	0	0	0	0	0	0	143	0	143	143
18	Pieria (Stadium)	0	0	0	0	0	0	81	0	81	81
19	Katsika	0	0	0	475	0	0	0	0	500	475
20	Tsepelovo	0	0	0	0	0	0	0	0	57	0
21	Filipiada	0	0	0	138	0	0	0	0	138	138
22	Volos	0	0	112	0	0	0	0	0	112	112
	Demand	71	1487	1319	770	258	787	1480	264		
	# refugees sent	71	1487	1319	770	258	787	1480	264		
	Total time:	1,755,746.00									

Table 5 on page 34 shows the sensitivity report for the linear programming problem. The table lists each of the constraints for all shelters, both sending and receiving refugees. The ***final value*** column displays the actual number of refugees either sent or received to that particular site according to the most optimal solution. Sensitivity reports determine the effect on optimal solutions of changes in the objective function coefficient (travel time) and the right-hand side constraint (capacity). In this table, the sensitivity range is measuring the right-hand side constraint, demonstrated by the allowable increase and decrease columns. The sensitivity range for the right-hand side constraint is the range over which the current optimal solution will remain optimal. One very insightful piece of information from the sensitivity analysis report is the shadow price; the marginal value of one additional unit of resource in relation to the right-hand side constraint sensitivity range.

The first eight rows of the sensitivity report (cells C25 through J25) show the final value, shadow price, constraint, and allowable increase/decrease for shelters that are over capacity. Final values represent the number of refugees sent out of the shelter. The shadow price depicts the amount of time, in minutes, that would be added to the total time overall if one additional refugee is sent from that shelter. For example, the number of refugees sent from Agios Andreas is 71. If one more person is sent from Agios Andreas, making the final value equal to 72, then it will take an additional 264 minutes to reassign that extra person. Up to 25 additional refugees could be sent from Agios Andreas, however this would add 264 minutes per person.

Cells L2 through L23 are the shelters receiving refugees. The final value represents the number of refugees assigned to that location. The shadow price depicts the amount of time, in minutes, that could be saved if the receiving shelter had more capacity. For example, Malakasa ended up receiving 189 refugees. If one additional refugee could be sent there, the total time calculated in the optimal solution would decrease by 220 minutes. 226 is the allowable increase indicated for Malakasa. Therefore, if capacity allowed for an additional 266 refugees to be sent to Malakasa, then total time would be reduced by 220 266 minutes per person. This would result in a total time savings of 58,520 minutes (220 minutes multiplied by 266 people) achieving a three percent reduction compared to the current optimal solution. If more than 266 additional refugees are sent there, it is unclear what the effect would have on the total travel time (i.e. travel time could increase exponentially). It is clear that Schisto has the highest shadow price in absolute value (which is -250). If more capacity could be added at Schisto, this would greatly improve the optimal solution.

Table 5 - Excel Solver: Sensitivity Analysis

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
C25	# refugees sent Agios Andreas	71	264	71	25	46
D25	# refugees sent Cherso	1487	165	1487	25	266
E25	# refugees sent Chios	1319	866	1319	25	266
F25	# refugees sent Eleonas	770	253	770	25	475
G25	# refugees sent Lavrio Accomodation Facility	258	278	258	25	46
H25	# refugees sent Lesvos	787	722	787	25	266
I25	# refugees sent Nea Kavala	1480	158	1480	25	231
J25	# refugees sent Samos	264	634	264	25	264
L2	Malakasa # received	189	-220	189	266	25
L3	Oinofyta # received	258	-209	258	266	25
L4	Ritsona # received	283	-200	283	46	25
L5	Elliniko # received	469	-231	469	475	25
L6	Oreokastro # received	1015	-122	1015	266	25
L7	Diavata # received	180	-119	180	231	25
L8	Doliana # received	0	0	174	1E+30	174
L9	Chalkero # received	64	-207	64	266	25
L10	Thessaloniki # received	18	-115	18	231	18
L11	Schisto # received	150	-250	150	266	25
L12	Giannitsa # received	149	-118	149	231	25
L13	Alexandreia # received	384	-111	384	231	25
L14	Kos # received	833	-221	833	266	25
L15	Larisa (Koutsochero) # received	731	-32	731	266	25
L16	Leros # received	470	-231	470	266	25
L17	Pieria (Orpheas Hotel) # received	294	-83	294	231	25
L18	Pieria (Petra Olympou) # received	143	-63	143	231	25
L19	Pieria (Stadium) # received	81	-92	81	231	25
L20	Katsika # received	475	0	500	1E+30	25
L21	Tsepelovo # received	0	0	57	1E+30	57
L22	Filipiada # received	138	-33	138	475	25
L23	Volos # received	112	-57	112	266	25

