Optimal Fit Non-linear Function for Allocating Emergency Goods during Initial Stage of Disaster Relief in Malolos City

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***Abstract*— This paper discusses the establishment of an automated allocation of emergency goods, through optimal fitting of non-linear function to a set of data from the past calamity experienced in Malolos City, as an alternative to existing manual allocation done by the Philippine Department of Social Welfare and Development (DSWD). Non-linear equations are generated specifically for every barangay in Malolos City using FITFUN function in Matlab. FMINSEARCH function, an implementation of the Nelder-Mead simplex (direct search) algorithm, is also used to minimize a nonlinear function of several variables of. The generated non-linear equations will be utilized to come up with the right number of emergency goods to be allocated on various affected points (barangay) depending on the intensity of the rain; rain factor is to be used as system's input. This paper aims to eliminate the manual process done by the authority in allocating emergency goods to affected areas. Although this paper focuses more on relief goods demand chain operations on flood and typhoon scenario, the simulation framework is intended to be general so that it can be used in modeling other types of natural and man-made disasters such as earthquake, fire and bioterrorism.**

***Keywords*— Emergency Goods Allocation, Disaster Relief Operation, Optimal fit non-linear equations**

Introduction

Philippines is ranked third in the list of 'Most Disaster-prone Countries' worldwide and first in Asia, as shown in Figure 1, due to its geographical location. It resides in the Western rim of the Pacific and along the circum-Pacific seismic belt, subjecting it to typhoons, earthquakes, floods, volcanic eruptions, droughts and other natural calamities [1]. As a result, the country experiences on average 887 earthquakes every year, some of which have proved to be damaging [2]. In addition, the Philippines is visited by an average of 19 to 20 tropical cyclones every year [3].

For the record, the most destructive typhoon which made a devastating impact in the country includes Typhoon Glenda (July 2014), Typhoon Pablo (Nov 2012), Typhoon Pedring (Sept 2011), Typhoon Juan (Oct 2010), Typhoon Pepeng (Oct 2009), Typhoon Ondoy (Sept 2009) Typhoon Frank (June 2008) [4]. Yolanda (Typhoon Haiyan), the strongest typhoon to ever make a landfall in the Philippines in 2013, affected 16 million people across nine regions. At least four million people lost their homes. The death toll has reached 6,300 while 1,061 remain missing. Journalist from CNN news, Anderson Cooper, witnessed the increasing casualties made by typhoon and stated that there is no real evidence of organized recovery or relief effort coming from the Philippine government. It has been reported that our countrymen in Eastern Visayas are going hungry while millions worth of relief goods just rot in DSWD's storehouses [5]. DSWD Secretary Corazon "Dinky" Soliman admits P2.8M worth of relief goods for Yolanda survivors spoiled. According to Commission on Audit (COA) 7,527 family food packs were damaged and some 19,172 canned goods,81 packs of noodles and 21 sacks of rice were also found unfit for human consumption [6]. This issue could have been avoided if there is a prescise and efficient system of allocating emergency goods.

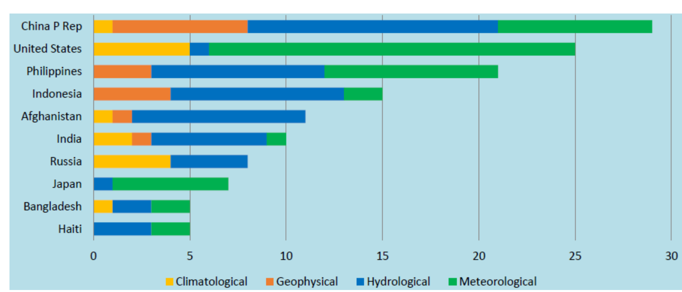

Figure 1. Top 10 countries by number of reported events in 2011

Source: Annual Disaster Statistical Review 2012: The Numbers and Trends

In the audit of the relief efforts of Department of Social Welfare and Development (DSWD), COA noted at least four lapses in the relief operations in Central and Eastern Visayas that resulted in the damage of relief goods. First, there was an inadequate supervision and monitoring of the unloading of goods from the barges and warehouses. In this regard Zhou [7] created a model to tracks the flow of materials shipments over networks from supply stations to people in need, as well as suggests locations for intermediate distribution stations where people may receive materials.

