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Predicting Relief Materials' Demand for EmergencyLogistics Planning using ARENA Input Analyzer

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Abstract :The determination of aggregate forecasts leads to efficient pre-disaster planning .This study develops a forecasting tool based on identifying the best fit probability distributions for four variables , Number of disasters , Number of people killed , Number of people affected and the economic losses using ARENA Input Analyzer. The estimates of the parameters are used to calculate natural disaster forecasts. Using ARENA Input Analyzer, the best fit probability distributions for four variables have been found as follow. The best fit probability distribution for Number of disaster is Beta, Number of people killed is Weibull, Number of people affected is Weibull and the economic losses is Exponential .Based on the research findings, the relief agencies can optimize the various resource allocation in emergency logistics planning.

Keywords: **Humanitarian logistics, relief agencies, probability distribution. Article Classification: Research paper**

I. INTRODUCTION

Recently, emergency logistics management has become an important world-wide issue due to severe effect of natural and man-made disasters. The major catastrophes occurred in last ten years causing greater levels of loss of life, and property damage, such as 9-11 attack in USA (2001), Bam earthquake in Iran (2003), the tsunami in the Indian Ocean (2004), the hurricane Katrina (2005), Pakistan earthquake (2005), flood in Bangladesh and Java earthquake (2006), Sichuan earthquake in China (2008), floods in south Asia (2008), Indonesia earthquake (2009, 2010), Haiti and Chile earthquakes (2010), Queensland and Pakistan floods (2010), tsunami in Japan (2011), and New Zealand earthquake (2010, 2011). Moreover, there has been a marked increase in the occurrence of natural disasters such as earthquakes, tsunami, floods, bushfires, hurricanes, droughts and so on globally during the last ten years along with exposure to greater levels of loss of life, and property damage. The number of natural disasters is increasing every year.

For instance, during 1980s the average number of disasters per year was 180, in 1990s increased to 300, and between 2000 and 2010 it was 384, indicating a dramatic increase. As the number of disasters increases every year, more people are affected by these disasters. Comparing 2011 with the previous decade indicates that the number of victims increased from annual average number of 232.0 million for years 2001 to 2010, to 244.7 million victims worldwide. Because of the population growth and new developments in risk prone regions, the exposure of the human kind to the natural disasters is increasing even more. A total of 101 countries were hit by these disasters last year.

In 2011, economic damages from the natural disasters were the highest ever registered, with an estimated US$366.1 billion, and increased by 235% compared to the annual average damages from 2001 to 2010 (US$109.3 billion). Asia was the most often hit by natural disasters in 2011 (44%), followed by Americas (28%), Africa (19.3%), Europe (5.4%) and Oceania (3.3%). Moreover, Asia accounted for 87% of victims affected, followed by Africa (9.2%). In 2011, Asia also suffered the most damages (75.4% of global disaster damages), followed by the Americas (18.4%) and Oceania (5.6%). The earthquake and tsunami in Japan was the most expensive disaster ever recorded, with estimated economic losses of US$210 billion. Floods in Thailand caused a loss of US$40 billion, followed by earthquake in New Zealand (US$15 billion), storms in the USA (US$14 billion). In terms of Gross Domestic Product (GDP), damages in Japan represented 3.0% of the country's GDP, whereas damages from natural disasters in El Salvador and Cambodia – a low middle income and low-income country, respectively – represented 4.7% and 4.6% of the countries' GDPs. New Zealand and Thailand also suffered great economic losses amounting to 12.8% and 12.7% of their GDPs respectively (Guha-Sapir. at el. 2011, World Bank Report, 2012). Immediately after the disaster, there is a huge surge of demand of relief materials with a short notice and the humanitarian relief organizations often face significant problems of emergency logistics management such as transporting large amounts of many different commodities including

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food, clothing, medicine, medical supplies, machinery, and personnel from several origins to several destinations inside the disaster area. The transportation of supplies and relief personnel must be done quickly and efficiently to maximize the survival rate of the affected population and minimize the cost of such operations. The demands in the relief chain occur in irregular amounts and at irregular intervals and occur suddenly, such that the locations are often completely unknown until the demand occurs. Moreover, these have been situation where an oversupply of resources leading to difficulty with coordination, greater traffic and complex scheduling.

Humanitarian relief organizations and NGO's are mostly non-profit organizations with the idea of providing critical services to the public in order to minimize the pain and sufferings after a natural disaster. According to UN Office for Humanitarian Affairs, there is increasing human vulnerability in natural disasters, 244.7 million affected in 2011, and in complex emergencies 54 million in need of life-saving assistance in 2011. Furthermore, emergency management involves preparing for disaster before it happens, responding to disasters immediately, as well as supporting, and rebuilding societies after the natural or human-made disasters have occurred. It is essential to have comprehensive emergency plans and evaluate and improve the plans continuously.