Limitations

While this model offers a solution for short-term planning, there are some limitations involved. First, the model fails to take into account groups of refugees that must remain together such as families. This would have to be added as a constraint so that parents and children and even extended families are able to travel together. Similarly, some families may request to be sent to

shelter sites where their extended family have already been established. Another consideration is resource availability. While some shelters may have capacity, individuals with disabilities, single mothers and children traveling alone all require special care. Not every shelter offers the same resources and amenities. The model also fails to account for the sites that may be closed. These include Chios, Kos, Leros, Lesvos, and Samos which are all islands that border Turkey in the east (see map in Appendix). Many of the shelters on these islands are designated "hotspots" where they receive a majority of file claims for asylum. If these sites are closed to receiving additional refugees, whether they have additional capacity or not, this would be an additional constraint that would need to be added to the model. If these sites are closed, this would add significant travel time to other shelters.

Organizations like UNHCR also have to consider their budget, and how much is designated not only to operations in Greece but also whether certain funds are earmarked for food and supplies as opposed to transportation or vehicle expenses. The travel time between each site would be cut down if air travel was feasible to accommodate thousands of refugees. However, this is not the case. As a result, distances and time were calculated with the time to travel by car and ferry. Some travel times are significantly shorter if routes are taken through Turkey as opposed to traveling by ferry from the islands to mainland Greece. However, potential issues could arise with crossing borders or for other objections that Turkey might raise. Lastly, this model does not set an upper limit on the amount of travel time. The longest travel time is 21 hours between Samos and Doliana.

Long-Term Strategies

Preference Matrix

With these limitations in mind, there are numerous factors to be considered. While the linear programming model gives an output that minimizes the total time traveled between shelters, it fails to account for other factors that will affect long-term outcomes. In order to address these limitations and, a preference matrix can be used. In the corporate world, a preference matrix is often useful for supplier selection and distinguishing qualification by various criteria. Each individual criterion is ranked and weighted, and then weighed as a percentage of the total overall.

Table 6 below uses this same process in a preference matrix that weighs criteria for refugee shelters. These eight criteria were first ranked by importance from 1-8, with 1 being most important. Family was ranked first, indicating the high need for family members to remain together when being moved to a different shelter. The next most important factor was the living conditions of a given shelter. Locations such as Lesvos have received international attention after multiple organizations and news sources, reported the dire conditions refugees are being subjected to. At Lesvos, the site is so overcrowded that refugees are housed in flimsy tents that do not protect against harsh winter weather. Violent hate crimes and high rates of depression and suicide have been reported at Lesvos. Furthermore, sexual and gender-based violence remains a major issue, and women and children are not offered adequate protection (Gogou). The shelters that are over capacity are typically those where we see the worst living conditions and lack of sanitation. From there, availability of food, health services, and supplies such as clothing or blankets for the winter were ranked. The availability of staff, the cost of maintaining and running the shelter, and the distance and travel time between shelters were considered least important relative to other criteria. In determining the order of importance, emphasis was placed on long-term impacts and outcomes. While budget and costs dictate a lot of decisions, especially when budgets are earmarked for

particular purposes, it is ranked among the least important factors in comparison to the other criteria that pose more serious consequences. For example, a lack of food or access to clean water is simply not a possible sacrifice that can be made without resulting in a loss of life. Similarly, health services are critical for preventing the spread of disease among close living quarters within the refugee shelters. Refugees traveling from all regions of the world can easily spread or contract diseases, and sanitation is also a major concern. Again, the consequences of a lack of adequate health services is not an option without resulting in casualties. Other considerations include access to education and care for unaccompanied children. The camp located at Theben, 100 km away from Athens, is one such camp that offers accommodation and special care for unaccompanied children (Gabeau).