Second, cargo containers, trucks, cargo ships, and other logistics were not always readily available, to transport the relief goods from the port to the storage buildings/drop-off points , because of inefficient scheduling and dispatching of vehicles available at local garages. This transport delay prevents the supplies from reaching the destination, so it increases the in-transit inventory and therefore decreases the shipment/supply level [8]. In this regard various researchers design different models with the objective of minimizing the number of vehicles used, total travel time and distribution time. Fan et. al. [9] and Chang et. al. [10] adopted genetic algorithm in dispatching vehicles to optimize routes. Wang and Miao [11] establish the mathematical model for B-Transportation problems of relief goods. Haiyan et. al [12] developed lean logistics distribution system whose goal is to optimize the relief materials logistics. Li et. al [13] proposed a multiobjective optimization model for location transportation problem from the viewpoint of integrated optimization in emergency logistics. Chung et. al. [15], given the disaster location, required supplies, proposed method that can generate optimal routing schedules with limited number of rescuing vehicles. Lee et. al [18] developed analytics for the optimal dispatch of relief supplies from local staging areas to point of distributions (PODs) and optimal cross-leveling among PODs.

Third, as what is noted in Central Visayas, open dump trucks were used to transport relief goods, exposing them to even more risks of damage. Some goods were also not covered while they were transported from Cebu City to Tacloban City on board the vessel. Lastly, there were no concrete guidelines in handling the huge amount of relief goods, and relief workers were not prepared to handle these.

In addition, as shown in figure 2, information delay (e.g. request number of relief goods for a particular drop-off point) greatly affect the flow of emergency goods since it limits the headquarter from taking reactions in time. Thus, it delays the feedback between concerned agencies lowering the amount of shipment/supply that may result to excessive warehouse stock [8]. There are researches that focused on prediction of number of demand of relief goods that somehow lessen information delay. Guo et. al [16] estimate the demand of each affected areas based on the fitting function derived from collected history disaster data.

Other lapses observed were in the documentation of donated cash and relief goods. There were no proper accounting of damaged relief goods and no documentation of how these were disposed of [14].The question on whether there is corruption is another issue and dissecting it will not be the purpose of this research. Instead, the researcher wants to focus on the problem of the non-moving relief goods or goods that are stocked at the warehouses by proposing a solution as an alternative to the existing guidelines followed by DSWD in order to have a fair, precise and efficient allocation system of emergency goods. In addition, automated acquisition of necessary number of emergency goods to be distributed on a particular distribution point will eliminate delay due to manual process of requesting, allocating and approving, to make sure that the relief goods reach the disaster victims in as little time as possible.

The remainder of this paper is organized as follows: In Section 1, the author presents an overview of the actual process of emergency goods distribution done by the DSWD. The overview Sri Lanka's Free and Open Source Disaster Management System (SAHANA) used by Philippine DSWD in their recent relief efforts is discussed in section 2. In section 3, the author presents the overview of optimal fitting of data of past relief operations in Malolos City to a non-linear equations using the FitFun and FMINSEARCH function of Matlab 7.8.0. In section 4, the author presents the summary, conclusions and recommendations.

I. Overview Of Current Disaster Management and Relief Operation in the Philippines

When disasters occur, the two main goals are to rescue the injured persons and deliver the relief materials. For relief distribution, Chung et. al [15] divide the process into several stages which includes information gathering, relief planning, resource gathering and rescuing process. Supposedly, there are multiple disaster points, their demand amount of relief materials are firstly issue or requested to supply point/distribution center/staging area. Whereas, Lee et. al [18]divides disaster preparedness and response modeling into four areas: supply chain model, POD distribution model, demand model and disaster model. This paper will focus on monitoring the process of relief materials delivery as well as designing a demand model for relief goods needed for Malolos City, Bulacan.