Where emergencies are sudden, roads unusable or ground conditions dangerous, or where much of the infrastructure has been damaged or destroyed, helicopters are used to deliver food and non-food items. Emergency logistics carries out helicopter airlifts to reach areas where fixed-wing aircraft cannot land.

Helicopters have become an indispensable aid for dealing with disasters. People who have fallen victim to a catastrophe or are endangered by disaster cannot afford to wait until a "clearer picture" of the damage has been established. Helicopters can contribute towards establishing this picture, and are promptly called out as soon as "a major occurrence" has taken place.

Every country hit by the natural disaster asks for international help to deal with the disaster. For instance, government of Japan received assistance from 123 countries, and 14 international organizations in 2011.

Moreover, severe floods resulted in losses of the 2011 main season paddy crop. Domestic prices of rice have come down since November 2011. The 2011 main season paddy crop, harvested from October 2011 to January 2012, is officially estimated at 20.4 million tonnes, some 5.1 million tonnes below the record harvest of the previous year's same season. A combination of heavy monsoon rains and tropical storms since late July and especially during December 2011 and January 2012 caused severe flash flooding in the North, Northeast, East and Central regions of Thailand. It damaged at least 1.6 million hectares of standing crops. The affected area covers 12.5% of total national cropped land. The main season paddy crop harvested from October onwards, accounts for approximately 60% of total annual paddy output Guha-Sapir. At el.(2011).

The secondary season crop currently being harvested is forecast at a record level of 11.3 million tonnes, indicating significant recovery from the flood affected paddy areas. Reduction in the national maize harvest is only about 1.6 %. In aggregate, the 2011 paddy output (the main crop of 2011 and the secondary crop in early 2012) is estimated at 31.6 million tonnes, 11 % down on the previous year's bumper level but still around the average of the past five years. According to the Ministry of Agriculture and Cooperatives, nearly 12.3 million of livestock were at risk during the flood period. Overall food security in the country is satisfactory and the rehabilitation of the flood affected population is underway.

Moreover, 72 per cent of flooded families stated that they had been informed of the incoming flood and most of them had moved out to a safer area during the time of crisis. In Sukhothai province, the flood had reached the City Hall and many other government offices, had been submerged under the flood of 50 centimeters deep. A number of shops had been closed while car owners had parked their vehicles on the shoulders of elevated roads to escape the floodwater. Prime Minister had already assigned all related officials to help with the flood draining operation in Sukhothai and asked for international help. One year after Thailand's worst flood since decades, the Director General of UNESCO visited Ayutthaya to assess the post-flood recovery works at the World Heritage site of Ayutthaya and to assist at the Inauguration Ceremony of UNESCO's project on restoring Thailand's Community Learning Centers damaged by the 2011 flood. He was informed about the damages caused by the heavy flood with water levels up to 3 meters in late 2011 and the main challenges for recovering damages at the monument. Over 300 community learning centres in Thailand were damaged, 106 of which in Ayutthaya province and the Government of Japan provided the depth of its support. Moreover, 2011 was an important year for the humanitarian community and relief organizations. There was barely a moment when humanitarian community was not faced with a relentless series of natural disasters, political crises and chronic emergencies. At the end of December, humanitarian response partners, UN agencies, NGOs and the International Red Cross/Red Crescent Movement agreed on a series of reforms that focused on making their response efforts faster and more effective.

Many of the traditional donor countries were affected by the global economic crisis. Political protests evolved into a year-long, region-wide series of uprisings in North Africa and the Middle East, with significant

