



Tactical network planning for food aid distribution in Kenya



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ABSTRACT

In Sub-Saharan Africa, annual weather patterns cause frequent and regular shocks which make the population more vulnerable to food insecurity. Countries are affected by periodic droughts between two irregular rainy seasons, which have a profound effect on seasonal food crises. This study is rooted in a food aid distribution problem arising in Kenya, but it can also be applied to other developing countries. Our aim is to design an effective last-mile food aid distribution network. We present location models to determine a set of distribution centers, where the food is directly distributed to the beneficiaries, for the region of Garissa in Kenya. Our models take into account the welfare of all stakeholders involved in the response system: the World Food Programme, the Kenya Red Cross, and the beneficiaries. We describe how we have combined need assessment and population data to plan food distribution in Garissa. We also show how we have used GIS data on the road network to establish a set of potential distribution centers. In addition to the results obtained by solving our primary model, we present several comparative analyses and variants of the basic covering model.

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1. Introduction

According to the United Nations (UN), hunger and malnutrition pose the largest risks to worldwide health. Some progress has been made toward achieving food security, but eradicating extreme poverty and hunger remains the first of the eight UN Millennium Development Goals [60]. Maintaining food security at the national and household levels is indeed a priority for most developing countries. Relief food aid is generally distributed in situations of war, natural disasters and population displacement, but a number of countries facing some forms of chronic food insecurity have also become permanent recipients of this form of aid [41]. Many developing countries suffer from food shortages, but Sub-Saharan Africa is the only region in the world that is constantly suffering from widespread chronic food insecurity and persistent threats [52]. Seasonalities have always had an important impact on hunger and poverty in Sub-Saharan Africa. The annual patterns of the two dry and the two rainy seasons cause frequent and regular shocks which make people vulnerable to food insecurity and hamper their opportunities to move out of poverty. Relatively little attention has been paid to the implications of seasonalities on food insecurity and rural poverty, despite the fact that they generate short-term hunger and

seasonal food crises every year [17]. Because seasonalities are repetitive, rural households and communities have developed coping strategies to buffer their effects, like pastoralist livelihood systems which enable populations to migrate where water and pastures are more abundant [67]. This project aims at providing a methodology for designing and managing a tactical food aid distribution network in such a context.

Food aid is an instrument used to reduce insecurity in poor nations. Although food aid has often been criticized [7,5,13,34], it remains an important component of humanitarian operations. Food aid management entails operations evolving within highly complex supply chains. As stated by Van Wassenhove [62] and Christopher and Tatham [11], logistics is now being recognized to be an integral part of relief operations. In the last decade, humanitarian organizations have started adopting supply chain management methodologies to increase their performance and enhance coordination between the actors involved in assistance operations. For example, the World Food Programme (WFP) has made continuous efforts to expand its logistics capacity and to improve the efficiency of its transportation operations, which has enabled it to acquire an acknowledged expertise in moving large amounts of food commodities, often under difficult circumstances, throughout the developing world [53].

Haddow and Bullock [24] distinguish four phases for disaster management operations of humanitarian organizations: response, recovery, mitigation and preparedness. The preparedness and response phases have a relief purpose whereas the recovery and the mitigation

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phases are more focused on capacity development. These four phases encompass strategic, tactical and operational planning. In disaster management, one typically considers that the shocks (disasters) occur before the response phase. These shocks are often unpredictable and devastating, and they only last a relatively short period of time. Our problem is related to the preparedness phase of continuous relief operations rather than to the disaster relief response (see [30,10], for a distinction between development aid and disaster relief operations). Although food aid is often associated with rapid and short-term disaster relief, there are cases in poor and low rainfall areas where food aid needs are more foreseeable since they result from regular and seasonal food insecurity. For long-term development operations, such as food aid distribution in Sub-Saharan Africa, the shocks grow gradually over time and are more predictable than food shortages arising in natural sudden catastrophes such as earthquakes and tsunamis, even if emergency responses can also occur in sustained food aid distribution operations, as was the case during the 2011 famine in the Horn of Africa. Nevertheless, the four phases of disaster management are still appropriate and applicable to the context of food security, but they overlap with each other over time. Using the framework of Haddow and Bullock [24], food aid distribution planning can be viewed as a tactical relief problem since it involves medium-term decisions reviewed every six months. Like the consequences of sudden-onset disasters, long-term development issues also engender human suffering, often coupled with economic damage or poverty, even if the causes cannot usually be attributed to one specific catastrophe.

In this context, where the welfare of the stakeholders is related to economical or accessibility concerns, the tactical management of food aid supply chains is a complex task. Humanitarian organizations

operate with limited resources which depend primarily on donations. It is therefore critical for these organizations to effectively design their supply chain and transportation plans in order to reach as many affected people as possible during crises. Humanitarian logistics shares several characteristics with its industrial counterpart. Indeed, multiple relevant location and transportation problems encountered in the context of food distribution are defined on networks and share a common structure with classical distribution management problems. Tzeng et al. [59] have compared general physical distribution systems for business with relief distribution systems. They have suggested that the points located in non-devastated areas where the commodities are collected act as supply nodes (depots), whereas the devastated areas where relief is provided to victims act as demand nodes (customers).