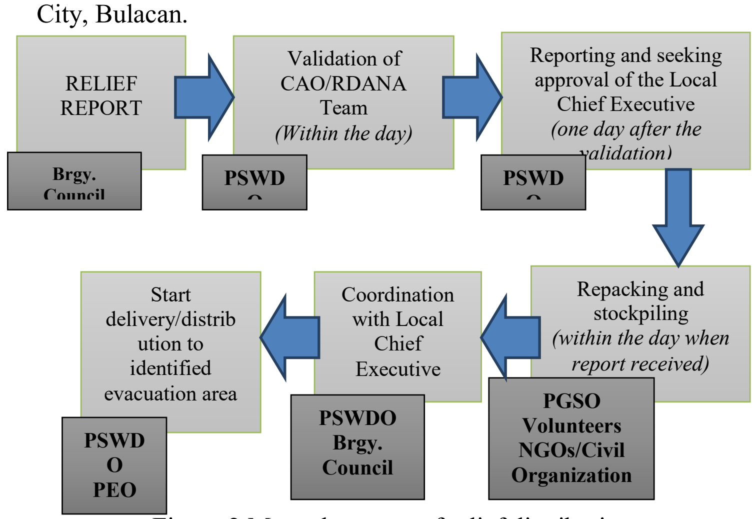

Figure 2 Manual process of relief distribution

Source: PDRRMO, Bulacan

Currently DSWD follows the manual process of relief operation. The process starts at the supply point where repacking of goods is done. As shown in figure 3, this may be done on state distribution center (DC) /warehouses of DSWD, regional staging area (RSA) and local staging area (LSA). The number of relief goods to be distributed to the affected areas are based on the report of local chief executive and Barangay Council, and upon approval of f mayors for LSA and governors for RSA, it then transferred to drop-off points or shelter near the affected areas. This process takes at least one day as shown in figure 2.

Representatives from the Department of Finance check if the goods to be delivered reflect the Tally Out Sheet. After the approval of the supervising administrative officer, a third-party courier service facilitates the loading in the presence of a DSWD personnel, who is in-charged of authorizing and making a record of the discharged goods. After authorizing the operation, the trucks transferring the goods are then allowed to leave escorted by the MMDA. DSWD then informs the drop-off point personnel about the status of the relief goods. Upon arrival, the goods are again checked by DSWD officials and give a feedback to the point of origin of the goods. After the necessary documentations, the relief goods will then be distributed by the Local Government Unit to the beneficiaries in the affected areas [17].

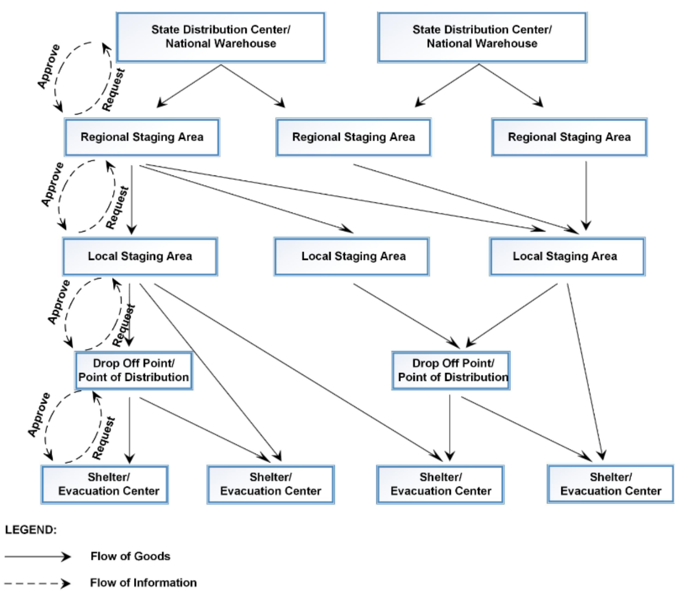

Figure 3. Flow of Emergency Relief Goods

The problem with manual relief operations is that, even if supplies and infrastructure are available, the effect of the disaster can still greatly overwhelm the preparations made to handle the situation. Coordination chaos may occur because each relief management element has a little idea what the other is actually doing. Those that need aid and the one that can provide it have lack of awareness and visibility to the aid available. This may result to waste of pledged support, imbalances in aid distribution and a lack of proper coverage of support and services. Obtaining and coordinating right information between management teams is essential in order to prevent chaos and alleviate human suffering and save lives. This information may include news about missing person, status of medical supplies and relief coordination in order to distribute resources to the right place and in the right quantity. Managing this information is very complicated especially when manually done in large scale that is where ICT performs. Through ICT coordinated data can be shared and accessed instantaneously by government, field operatives, civil society groups and victims itself to enhance the relief effort and avoid problems stated above. (de Silva and Prutsalis, 2010).

II. The Sahana Free and Open Source Disaster Management System in the Philippines

For better management of delivery of humanitarian aid across the country during typhoon Yolanda, Philippine Department of Social Welfare and Development (DSWD) utilized the Sahana Free and Open Source Disaster Management System (SAHANA) Eden based Relief Goods Inventory and Monitoring System (RGIMS). Even before typhoon Yolanda struck the country, when tropical storm Maring hit and causes flooding over 70% of Metro Manila, the system is already been utilizing in order to view the real-time inventory of family food packs in warehouses and donations of relief goods received and dispatched to victims from the time they are first requested by DSWD field offices to their handover to implementing partner and local government units (Prutsalis, 2013). It also allows DSWD warehouses to track donations, requests, the expiration dates of perishable items, and the movement of relief goods (Cruz, 2013).