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humanitarian consequences in Libya, Yemen and Syria. And persistent conflict continued in Sudan, South Sudan, Somalia, Democratic Republic of the Congo, Afghanistan and elsewhere, affecting millions of people. Despite these global problems, relief agencies established stronger leadership more quickly and worked with new partners, and stronger relationships were built worldwide between international agencies and national and regional authorities, which were increasingly taking the lead in preparedness-and-response efforts. The progress made in 2011, offers hope that the goal of a rational, coordinated and effective aid system is within our reach.
The increase in the number of natural disasters in Thailand and other parts of Asia highlights the need for a better planning and operation of the responding agencies. In 2011, 52.1% of the natural disasters in Asia were hydrological disasters, 21.2% meteorological and 19.2% geophysical, while climatologically disasters accounted for 7.5% of total disaster occurrence. Moreover, the number of hydrological disaster victims increased from an annual average of 101 million during 2001-2010 to 132 million in 2011. Hydrological disasters represented 62.2% of total disaster victims in Asia, flowed by climatological (19.4%) and meteorological (17.7%) disasters Guha-Sapiret al.(2011). Because of climate change, predictions are that intervals of heavy precipitation and extreme temperatures will likely become more frequent in the future. In other words, what was formerly a “once-in-a-century” disaster might become a “once-in-a-generation” disaster. Furthermore, new “once-in-a-century” disasters may simply overwhelm the current state of preparations.
Several positive trends in international humanitarian response were evident in the course of 2011, including promising developments in international disaster law, greater emphasis on disaster risk reduction and preparedness, and better communications during crises, including the use of social media in disaster response. Post-disaster recovery and reconstruction after a major disaster are long-term processes which need much more scrutiny and attention. Examples from rich countries suggest that rebuilding processes can be participatory and can incorporate sound principles such as risk reduction and green technologies. It is very difficult, if not impossible, to efficiently operate such a complex system without comprehensive mathematical models and forecasting tools.
Most humanitarian relief organizations are unable to plan an efficient and effective relief work or prepare for large disaster due to difficulty in accurately guessing the location of disaster. These agencies need to plan for huge surge in demand with a short notice under most difficult scenarios such as submerged and damaged roadways and rail lines, chaotic behaviour of victims, breakdown of communication lines, short lead time and so on. A review of the existing literature indicates that in majority of the situations, the emergency logistics planning and distribution of relief goods from source to the victims take place during post-disaster period Yi and Kumar (2007). Shortage of relief goods have been experienced by the donor organizations. In order to develop useful emergency plan and respond to the natural disasters, humanitarian relief organizations, governments and NGOs need to estimate the number of people affected, number of people killed and the economic damages from disasters. Therefore, there is a need to develop a mathematical or probabilistic forecasting tool to predict global annual demand of relief goods. This research develops a probabilistic model to predict the number of natural disasters, bulk economic losses, potential number of victims affected, and the number of people killed and subsequently the demand of certain commodities.

II. LITERATURE REVIEW

One of the earliest studies for logistics management in relief operations was addressed by Kemball-Cook and Stephenson (1984), for the increasing refugee population in Somalia. Subsequently, Ardekani and Hobeika (1988) addressed the need of logistics management in relief operations for the 1985 Mexico City earthquake. Some specific features of the emergency logistics problem were studied in the routing literature by Ben-Tal et al.(2011), Dror and Trudeau (1989); Frizzell and Giffin (1995); Gendreau et al., (1999);Golden et al.,(1985) ;Hu (2011) ; Knott (1987); Kontoravdis and Bard (1995); Min (1989); Nagy and Salhi (2005); Tatham and Kova´cs (2010) ; however, the general logistics problem involving relief supplies distribution characteristics received far less attention. Chang et al.,(2003); Chen et al.,(2006); Haghani and Oh (1996); Özdamar et al.,(2004) addressed the mathematical formulations for commodities transportation in emergency. Yi and Ozdamar (2007) extend the commodity logistics model to integrate the wounded evacuation and emergency medical centre location problems and the logistics operations are illustrated by a concrete application on earthquake scenario. Further, Yi and Kumar (2007) presents a meta-heuristic of ant colony optimization (ACO) for solving the logistics problem arising in disaster relief activities. The logistics planning involves dispatching commodities to distribution centres in the affected areas and evacuating the wounded people to medical centres. Furthermore, Balcik and Beamon (2008) proposed a model to determine the number and locations of distribution centres to be used in relief operations.

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Humanitarian logistics, also called relief supply chain management, have gained attention due to an increasing number of natural and man-made disasters and the recognition of the central role of logistics in responding to these (Jahre, 2008). The needs are expected to increase another five-fold over the next fifty years' (Thomas and Kopczak , 2005). However, the literature in the area of humanitarian logistics is largely focused on handbooks and general procedures (Beamon and Kotleba,2006). Altay et al., (2006) has made a literature review on disaster operations management, resulting in only 109 academic articles published in operations management related journals, indicating needs for more research on the subject. The analytical techniques used in the field of operations research and management include mainly simulation, optimization and statistics. They concluded that most of the disaster management research was related to social sciences and humanities literature. Kovács and Spens (2006) and Thomas (2003) discuss the need for speed and better coordination between those involved in the humanitarian logistics network. Logistics in humanitarian aid operations are highly dynamic, innovative and characterized by complexity of operational conditions and often politically volatile climate, high level of uncertainties in terms of demand and supplies, pressure of time and high staff turnover (Oloruntoba and Gray ,2006) and Van Wassenhove (2006). Some studies such as Beamon (2004) ,Oloruntoba and Gray(2006), Thomas (2007),Thomas and Kopczak (2005),Van Wassenhove (2006) and Ye and Liu (2011), emphasized that some supply chain concepts share similarities to emergency logistics and therefore can be successfully adapted in emergency response logistics. Doocy et al., (2011) discussed the food security and humanitarian assistance among displaced Iraqi populations in Jordan and Syria. In a recent study, Lodree and Emmett (2011) highlighted pre-storm emergency supplies inventory planning. More research is needed to develop new models or new variants of old ones, especially in preparedness, response and recovery stages of the disaster management.
Although the literature in logistics management is extensive, the particular problem on the reliability of supply chains in emergency logistics planning has received little attention. Meiling et al., (2008) studied the supply chain system reliability based on Markov process for normal business supply chains. Huang evaluated the reliability of railway emergency supply chain in China. Cai and Li (2011) proposed the GO methodology to analyze the transportation network reliability for emergency logistics; Zhang (2012) recently studied the supply chain reliability in emergency situations in China. However, none of these studies provide an in-depth analysis of reliability of supply chains under natural disasters and vulnerability. Moreover, to my best knowledge, there is no research dealing with these two aspects humanitarian and commercial logistics in an integrated manner which is the subject of this study, though such plan can significantly enhance the system-wide operational efficiency.

