World Bank Disaster Relief Decision Support System

The World Bank Group

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Abstract

Natural disasters are an inevitable part of existence in every country in the world. However, some countries are more able to recover from these disasters on their own than others. The World Bank Group provides financing for in the form of grants and low-interest loans for countries that are less able to recover by their own means. How much funding is needed after a particular disaster is often little more than an educated guess, since collecting true data from the disaster site would be extremely time consuming and help is needed immediately. The purpose of this paper and model is to use data from past disasters in 32 countries throughout Africa and Asia to develop a decision support system to be used to make disaster relief funding decisions more timely and accurate.

1. Introduction

World Bank began in 1944 as a single institution. Since then, it has expanded to include five associated institutions. The five institutions are: the International Bank for Reconstruction and Development, the International Development Association, the International Finance Corporation, the Multilateral Investment Guarantee Agency, and the International Centre for Settlement of Investment Disputes. World Bank's headquarters are in Washington D.C. Further more, World Bank has over 100 offices around the World. World Bank employs over 10,000 people, all with diverse backgrounds, skills, and experiences.

World Bank has developed a mission "to help developing countries and their people reach the goals by working with our partners to alleviate poverty" (World Bank, 2006). World Bank tends to focus their efforts on the "poorest people and the poorest

countries" (World Bank, 2006). The Bank is currently involved in over 1,800 projects to help and reach their mission. The projects can range anywhere from AIDS prevention in Guinea, to helping countries rebuild after a natural disaster strikes. The Bank helps the countries by providing "low-interest loans and interest-free credits and grants to developing countries for education, health, infrastructure, communications and many other purposes" (World Bank, 2006).

In developing this project for World Bank, the issue that we are facing is finding a way to determine how much financial assistance a given country would need in order to effectively recover from a given natural disaster. Four specific disasters appeared as the most common throughout the group of 32 countries, so our efforts are primarily focused on these. They include: earthquakes, droughts, cyclones, and floods. Different countries are susceptible to different natural hazards, and several of the countries in question are not vulnerable to the four primary disasters. These four, however, were by far the most common and the most damaging among the group as a whole.

Our solution is to create a decision support system to be used by World Bank to determine the most effective way to distribute funding in the event of a natural disaster in any of the countries studied in this project. This system will take into account data from past disasters in the area along with the purchasing power parity in order to determine not only how badly a given area may be affected, but also their financial ability to recover without assistance. With additional data, the same concept could be used as a decision support tool for any country in the world.

In the following section, we will discuss the many literatures that we reviewed in order to gain a better understanding of the issue before us. Following the literature

review will be the definition of the problem that we are facing, the model we designed to resolve the problem, the implementation of the model, as well as future expansions, and improvements that could be done to the model.

2. Literature Review

To develop an understanding in this field, we reviewed literatures relating to the measurement of poverty, poverty reduction, natural disaster recovery, and decision support systems. This serves as an aid in determining constraints and their respective measurement items. It helps in deciding what variables to measure, how to measure them, and how to organize and use them in a decision support system that will aid in the relief of disaster stricken areas.

2.1 Measuring poverty

In a most basic sense, poverty is "according to what is prioritized as a need," (Nunan et al. 2002). This definition can be expanded to include "[Poverty] is deprivation in the most essential capabilities of life, including leading a long and healthy life, being knowledgeable, having adequate economic provisioning and participating fully in the life of the community" (UNDP, 1997). Other definitions of poverty go even further to include items such as, "vulnerability, risk, powerlessness, and voicelessness," (Nunan et al. 2002).

With such vast varieties of poverty definition, there are correspondingly many ways to measure it. The most accepted method for measuring poverty is to use the country's gross domestic product (GDP) on a percentage basis. The GDP measures the value of the goods and services a country produces and accounts for total income. The

downfall of such a means is that it does not sufficiently account for purchasing power at the household level. In addition, GDP does not account for differences in costs among various countries. Thus, in this model we employ an adaptation of GDP, which accounts for the local purchasing power parity.

The purchasing power parity (PPP) takes into account the price differences between countries and makes the proper adjustments (Global Education, 2006). This leads us to believe that PPP will be very useful when comparing the living standards between countries. In our model, we will use the purchasing power parity of the various countries to help determine the total vulnerability for disasters.

2.2 Poverty Reduction

Several research studies have examined ways to reduce poverty in impoverished areas. One such study was done at Duke University in the past few months, studying 36 villages in Uganda. It examined the movement into and out of poverty levels for households in these villages. According to the study, 24% have escaped poverty in the last 25 years, but another 15% fell into poverty at the same time (Anirudh, 2006). Among the 15% that fell into poverty in the 25-year time frame, most have become poor in the last 10 years, indicating that the causes of poverty are increasing sharply.