The RGIMS is part of the SAHANA was developed by volunteers from the ICT industry in Sri Lanka and been realized due to December 2004 Indian Ocean Tsunami in Sri Lanka. It was designed initially to manage and coordinate its relief efforts among affected families during and after disaster. The project took its second phase to make it a global public good by utilizing Free and Open Source Software (FOSS). Thus, Humanitarian FOSS (H-FOSS) was created. It helps empower number of groups from Government, Emergency Management, NGOs, INGOs, volunteers and victims by allowing them to share and coordinate information on a common platform. This system incorporates multiple sub-applications that address the common coordination problems in the aftermath of a disaster. Each of these subapplications are independent modules that can either be included or removed from the final custom solution depending on the needs of the user. SAHANA subapplications include Missing Persons Registry, Organization Registry, Request Management System and Inventory, Volunteer Management System, Situation Mapping System, Displaced Victim Registry and Shelter Registry. The first subapplication is an online bulletin board of missing and found people. The second keeps track of all the relief organizations and civil society groups working in the disaster effected region. The third is an online aid trading system that tracks requests through to fulfillment. It acts as a simple logical system that track the storage and distribution of aid between the time a pledge is delivered to a warehouse to its final distribution among recipients. It can effectively match requests of aid and supplies to pledges of support. The fourth module tracks an individual record such as their skills/professions, their availability and what projects they are currently working on. The fifth subsystem permits the scalable entry of all the volunteer data and search a system that allows for a database search of volunteers for a particular project. The sixth has a mapping functionality which is essential whenever there is a need to enter points or display custom maps. The sixth module is about tracking displaced families or groups and the last one is a simple system to plot the location of temporary and permanent shelters for victims, illustrating the main concentration points of shelters after a disaster (19). The stated advantages and features can be considered as solution for keeping and tracking of relief in warehouse which can be improved. All of this sub application are merely database to monitor and do not allow prediction of amount of demand relief goods which is the focused of this paper in order to reduce and avoid information delay

III. Optimal Fitting of Data to Non-linear Equations

The researcher created various non-linear equations that are best fitted for every barangay in Malolos City. Available data from the past calamity which include Typhoon Maring (2013), Falcon (2011), Gener (2012) and Pedring (2011) are being collected and analysed. Number of affected families during these typhoons is the focus the paper since it will dictates the number of emergency goods needed. Table 1 shows the part of the population that is being affected directly by the typhoon which is in need of assistance/relief. Rain intensity is also collected and will be used to create relationships between the numbers of affected families. As shown in the table, generally as the rain intensity in the form of rain factor increases the number of affected families also increases except for typhoon Pedring. Consequently, this particular data will not be included in the generation of non-linear equations.

Table 1 Population being affected, rain intensity, height of tides

Typhoon	Maring	Falcon	Gener	Pedring
% of Population	43.43%	14.13%	4.05%	14.27%
Rain Factor	2.2570313	1.4865165	0.5924638	0.9666667

The output of this paper is various non-linear equations that are fitted for every barangay in Malolos City. Thus, the observation stated above must be validated individually for every barangay. For the record, there are five (5) barangays namely Babatnin, Guinhawa, Liang, San Vicente and Sto. Rosario which do not conform to the findings above. Thus, they will not be included in generating non-linear equations.

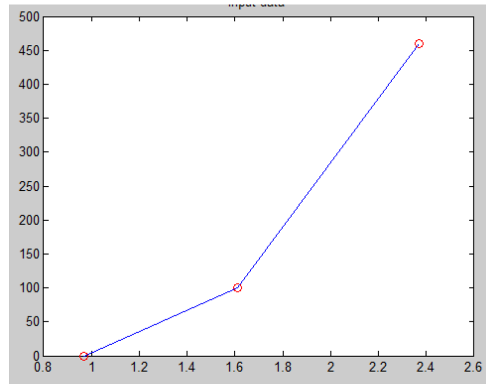

Figure 4. Affected population in Barangay Anilao, Malolos City

Number of population affected by three typhoon (y) as well as the rain intensity in the form of rain factor (t) is plotted in Matlab for every barangay such as in Anilao shown in figure 4.