III. MODEL DEVELOPMENT

There are many standard statistical distributions which may be used to model the number of natural disasters, economic losses, number of people affected, and number of people killed over time. It has been found that a relatively small number of statistical distributions satisfy most needs in emergency logistics planning. The particular distribution used depends upon the nature of the data, in each case. The probability distribution of a random variable may be defined empirically or through one of many well-known probability distributions. In many cases the analyst may fail in an attempt to describe the behavior of a random variable through a well-known distribution and thus be forced to use an empirically derived probability distribution. However, where the behavior of the random variable can be adequately characterized by a well- known probability distribution it will be convenient and useful to do so. In this paper, we present the properties of relevant well known random variables and their probability distributions.

- ***Exponential Distribution***

This is probably the most important distribution in engineering and lifetime work [Reliability, Handbook]. It has the advantages of a single, easily estimated parameter (λ), mathematically very tractable, and fairly wide applicability.
The probability density function is
$f(t)=\lambda e{-}\lambda$ for $t > 0$,
where λ is the parameter.

- ***Weibull Distribution***

The Weibull random variable finds its most frequent application in engineering. It is a general distribution and by adjustment of the distribution parameters, it can be made to model a wide range of the distribution characteristics.
The probability density function of a two parameter Weibull distribution is
$f(t) = \alpha\beta\ t\beta\text{-}1\exp(-\alpha t\beta)$, $t \geq 0, \alpha > 0, \beta > 0$.
Where β is referred to as a shape parameter and α a scale parameter.

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There are several methods by which one can obtain good point estimates of the unknown parameters, α and β of the two parameter Weibull distribution. The methods include the iterative solution of the maximum-likelihood equations, moment estimators, and several types of linear estimation techniques. A discussion of these methods is presented in (Kumar 1988) .

Data has been collected from the Centre for Research on the Epidemiology of Disasters (CRED)'s EM-DAT worldwide database for natural disasters. This has been sponsored by the United States Agency for International Development's Office of Foreign Disaster Assistance (USAID/OFDA). It contains data from year 1900 to 2011. CRED has compiled the data from numerous sources including UN agencies, NGOs, insurance companies and research institutes (Guha-Sapir et al., 2011). Systematic collection and analysis of these data provides invaluable information to governments and relief agencies in charge of relief and recovery activities. EM-DAT provides an objective basis for vulnerability assessment and rational decision making in disaster situations. In addition to providing information on the human impact of disasters, such as the number of people killed, injured or affected, EM-DAT provides disaster-related economic damage estimates and disaster-specific international aid contributions.

We have used the ARENA Input Analyzer Software's built-in "trend analysis plot" option, where we can add trend lines to data sets (from year 1900 to 2011 for different variables) after the charts have been generated. Figures 1 thru 4 illustrate the charts and trend lines. Subsequently, we have used Input Analyzer Individual Distribution Identification tool to find the distribution of data. The tool generates a table that includes the square error. A given distribution is togive minimum square error. The tool allows us to easily compare how well our data fit 9 different probability distributions. Tables 1 thru 4 illustrate the square error for each distribution for the variables.