Table 6 - Weighted Criteria

Weight	Criteria	Rank	% of decision
1	Distance/Travel time	8	4.00%
1.5	Cost	7	6.00%
2	Available staff	6	8.00%
3	Other equipment and supplies (i.e. clothing)	5	12.00%
4	Health services	4	16.00%
4	Food	3	16.00%
4.5	Shelter in good condition (livable)	2	18.00%
5	Family	1	20.00%

From these rankings, each criterion is given an individual weight on a scale from 1-5, with 5 representing the most important criterion. Finally, the criteria are weighed as a percentage of the total, adding up to 100 percent. Once these have been determined, UNHCR can use a preference matrix to allocate refugees to other shelters accordingly.

Table 7 shows a template for the preference matrix. All of the possible receiving shelters are listed in the left column, and these are measured by the criteria. The criteria would be rated on

a scale from 1-10 for each shelter, with 10 being the highest score. One thing to note is that it is possible for multiple shelters to receive the same score in the same criterion category (i.e. more than one shelter can receive a score of 10). It is also possible that none of the shelters in that particular criterion category will receive a score of 10. After the table is completed with the remaining scores, these are converted to a raw score, weighted score, and a final ranking. The receiving shelter with the highest rated score is the optimal choice since it reflects a balanced score between all of the qualifying criteria. In this way, a preference matrix is useful for decision-making in complex situations by evaluating criteria and weighing options effectively.

Table 7 - Preference Matrix

	Criteria								Results		
Weights:	1	1.5	2	3	4	4	4.5	5			
Shelters:	Distance/ Travel time	Cost	Available Staff	Supplies	Health Services	Food	Living Conditions	Family	**Raw Score**	**Weighted Score**	**Rank**
Malakasa											
Oinofyta											
Ritsona											
Elliniko											
Oreokastro											
Diavata											
Doliana											
Chalkero											
Thessaloniki											
Schisto											
Giannitsa											
Alexandreia											
Kos											
Larisa (Koutsochero)											
Leros											
Pieria (Orpheas Hotel)											
Pieria (Petra Olympou)											
Pieria (Stadium)											
Katsika											
Tsepelovo											
Filipiada											
Volos											

Once the preference matrix is complete, organizations will have a more holistic view of the tradeoffs between various shelters. To take this a step further, a multivariable problem could be

applied to the previous short-term linear programming problem. Instead of maximizing or minimizing one objective function, there would be two objective functions to take into account. The original short-term problem would remain the same, where the objective function minimizes the total travel time between shelters. The second objective function would maximize the scores of the preference matrix, considering the quality of each receiving shelter. The new optimal solution of this multivariable model would find a "middle ground" between prioritizing shelters with the highest scores, reflecting the most important criteria, as well as minimizing travel time and remaining efficient.

The refugee re-assignment problem is just one example of where data analysis can be used to improve decision-making. Similar tools can help manage inventory allocation to certain areas, selection of locations for new camps or hospitals, assign resources, plan delivery routes, and many other important operational tasks in humanitarian relief. Considering uncertainties surrounding demand and the fluctuating conditions of a given crisis, data analysis and management science tools lead to faster solutions and better insight into decision-making.