As mentioned by White et al. [64] operations research can make important contributions to the improvement of decision making in developing countries. Nevertheless, most of the works published in the humanitarian operations literature rely on generated data to solve mathematical models. There are, however, some exceptions, such as Pedraza-Martinez and Van Wassenhove [44], Besiou et al. [6] and McCoy and Lee [37], but these contributions focus on different problems than the one tackled in this paper. Van Wassenhove [62] pinpoints the cross-learning potential for both humanitarian and private sectors in emergency food relief operations and the benefits of potential collaborations. This has motivated us to analyze the food aid distribution problem in developing countries through the use of a mathematical programming based methodology and by collaborating with humanitarian organizations to gather real data, an approach not commonly used in this context. We believe that the results obtained by exploiting

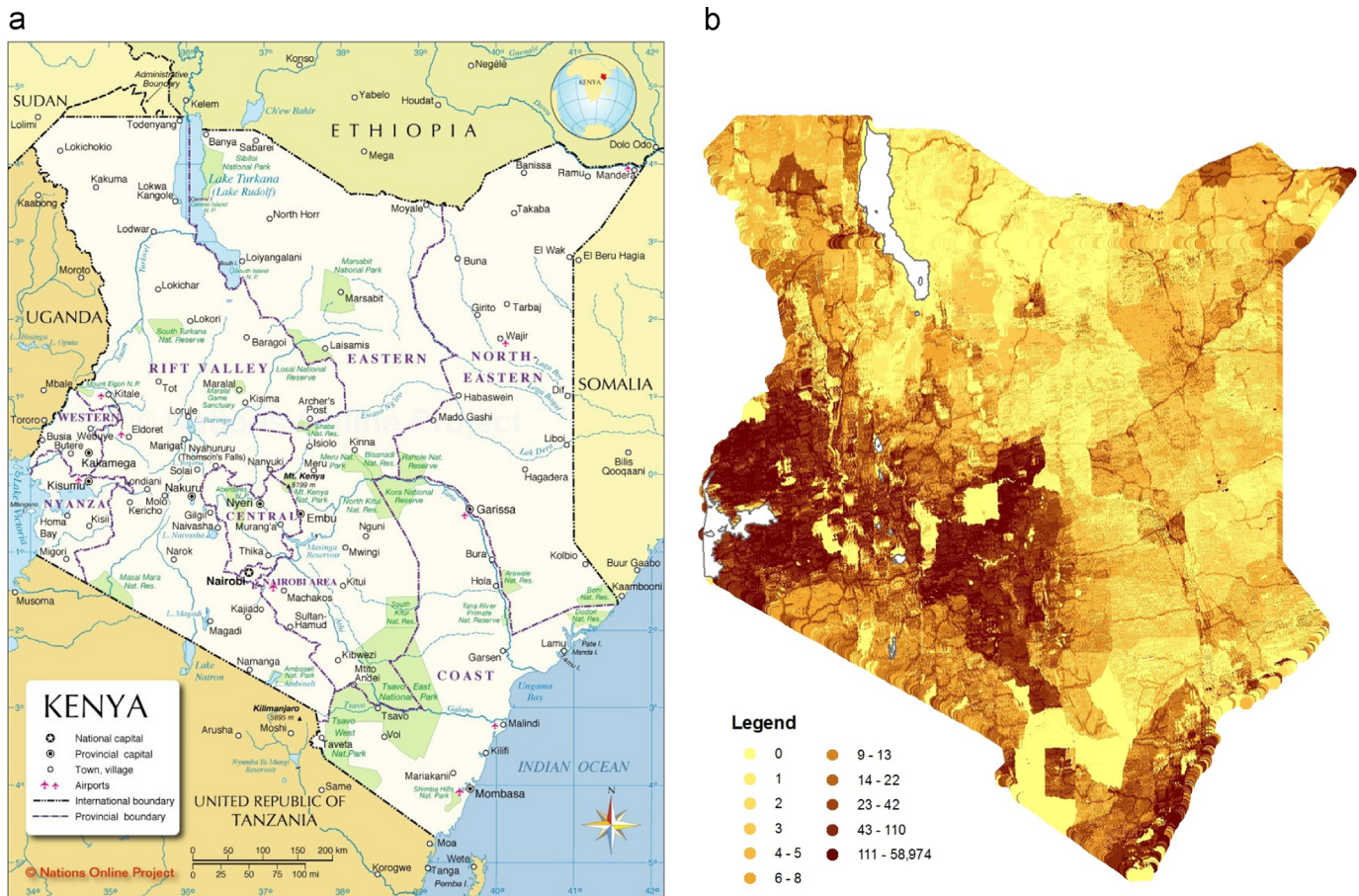


Fig. 1. (a) Map of Kenya [43]. (b) Population data for Kenya [27].

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