- ***Number of disaster:***

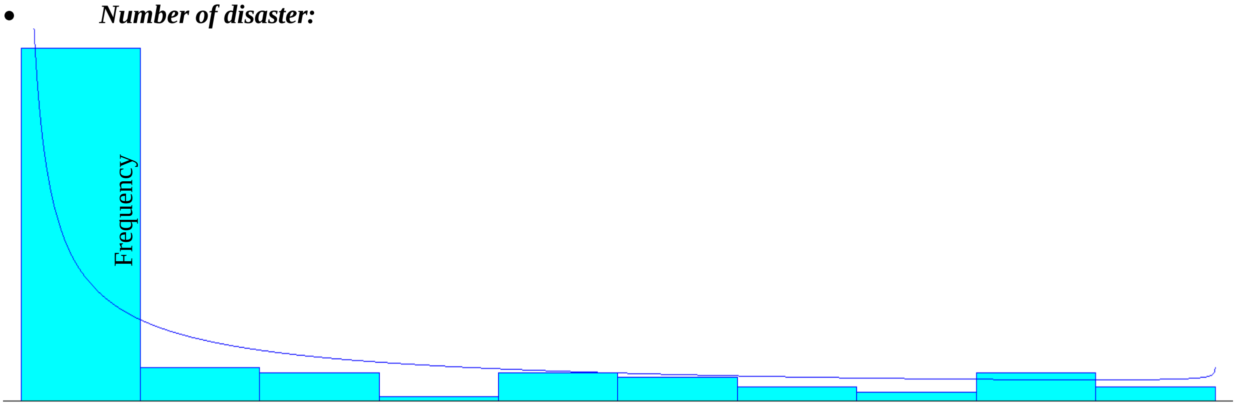

Figure 1. Number of Disasters Reported 1900 – 2011. Number of disasters

Subsequently, the probability distribution function is used to calculate the values of the variables of interest for future periods such as year 2012 thru 2020. Relief agencies need to know the future aggregate demand of relief goods much in advance to plan for supply and distribution. Figure 1 illustrates the number of disasters reported from year 1900 to 2011. The trend indicates that the number of disasters is Beta increasing with respect to time as shown in equation (1) below. Identifying the best fit curve indicates that the aggregate number of natural disasters is also Beta distributed with minimum square error 0.00977 as shown in table 1.

Table 1:Squer Error for the Disturbuation for Number of Disasters

Function	**Sq Error**
Beta	0.00977
Lognormal	0.0125
Weibull	0.0166
Gamma	0.0573
Exponential	0.11
Erlang	0.11
Triangular	0.306
Normal	0.309
Uniform	0.341

Fitted trend equation is:

$F_t = 4 + 891 * \text{BETA}(0.316, 0.922)$ (1)

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- ***The aggregate number of people affected:***

Fig. 2 shows the aggregate number of people affected due to natural disasters from year 1900 to 2011. Moreover, this trend also indicates that the number of people affected is exponentially increasing with respect to time as shown in equation (2). Identifying the best fit curve indicates that the aggregate number of people reported affected is Weibull distributed with minimum square error 0.0125 as shown in table 2 .

Fitted trend equation is:

$F_t = 2 + WEIB(1.41e+007, 0.291)$ (2)

Where Ft is the forecast value of the number of people affected for time period t or year (t+1954).

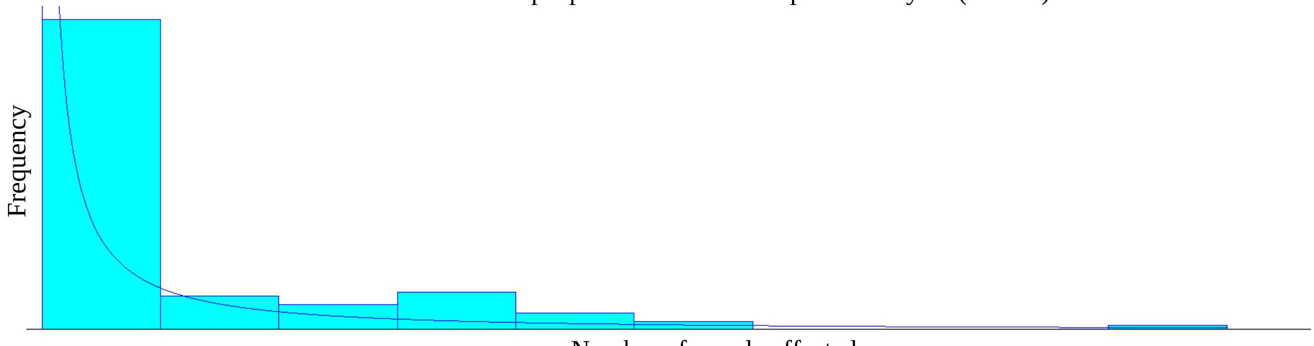

Figure 2. Number of People Affected 1900 – 2011.