Other Long-Term Considerations

Recent developments have promoted closer partnerships between corporate and humanitarian groups. One case is the creation of Better Shelter, a flat pack refugee shelter designed by Swedish company Ikea and UNHCR. The shelter is made up of a steel frame, insulated polypropylene panels, and recycled plastic. It can last three years and accommodate up to five people (Tubertini). Traditional tents that house refugees rely on canvas, ropes, and poles. They are more prone to leak during heavy rains, provide little insulation during the winter, and can easily be uprooted in strong winds. The Better Shelter is solar-powered and offers four hours of electric light and the ability to charge mobile phones. Shelters can fit into two boxes and be fully assembled

in four hours without the use of tools. Although each unit comes at a cost of $1,250, Better Shelter lasts six times longer than a typical emergency tent (Wainwright). More importantly, the Better Shelter offers privacy, security, electricity and durability.

Beyond innovation, other measures to improve the living conditions of refugees stuck in Greece involve utilizing urban spaces. After the economic crisis, large cities in Greece are still recovering and lack infrastructural development. The housing and construction industries were severely affected, leaving many projects unfinished and some buildings vacant and unused. By expanding shelter sites into more urban areas, unused spaces will serve a new purpose. This would be sustainable and provide support for rehabilitation and reconversion projects in the area, stimulating the construction industry and the urban economy as a whole (Wain).

The task of moving refugees to urban areas within Greece has already been initiated. Since July 2017, the Emergency Support to Integration and Accommodation programme (ESTIA) was created to combat housing shortages for refugees in Greece. Under this program, UNHCR works with the Greek Government, local authorities and NGOs to provide urban accommodation and cash assistance to refugees and asylum-seekers in Greece ("Emergency Support to Integration & Accommodation"). ESTIA is funded by the Asylum, Migration and Integration Fund of the European Union. Eight cities have already committed to the ESTIA program: Athens, Thessaloniki, Livadia, Trikala, Larissa, Karditsa, Crete and Nea Filadelfia (Edwards). Most refugees and asylum seekers are relocated to the Attica region and northern Greece. The total number of accommodation places created thus far has amounted to 26,186.

Uncertainty over relocation and reunification in the EU, legal status, and a recovering economy in Greece are all obstacles to long-term planning. Outside of shelter capacity, UNHCR and Greek asylum officials should expedite the processing of asylum claims and resettlement

cases. For refugees who are refused relocation, reunification or asylum in Greece, and for those deciding to remain in Greece, a two-step transitional approach to accommodation may be more appropriate than long-term residency in a camp ("Service Delivery in the Refugee Camps of Greece"). It is recommended that alternative legal pathways are made available, such as humanitarian, student, and work visas and private sponsorships, for asylum seekers, migrants and refugees who are not eligible for resettlement or family reunification ("EU Policies Put Refugees at Risk").

In order to facilitate faster communication and coordination between various humanitarian, government, and private sector stakeholders involved in Greece, it is recommended that a camp management information system is implemented ("Service Delivery in the Refugee Camps of Greece"). One central information system would create transparency among various stakeholders and track decisions and changes in real time. The linear programming model presented in this paper could also be integrated into this information system. The system is not only useful for tackling shelter capacity issues, but also organizing procurement activities, supplier information, and, logistics and delivery. This would allow for oversight of high-level needs and has potential to eliminate redundancies or shortfalls in the case where organizations are unaware of which supplies are needed at each site.

Outside of Greece, such systems are already in use. A team at Purdue University is working with Catholic Relief Services (CRS) to create an Emergency Response E-Supply Chain Management System, "a web-based, multi-platform, centralized, offline-compatible electrical emergency response system" (Yih, Yuehwern et al). The system enables CRS to monitor stock levels in its various warehouses in real time, file emergency procurement requests instantly, and tracks relief materials from donors all the way to the end beneficiary. Prior to the development of

the Emergency Response E-Supply Chain Management System, CRS had a paper-based system that had a high potential for human error. The newer web-based system is reliable, efficient, and sustainable, which allows CRS to better anticipate delays, shortages, and bottlenecks within its supply chain.