Among those in poverty the whole time, and those who recently fell into it, the causes are often very similar. Nearly two-thirds of all households in poverty in the region are poor due to illness and health-related costs (Anirudh, 2006). Health issues keep the main earner in the household from earning money, as well as costs the household money in health care costs. Judging by this report, increasing the availability and decreasing the

cost of health care in Uganda would seemingly improve the poverty situation significantly.

This type of situation is what we intend to account for by using the purchasing power parity. Rather than just accounting for the population that is currently below the poverty level, it accounts for those who are close and those that move in and out of poverty.

2.3 Natural Disaster Recovery

In looking at the techniques used to recover from a natural disaster, we came to an article reviewing the recovery process in Aceh, Indonesia after the devastating tsunami hit the region in December 2004. This type of natural disaster causes damage unlike any other. Not only were crops destroyed for that year, but the salt water also contaminated the soil enough that crops were not able to be grown there for years to come. A significant shortage in clean drinking water was also almost immediate, even though water was literally everywhere. An estimated 60,000 wells were severely damaged or destroyed, and the environmental infrastructure that purified the water in them has been damaged to the point that it may not return to its previous state for decades (Paul, 2006). Sanitation and solid waste disposal systems were destroyed, and the solid waste from years before is now mixed in with the rubble since the tsunami's waters overturned dumping sites. All of the region's effective healthcare services had been wiped out in the areas where they were needed most. An estimated 360 healthcare facilities were either destroyed or damaged beyond effective use by the tsunami, leaving the hardest hit areas

with little or no medical assistance available (Paul, 2006). It may be many years before the region will be able to be as self-sufficient as they were prior to the tsunami.

According to the Earth Institute at Columbia University, more than half of the world's populations (3.4 billion) live in areas where at least one natural hazard could significantly impact them, and approximately 20 percent of the Earth's land surface is exposed to at least one natural disaster. Another fact states that 160 countries have more than one quarter of their population in areas of high mortality risk from natural disasters. Therefore, we must take into consideration what the major costs are when disaster strikes. Costs related to disaster can be either direct costs such as physical/structural damage or indirect costs such as economic losses from disruption in production etc. This knowledge will be especially useful when employing our model. It is obvious that an area will need financial backing after a natural disaster, but if funds are not properly allocated, the money will quickly run out and leave many problems unaddressed. Another fact from the Earth Institute states that "poorer countries in the developing world are more likely to have difficulty absorbing repeated disaster-related losses and costs associated with disaster relief, recovery, rehabilitation and reconstruction." With this research, better insight can be had as far as what types of programs to invest relief funds into.

2.4 Decision Support Systems

Decision Support Systems consist of compiled information and research that can be used to assist organizations in making decisions quickly following a disaster with an acceptable amount of accuracy. In dealing with natural disasters, there is simply no time to attain field statistics, compile them, analyze them, and make a decision based on data.

This process can take several months, and problems need to be addressed immediately. A DSS system will help organizations to make the most educated decisions possible when hard data is not available or practical to obtain.

To develop a decision support system for World Bank, we looked into other decision support systems that have been developed concerning natural disaster recovery. One such system was one that looked into flood damage evaluation. This system used a simple technique employing a digital elevation model and radar/satellite images to determine the areas that experienced the worst flooding. This information was then used in a decision support system to allocate resources for reversing the damage. This technique has been successfully applied in eastern Tennessee in December 2001, as well as Piemonte Region, Italy in November 1994. The system was used with a producer accuracy of 97.5%, and an overall 83% accuracy between the system's estimates and actual ground measure data (Gianinetto, 2006).

Creating this decision support system for World Bank will show not only how vulnerable a given area is to a particular disaster, but will also take into account the area's purchasing power, giving an indication of how able they are to recover on their own and how much additional aid they may need to restore the area to its pre-disaster state.

3. Model Description

The purpose of the Delta group's project is to develop a tool to help national and international officials make decisions based on the income level in third world countries accounting for their vulnerability due to four types of natural disasters. Our model is developed by data accumulated on 32 countries specified by World Bank. The developed

model is dynamic and can capture future changes in income and vulnerability with changes to certain input data.

3.1 Variables, Parameters, & Constraints

Delta group has defined the variables in the model as the following:

- Relative vulnerability
- Purchasing power parity
- Distribution of income
- Death-to-wounded ratio
- Family size
- Loss of income due to death
- Loss of income due to wounded
- Poverty level income per day
- Population

Its parameters have been set by World Bank Group as the 32 countries we were instructed to research and the current date. However, the parameters can change with the adjustment of future dates. The model's constraints are the 4 natural disasters (earthquakes, droughts, cyclones, and floods); reason being, data for these disasters was the most common and most consistent among the 32 countries.