Table 2:Squer Error for the Disturbuation for Number of People Affected

Function	**Sq Error**
Weibull	0.0125
Beta	0.0184
Exponential	0.0356
Erlang	0.0356
Gamma	0.105
Lognormal	0.192
Normal	0.269
Triangular	0.362
Uniform	0.425

- ***The estimated aggregate economic damage/loss per million:***

Fig. 3 depicts the estimated aggregate economic damage/loss per million caused by natural disasters from year 1900 to 2011. As can be observed from the time series plot, in 2011, floods in Thailand caused a major economic loss. Furthermore, the trend indicates that the economic loss caused by natural disasters is increasing with time in trend equation (3). This trend is similar to other trends for the number of disasters and the number of people affected. Identifying a best curve fit indicates that estimated damage is Exponential distributedwith minimum square error 0.00496 as shown in table 3. Future economic loss per million forecasts can be calculated using the fitted trend equation (3) below.

$F_t = 2 + EXPO(2.33e+004)$ (3)

Where F_t is the forecast value of the economic loss in millions for time period t or year (t+1954).

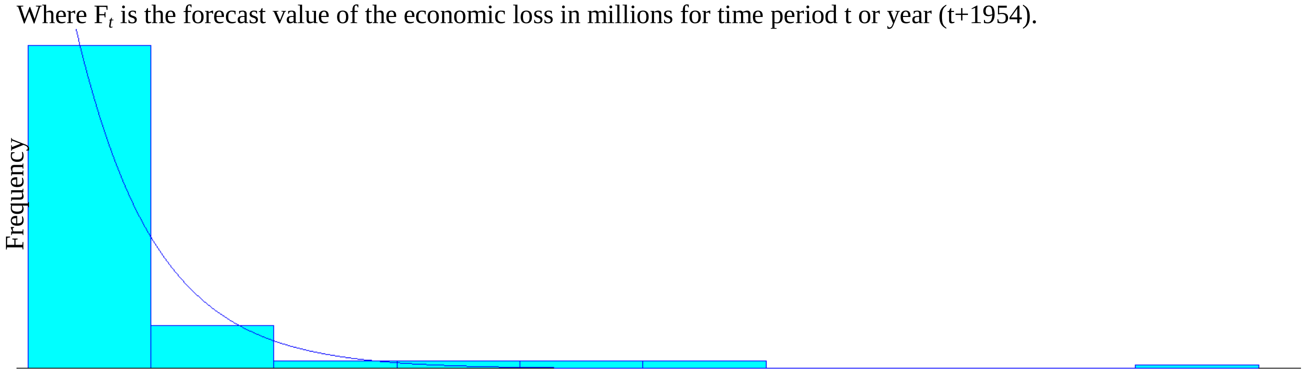

Figure 3. Economic Damage/Loss Per Million 1900 – 2011.

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Table 3:Squer Error for the Disturbuation for Economic Damage/Loss

Function	Sq Error
Erlang	0.00496
Exponential	0.00496
Weibull	0.00539
Beta	0.00872
Gamma	0.111
Lognormal	0.141
Normal	0.316
Triangular	0.496
Uniform	0.562

- ***The number of people reported killed:***

Fig. 4 shows the number of people reported killed by natural disasters from year 1900 to 2011. The fitted trend line is given by equation (4). Identifying the best fit curve indicates that the number of people reported killed is Weibull distributed with minimum square error 0.00479 as show in table 4. Future forecasts for the number of people reported killed by natural disasters can be calculated using equation (4).

F_t = 1.11e+003 + WEIB(1.36e+005, 0.48) (4)

Where F_t is the forecast value of the number of people reported killed for time period t or year (t+1954).

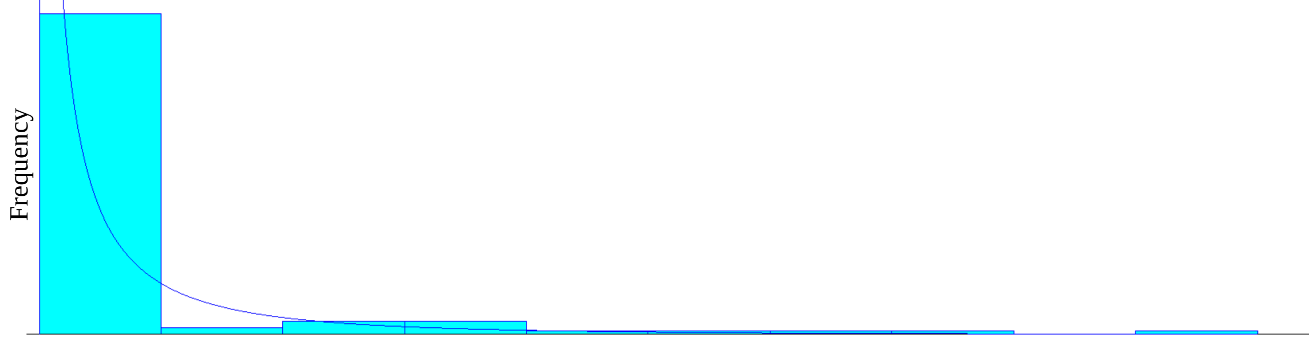

Figure 4. Number of People Reported Killed 1900 – 2011.