Conclusion

By analyzing the field of humanitarian aid logistics in the context of the 2015 Refugee Crisis, it is clear that there are many complex decisions that must be made. The nature of any refugee crisis is very serious and the need to save lives and reduce suffering is the central focus of decision-making. While Greece continues to grapple with the issue of hosting refugees, it draws attention to the greater need for collaboration between governments, relief organizations, and private corporations. The number of refugees arriving on a daily basis on Greek islands has significantly decreased, but there are still new daily arrivals today. As civil conflicts arise and new refugee flows occur, Greece could receive an unprecedented number of new arrivals at any time. There is a pressing need for supply chain analysis and improvement in operations so that the country is better equipped to handle any future influx of migrants.

By providing a linear programming model that optimizes shelter capacity at refugee centers, Greek officials and leading relief organizations can better manage their operations. It also serves as a step towards alleviating suffering among refugees in Greece. Shelter capacity is just one aspect of site operations. The consideration of food supply, staffing, medical equipment, and other resources could be added as additional constraints to a linear programming model. The use of a multi-variable model would be more realistic to consider a holistic view of the refugee situation in Greece. Organizations can aim to establish objective measurements of the quality of various sites in Greece in order to ensure both sufficient conditions and efficient optimization of capacity at any given site. This is an opportunity for future research and application for more complex models and supply chain optimization.

As programs like ESTIA expand, there is less stress on occupancy rates and shelter capacity. However, this excludes hotspots and other sites with high receiving rates. As shelter

capacity improves, more funds can be allocated towards other issues faced by refugees in Greece such as health initiatives and access to education. Refugees that spend upwards of two years or more in temporary shelter sites should have access to these resources. There is also a need for reform in asylum policy within the European Union. Cooperation is needed not only within the EU but also with the international community as a whole. In the meantime, supply chain experts and relief organizations can look at issues such as the bottleneck created in processing asylum claims. Efforts to reduce processing times would be impactful for countries like Greece from long, drawn out processes that are inefficient. Not only would this result in cost savings, but it would also shorten the amount of time that refugees need to spend living in temporary shelters.

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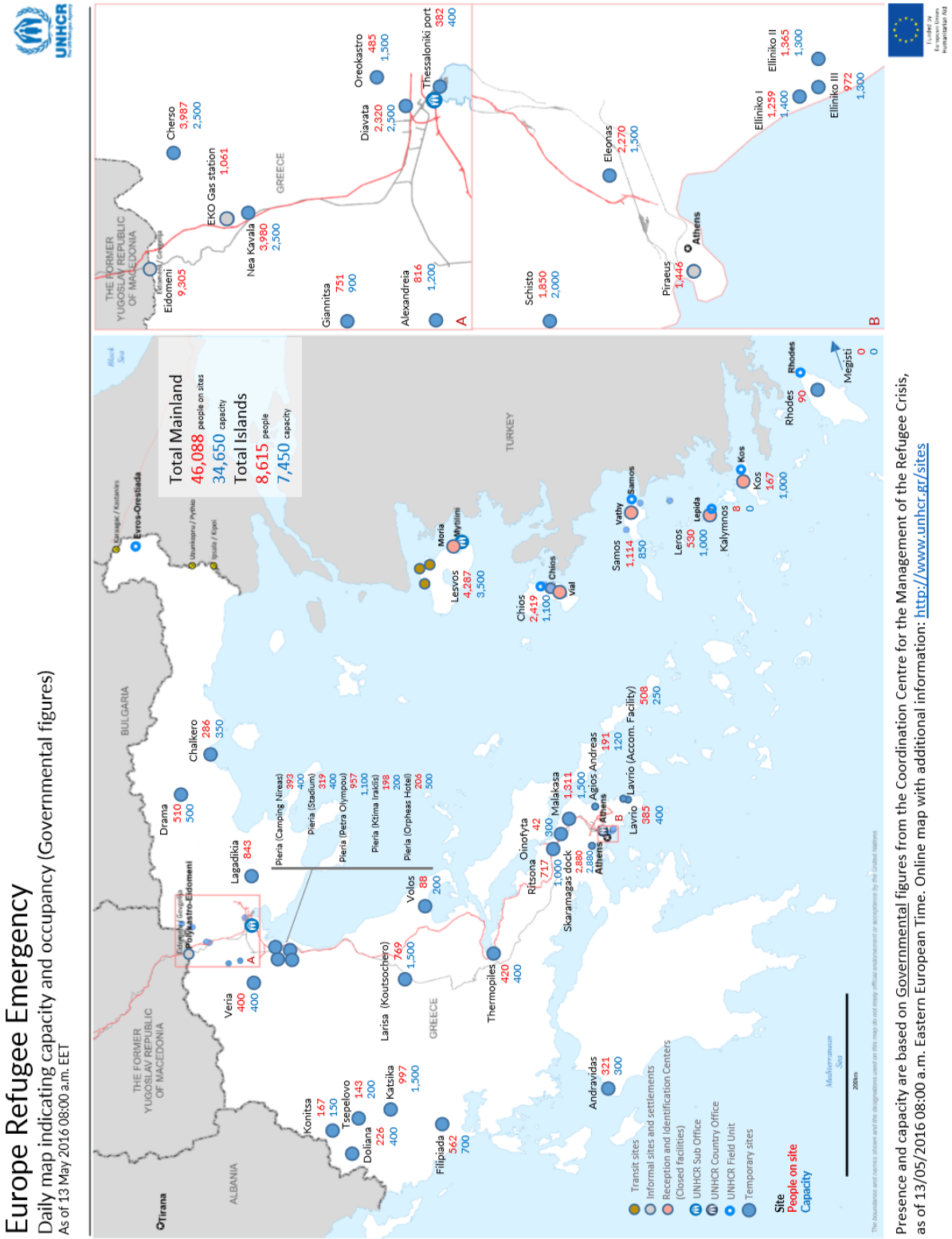
Appendix