Next step is to fit the following data in a function two linear parameters and two nonlinear parameters:

y = C(1)*exp(-lambda(1)*t) + C(2)*exp(-lambda(2)*t) *eq.1*

To fit this function, the researcher made use of the FITFUN function in Matlab by computing for the values of lamda. It uses FMINSEARCH, an implementation of the Nelder-Mead simplex (direct search) algorithm, to minimize a nonlinear function of several variables. For the given above, the function computed *-1.5613 and 0.0022* for the values of lamda(1) and lamda(2) respectively.

From equation 1, two values of y and t from the data are used in order to generate two equations in order to solve for the values of C(1) and C(2).

The computed non-linear equation that is best fitted for barangay Anilao is;

y = 12.8*exp(1.5613*t) – 58.345*exp(-0.0022*t) *eq. 2*

This process is repeated in to get various non-linear equations for every barangay in Malolos City. In future use, rain factor will be the input of the equation and the system will generate list of number of predicted affected families/number of relief goods.

IV. Summary, Conclusions And Recommendations

The current manual process of emergency relief allocation/distribution will result to various uncoordinated and delayed information. Because of this, request and approval of number of relief goods to be distributed in every barangay takes at least one (1) day of process. The researcher solved this problem and came up with various non-linear equations generated based on the past information/data that will predict number of families that will be affected by the future typhoon/monsoons.

For future work, it is recommended to use not just the rain factor/intensity as the input factor to determine the required number of relief goods. Height of the tides, wind intensity, amount of water being release by the surrounding dams may be used to come up with more accurate non-linear equations.

V. REFERENCES

[1] Commission on Audit (COA) (2014). Report on the Audit of Typhoon Yolanda Relief Operations.

[2] PHIVOLCS, 2013. http://www.phivolcs.dost.gov.ph

[3] PAGASA (2013). http://www.pagasa.dost.gov.ph

[4] PAGASA, (2014). http://www.pagasa.dost.gov.ph

[5] Romero, Paolo (2014). House Probe Slow Disbursement of Yolanda Aid. http://www.philstar.com

[6] Hegina, Aries (2014). Inquirer. http://www.newsflash.org

[7] Zhou, Lei, (2012, September). Disaster Relief Materials Distribution and Transportation Research Based on Spatial Model. 2012 International Conference on Management Science & Engineering (19th). Dallas, USA.

[8] Peng, M., Chen, H. (2011, September). System Dynamics Analysis for the Impact of Dynamic Transport and Information Delay to Disaster Relief Supplies. 2011 International Conference on Management Science & Engineering (18th). Rome, Italy.

[9] Fan, H., Zhao, T., Zhao, X., Jang, M., Dong, G. (2008). Research on Emergency Relief Goods Distribution After Regional Natural Disaster Occurring. 2008 International Conference on Information Management, Innovation Management and Industrial Engineering.

[10] Chang, C., Ma, X., Song, X., Gao, B. (2010). Emergency Goods Scheduling Model and Algorithm during Initial Stage of Disaster Relief.

[11] Wang Zhufang, Miao Wenqing (2010). An Improved Algorithm to Solve the Transportation Problems of Relief Materials.

[12] Yang Haiyan, Yang Weiping, Zhao Xinxin (2011). Lean distribution system of earthquake relief resources research.

[13] Shuang-lin Li, Zu-jun Ma, Bin Zheng, Ying Dai (2011). Multiobjective Location-Transportation Problem in Post-Earthquake Delivery of Relief Materials.

[14] Cantalejo, Linette R. (2014), Relief goods Yolanda Survivors Late. http://archive.sunstar.com.ph

[15] Chung, L., Chou, T., Lee, C. (2012). Multiobjective Dynamic Length Genetic Algorithm to Solve the Emergency Logistic Problem. The 2012 IEEE/ASME International Conference on Advanced Intelligent Mechatronics. Kaohsiung, Taiwan.

[16] Guo, Q., Zhu, J., Che, T., Huang, J. (2014) Study Two-Stages Relief Supplies Distribution Problem based on Characteristics of Disaster Situation Information. Seventh International Joint Conference on Computational Sciences and Optimization.

[17] COA Video process of relief, 2014 http://www.coa.gov.ph/disaster_audit/article5.html

[18] Lee, Y., Ghosh, S., Ettl, M. (2009). Simulating Distribution of Emergency Relief Supplies for Disaster Response Operations. Proceedings of the 2009 Winter Simulation Conference.

[19] Prutsalis, Mark (2013). Sahana Eden based RGIMS aids Philippine Government Response to Typhoon Haiyan. http://sahanafoundation.org