Table 4:Squer Error for the Disturbuation for Number of People Reported Killed

Function	Sq Error
Weibull	0.00479
Beta	0.00513
Exponential	0.0346
Erlang	0.0346
Lognormal	0.11
Gamma	0.112
Normal	0.437
Triangular	0.594
Uniform	0.653

Table 5 summarizes the results of the best fit test and the equation of probability distribution for each variable. The relief organizations can use the aggregate forecast values of number of disasters, number of affected people, economic loss and the number of people killed in the coming years to assess the future global demand of relief goods as part of the pre-disaster planning. It will assist in determining the logistical needs. They can consider and assess the total financial resources required and their availability, staff availability, logistics capacity, transport information such as port operations, airport operations, road transport, water transport, fuel and so on, distribution plans, commodities and supplies required. Inability of the relief agencies to accurately forecast and assess the impact of natural disasters, the resulting needs and the response capacities, would result in inadequate help, poor utilization of resources, shortage of funds and a poorly planned response. Donor agencies and governments can

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also use the aggregate forecasts to determine the required amount of funds to be raised in advance, fuel purchased for air operations and cargo movement, number of helicopters rented, and other preparedness activities.

Table 5:Results of Probability Distribution Identification

Random Variable	Best fit Distribution Identified	Sq Error	Equation
Number of people affected by natural disasters	Weibull	0.012501	2 + WEIB(1.41e+007, 0.291)
Estimated economic loss caused by disasters	Exponential	0.004962	2 + EXPO(2.33e+004)
Number of people killed by disasters	Weibull	0.004787	1.11e+003 + WEIB(1.36e+005, 0.48)
Number of disasters	Beta	0.00977	4 + 891 * BETA(0.316, 0.922)

IV. CONCLUSION

In disaster response actions, the survival rate among affected people depends on the effectiveness of search and rescue operations and this requires, in turn, a good pre-disaster planning. Despite availability of annual natural disaster related data from 1900 to 2011, there is no forecasting tool available to humanitarian relief organizations to forecast the aggregate number of people affected, economic losses, number of natural disasters, and the number of people killed in the coming years. Using the past time series data, a trend analysis of the data has been conducted and the best fit curve or probability distribution has been identified. The estimates of the parameters of probability distribution are used to calculate the forecasts. These forecasts are used by the various international and national humanitarian organizations in emergency logistics planning. This leads to better coordination of search and rescue activities and efficient evacuation of injured people. Furthermore, overall health conditions of everyone in the affected area depend on the timely availability of commodities such as food shelter and medicine.

REFERENCES

[1] Altay, Altay, N., and Green, W. G., (2006), OR/MS research in disaster operations management. European Journal of Operational Research, 175, p475-493.

[2] Ardekani S. A. and Hobeika A., (1988), Logistics problems in the aftermath of the1985 Mexico City earthquake. Transportation Quarterly. 42(1), 107-124.

[3] Balcik, B. and Beamon, B., (2008), Facility location in humanitarian relief. International Journal of Logistics: Research and Applications. Vol. 11, No. 2, 101-121.

[4] Beamon, B.,(2004), Humanitarian relief chains: Issues and challenges, in Proceedings of the 34th International Conference on Computers and Industrial Engineering, San Francisco, CA.

[5] Beamon, B. and Kotleba, S., (2006), Inventory Modeling for complex emergencies in humanitarian relief operations. International Journal of Logistics. Vol. 9, No. 1, March, 1-18.

[6] Ben-Tal, A., Chung, B.D., Mandala, S.R., Yao,T. (2011), Robust optimization for emergency logistics planning: Risk mitigation in humanitarian relief supply chains. Transportation Research Part B.

[7] Chang, M.S., Chen, S.R. and Hsueh, C.F., (2003), “Real-time vehicle routing problem with time windows and simultaneous delivery/pickup demands,” Journal of the Eastern Asia Society for Transportation Studies, Vol. 5, pp. 2273-2286.

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 5, September 2013
[8] Chen, H.K., C.F. Hsueh and M.S. Chang, (2006), "The real-time time dependent vehicle routing problem," Transportation Research Part E. (Accepted)

[9] Doocy, S., Sirois, A., Anderson, J. (2011). Food security and humanitarian assistance among displaced Iraqi populations in Jordan and Syria. Social Science & Medicine, 72(2), 273-282.