Europe Refugee Emergency
Daily map indicating capacity and occupancy (Governmental figures)
As of 13 May 2016 08:00 a.m. EET
Total Mainland
46,088 people on sites
34,650 capacity
Total Islands
8,615 people
7,450 capacity
Site
People on site
Capacity
Transit sites
Informal sites and settlements
Reception and Identification Centers (Closed facilities)
UNHCR Sub Office
UNHCR Country Office
UNHCR Field Unit
Temporary sites
THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA
ALBANIA
BULGARIA
GREECE
TURKEY
Tirana
Evros-Orestiada
Eidomeni 9,305
Cherso 3,987 2,500
EKO Gas station 1,061
Nea Kavala 3,980 2,500
Giannitsa 751 900
Diavata 2,320 2,500
Oreokastro 485 1,500
Thessaloniki port 382 400
Alexandreia 816 1,200
Schisto 1,850 2,000
Elepnas 2,270 1,500
Piraeus 1,446
Athens
Elliniko I 1,259 1,400
Elliniko II 1,365 1,300
Elliniko III 972 1,300
Drama 510 500
Chalkero 286 350
Lagadikia 843
Pieria (Camping Nireas) 393 400
Pieria (Stadium) 319 400
Pieria (Petra Olympou) 957 1,100
Pieria (Ktima Iraklis) 198 200
Pieria (Orpheas Hotel) 206 500
Veria 400 400
Volos 88 200
Larisa (Koutsochero) 769 1,500
Thermopiles 420 400
Oinofyta 42
Ritsona 717 1,000
Malakasa 1,311 1,500
Skaramagas dock 2,880
Agios Andreas 191 120
Lavrio (Accom. Facility) 508 250
Lavrio 385 400
Andravidas 321 300
Konitsa 167 150
Tsepelovo 143 200
Doliana 226 400
Katsika 997 1,500
Filipiada 562 700
Moria
Mytilini
Lesvos 4,287 3,500
Chios 2,419 1,100
Vial
Samos 1,114 850
Vathy
Samos
Leros 530 1,000
Lepida
Kalymnos 8 0
Kos 167 1,000
Kos
Rhodes 90
Rhodes
Megisti 0 0
Presence and capacity are based on Governmental figures from the Coordination Centre for the Management of the Refugee Crisis, as of 13/05/2016 08:00 a.m. Eastern European Time. Online map with additional information: http://www.unhcr.gr/sites