3.2 Hierarchy of Decision Making

The hierarchy of decision making refers to all of the raw data, or sub factors, used for each country to calculate the weights and final adjusted outputs of the model. This hierarchy consists of several items:

- Relative Vulnerability
- GDP per capita (on a purchasing power parity)
- Total Vulnerability
- Purchasing Power Loss Ratio
- Adjusted Vulnerability
- Number of people in income class
- Distribution
- Income purchasing power parity
- Gross income by distribution
- Individuals affected due to death or wounds
- Total income loss
- Post event income
- Adjusted distribution

Each sub factor is used in one of many formulas to reach the final output of the model. An assumption used in all formulas is that the population is already a result of the disaster losses. Each sub factor will be explained in greater detail, and the flow of sub factors into major factors will be seen in the proceeding calculations of raw data.

3.3 Calculations of Raw Data

To better illustrate the calculations, each sub-factor for the final output of the decision support system is given an alphabetical notation. Once the model is open, the calculations will be explained beginning in the first column.

Ranking Portion

Notations		*Value*	*Calculation*
RV	=	Relative Vulnerability	*http://gridca.grid.unep.ch/undp/
GDP	=	GDP per capita	
TV	=	Total Vulnerability	= ∑RV
PPP_R	=	Purchasing Power Parity Loss Ratio	= TV/GDP
AV	=	Adjusted Vulnerability	= (TV/GDP)/Average GDP of all countries
R	=	Rank	= Ascending order of AV (1 = most at risk)

Income Portion

Notations		*Value*	*Calculation*
I_C	=	# of People in Income Class	= P*D
D	=	Distribution of Income	*http://devdata.worldbank.org/wdi2005/section2.htm
PPP_i	=	Income Purchasing Power Parity	= (D/100)*GDP
I_G	=	Gross Income by Distribution	= I_{C*} PPP_i
P	=	Population	
A	=	# Individuals Affected Due to Death & Wounded	= $(M_i / \sum M_i)*(d*w)$
L	=	Loss $	= $F*A*(I_d * d)*(I_w * w)$
E	=	Post Event Income	= $I_G - L$
D_A	=	Adjusted Distribution of Income	= E / I_C
Poverty Level =			= *IF* $C > D_A$ *THEN* Poverty

Mortality Portion

Notations	*Value*	*Calculation*

M_i	=	Distribution of Mortality	= Variable
$\sum M_i$	=	Sum of Distribution of Mortality	= $\sum M_i$
d	=	Total # Dead	= TV * (P/1,000,000)
R_{dw}	=	Death to Wounded Ratio	= Variable (ex: 1dead to 50 wounded)
w	=	Total Wounded	= d * R_{dw}
F	=	Family Size	= Variable
I_d	=	Loss of Income Due to Death	= Variable
I_w	=	Loss of Income Due to Wounded	= Variable
C	=	Poverty Cutoff	= Income per Day * 365days

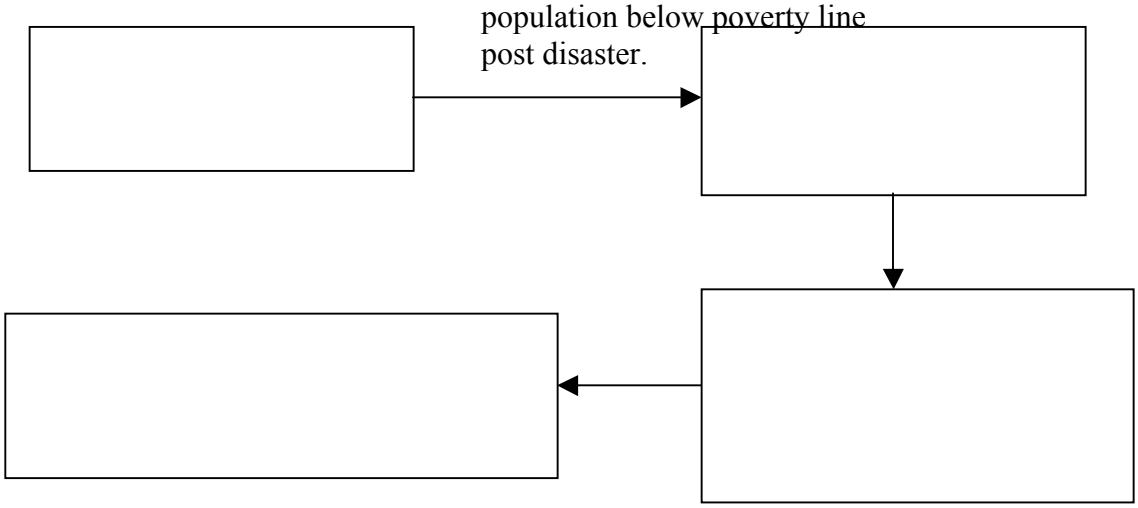
3.4 Final Model

The final decision support system is in an excel file that contains three sheets; instructions, front page, and formula sheet. Each page serves a particular purpose and is useful in properly using the decision support system. The instruction page will guide a user through the process of selecting a country to retrieve data and explain the variables that may be changed. The front page consists of a dropdown menu that retrieves data from the formula sheet to show the final display. A VLOOKUP[1] is used to retrieve the information selected in the dropdown menu from the layered formula sheet that holds the calculations. Once a country is selected, the output will appear, displaying the results from the calculations of raw data shown above. With the data that is generated and the user's variable specified, the model should give an idea of which countries will need the most assistance, and which are at the most risk in the event of one or multiple natural disasters.