[10] Dror, M., Trudeau, P., 1989. Savings by split delivery routing. Transportation Science 23, 141–149.

[11] Frizzell, P.W., Giffin, J.W., (1995), The split delivery vehicle scheduling problem with time windows and grid network distances. Computers and Operational Research 22, 655–667.

[12] Gendreau, M., Laporte, G., Vigo, D., (1999), Heuristics for the traveling salesman problem with pickup and delivery. Computers and Operations Research 26, 699–714.

[13] Golden, B.L., Baker, E.K., Alfaro, J.L., Schaffer, J.R., (1985), The vehicle routing problem with backhauling: two approaches. In: Proceedings of the Twenty-First Annual Meeting of the S.E. TIMS, Myrtle Beach, SC, USA.

[14] Guha-Sapir, D., Vos, F., Below, R., Ponserre, S., (2011), Annual Disaster Statistical Review 2011, the numbers and trends, CRED, IRSS, Universite Catholique de Louvain, Brussels, Belgium.

[15] Haghani, A. and Oh, S.C.,(1996), Formulation and solution of a multicommodity, multimodal network flow model for disaster relief operations. Transportation Research: Part A, Policy and Practice, 30(3), 231–250.

[16] Hu, Z.H., (2011). A container multimodal transportation scheduling approach based on immune affinity model for emergency relief. Expert Systems with Applications, 38(3), 2632–2639.

[17] Jahre, M., (2008), Researcher project: HUMLOG-NET – Humanitarian Logistics Networks, Norway. [18] Kemball-Cook, D., Stephenson, R (1984), "Lessons in logistics from Somalia", Disasters, Vol. 8, 57-66.

[18] Knott R. (1987) the logistics of bulk relief supplies. Disasters 11, 113- 115.

[19] Kontoravdis, G., Bard, J.F., (1995), A GRASP for the vehicle routing problem with time windows. ORSA Journal on Computing 7, 10–23.

[20] Kovács, G. and Spens, K.M., (2006),. Humanitarian logistics in disaster relief operations. In Jahre, Marianne (ed.): Logistics in the New Valley. CD-ROM Proceedings of the 18th Annual Conference for Nordic Researchers in Logistics, NOFOMA 2006, Oslo, Norway.

[21] Kumar, A. (1988),. Reliability estimation using doubly censored field data. PhD dissertation, Department of Industrial Engineering, Virginia Tech, Blacksburg, Virginia, USA.

[22] Lodree, Emmett J., (2011),. "Pre-storm emergency supplies inventory planning", Journal of Humanitarian Logistics and Supply Chain Management, Vol. 1 Iss: 1, pp.50 – 77.

[23] Min, H., (1989),. The multiple vehicle routing problems with simultaneous delivery and pickup points. International Journal of Management Science 3, 1–14.

[24] Nagy, G., Salhi, S., (2005). Heuristic algorithms for single and multidepot vehicle routing problems with pickups and deliveries. European Journal of Operational Research 162, 126–141.

[25] Oloruntoba, R. and Gray, R.,(2006), Humanitarian aid: an agile supply chain, Supply Chain Management, 11(2), 115–120.

[26] Özdamar, L., Ekinci, E. and Küçükyazaci, B., (2004), "Emergency logistics planning in natural disasters," Annals of Operations Research, Vol. 129, pp. 217-245.

[27] Tatham, P., Kova´cs, G., (2010). The application of ''swift trust'' to humanitarian logistics. International Journal of Production Economics, 126(1),35–45.

[28] Thomas, A. (2003) ,Why logistics? Forced Migration Review, Vol. 18, p.4.

[29] Thomas, A.S.,(2007), Humanitarian logistics: enabling disaster response, Fritz Institute.

[30] Thomas, A.S. and Kopczak. L.R., (2005).From logistics to supply chain management: The path forward in the humanitarian sector. Fritz Institute.

[31] Van Wassenhove, L.N., (2006). Humanitarian aid logistics: supply chain management in high gear. Journal of Operational Research Society, 57(5), 475–489.

[32] Ye, Y., Liu, N., (2011). A Bayesian Group-Information-Updated sequential approach for humanitarian logistics planning in natural disasters, Report, Institution of Logistics and Decision Optimization, School of Management, Zhejiang University, China.

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[33] Yi, W. and Ozdamar, L., (2007). A dynamic logistics coordination model for evacuation and support in disaster response activities. European Journal of Operations Research, 179, 1177-1193.

[34] Yi, W. and Kumar, A., (2007). Ant colony optimization for disaster relief operations. Transportation Research Part E, 43, 660-672.

[35] World Bank Report, (2012).