[1] Example: VLOOKUP(F7, Sheet2!A14:T24, 1, FALSE)

bles may be adjusted to see their
ts.
on the calculations. User can
elect countries from both modules
ompare results.

two models.
Calculations are displayed showing rank, % population below the poverty line, and % population below poverty line post disaster.



All of the information that feeds this final model will be hidden from the view of the casual user to create a professional, sleek look. Certain information that may be updated over time will be password protected and only an administrator will be granted access. Mr. Saroj Kumar Jha will be the only individual given the password. Some information will be permanently locked, including formulas and calculations that form the final model. The model will have the ability to be updated over time as data changes, and all changes in data that feed the final model, will take effect immediately. The variables listed above are the data sets that may be updated. Instructions of how to find and calculate a country's relative vulnerability for updating is given on the instructions sheet.

4. Implementation

World Bank will be able to use this model as a research tool to find out which of their specified countries are currently at the greatest risk and require the most assistance in times of disaster recovery. By using this model, World Bank will be able to make

more timely and accurate funding decisions based on the outputs, primarily the poverty level and distribution of income post disaster. For instance, 40% of Indonesia's population is below the poverty line pre-disaster. Post disaster income is adjusted by number of individuals affected and loss of income, and the entire country would fall below the poverty line. An example such as this illustrates World Banks ability to view the adjusted income post disaster to make rational decisions of where to allocate their financial resources. If, for instance, World Bank would like to see the affects of only one disaster in a country, they may change all other disaster relative vulnerabilities to zero. This will allow them to view the impact of only one disaster versus several. This also gives World Bank the ability to view the financial affects of two natural disasters striking a country at the same time.

5. Conclusion

As stated in the introduction, natural disasters are an inevitable part of existence in every country in the world. Extensive research has been conducted in this field, however, models to facilitate decision making have been widely neglected. Delta has gone beyond research to develop a dynamic model to aid the post-disaster decision making process for World Bank. As populations rise and disasters strike countries around the world, disaster relief through World Bank is imperative. Without the aid provided through World Bank, these 32 countries would find themselves at a standstill during disaster recovery. During a disaster and times of such uncertainty, this model will serve as a vital tool to provide some inkling of the critical financial help needed.

Resources

Cheru, Fantu. "Building and supporting prsps in Africa: What has worked well so far? What needs changing?" Third World Quarterly. Mar2006 Vol.27 p355-376

Cia.gov. 2006. U.S. Central Intelligence Agency. 9 Mar 2006. http://www.cia.gov/cia/publications/factbook/

Gianinetto, Marco, Villa, Paolo, and Giovanmaria Lechi. "Postflood Damage Evaluation Using Landsat TM and ETM+ Data Integrated With DEM." IEEE Transactions on Geoscience & Remote Sensing. Jan2006 Vol. 44: p236-243

GlobalEducation.edna.edu.au. 17 Jan. 2006. "Poverty Reduction." Accessed: 5 Apr. 2006. http://www.globaleducation.edna.edu.au/globaled/go/pid/181

Krishna, Anirudh, et. al. "Escaping poverty and becoming poor in 36 villages of Central and Western Uganda." Journal of Development Studies. Apr2006 Vol.42: p346-370

Nunan, et. al. "Poverty and the Environment: Measuring the Links." Environment Policy Department Issue Paper No. 2 Feb 2002. p15-17

Paul, Alina. "The Tsunami One Year On: Rebuilding Lives in Aceh." Geographical. Jan2006 Vol. 78 p30-38

Tobin, Mary. "Risk Analysis Reports Over Half of World's Population Exposed to One or More major Natural Hazards." The Earth Institute at Columbia University. http://www.earthinstitute.columbia.edu/news/2005/story03-29-05.html Accessed on 13 Feb 2006.

UNDP (1997) *Human Development Report*. Oxford University Press, New York.

United Nations Development Programme 2003. Date accessed: 10 Mar 2006. http://gridca.grid.unep.ch/undp/

WorldBank.org. 2006. The World Bank Group. 17 Apr. 2006. http://www.worldbank.org/