Simulating Non Structural Factors in Disaster Mitigation: The Csae of Typhoon Ondoy on the Marikina Watershed

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Abstract: The typical factors studied in disaster mitigation typically focus on physical and engineering factors such as infrastructure in the area, and informational, such as training and education in disaster preparedness. This paper highlights the non-structural approaches to understanding disaster mitigation. This paper suggests that some well-intentioned socio-economic policies, which seemingly have no impact on the environment and disasters, could develop longer term negative impact. Cumulative effects and feedbacks may unwittingly lead to disasters. The study focuses on the disaster following Typhoon Ondoy (international name Ketsana) in 2009. Past studies suggest that the flooding was related to denudation of the Marikina Watershed, which in turn, was related to the resettlement program in 1986. A System Dynamics model was developed to explore the interactions of socio-economic factors leading to the disaster.
Key Words: environment; disaster mitigation; system dynamics; simulation

1. INTRODUCTION

There are differing approaches to disaster management (de Guzman, 2003). This leads to different focus and concern as well as varied degrees of success. McCarthy and Keegan (2009), however, note that the more important debate focuses on structural and non-structural mitigation. Engineering interventions such as infrastructure and barriers to protect populations form typical structural mitigation approaches. On the other hand, new land use which may also include removal of structures is an example of non structural approaches. Wright and Rossi (1981) noted that structural mitigation can encourage people to move into hazardous areas as structural protection can lead them into extreme complacency.

This paper takes the view of the importance that non-structural mitigation is also important, if not more important. It observes that government policies, even as they are well-intentioned, could lead to effects that might eventually create disasters.

Secondly, some resulting socio-economic relationships that develop among the population could make solutions to alleviate the disaster more challenging, if not impossible, to implement as in the case of the Marikina Watershed.

This paper is an exploratory study of the non structural factors at the Marikina Watershed long before the Ondoy tragedy occurred. It is an exploratory study because there is a dearth of available data about the Marikina Watershed. Thus, the simulation model developed will simply assume values where the data is not available.

2. THE MARIKINA WATERSHED

Typhoon Ondoy brought 347.5 mm rainfall in only 6 hours and reached 413 mm in 9 hours. It totalled 448.5 mm after 12 hours. In the end, about 800 people died, 400,000 people were displaced, and PhP17 billion worth of infrastructure and agriculture were damaged. The flood waters in adjoining cities reached 10 feet in many areas and it came from the upper slopes of the Marikina Watershed.

The watershed has been a protected area since 1904, but over the years deforestation continued. In an effort to encourage reforestation, some 1,430 hectares were made open to residents in exchange for responsibility for tree planting and taking care of the reservation area as well as keeping unlawful residents. Their tenure was assured for 25 year periods by issuing certificates of stewardship.

Most of the people assumed they would stay in the area permanently without considering the limited time stewardship that was granted to them. In fact, they had built concrete houses in the area.

Vegetable farming was the basic source of income for these residents. Part of the forest was cleared for the settlers' farms. However, income from vegetables was not stable and there were problems with vegetable growing. The people then shifted to charcoal production. This led to cutting down of more trees. In addition, the residents did not fulfil their contract of reforesting the area.

Another unanticipated effect from the grant of certificates of stewardship occurred. The land was sold illegally (as much as PhP900,000 for 9 hectares) to others while other non-certified settlers came to the area to create slums. In many cases, they paid the original settlers for some rent.

The result of these socio-economic activities had impact on the forest cover of the Marikina watershed. From a natural forest cover of 1,493 hectares in 1981, only 376 hectares of forest cover is left in 2007. As much as 75% of the forest cover was lost in less than 30 years. The old growth forests have been all turned into brush lands and secondary forest.

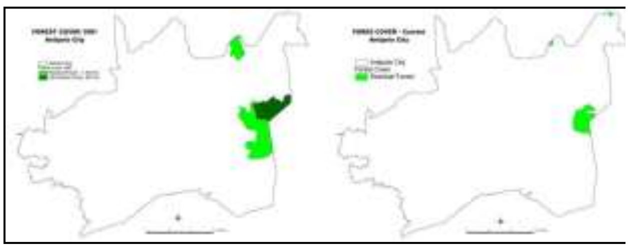

Figure 1. Forest Cover Comparison of 1981 and 2007
Source: (Local Government Unit of Antipolo and its Constituents, 2007)

The resulting deforestation led to gradual erosion in the watershed and silting in the rivers over the years. Coupled with these events, the unusual heavy rainfall and the silted drainage systems in city led to the disaster of 2009.

3. SIMULATION MODEL

The framework of the simulation model is based on causality of factors and feedback loops based observed from the environmental and socio-economic activities.

The initial relationships relate forest cover with the vulnerability of the river system to overflowing. Such vulnerability is a function of the structural protection of the river as well as silting of the river. Silting is, in turn, a cumulative effect of erosion over many years. As such, the effect of silting on the river in the early years was relatively low and the structural protection was adequate. Moreover, more forest cover or trees prevent soil erosion. This is shown on the left side of Figure 2.

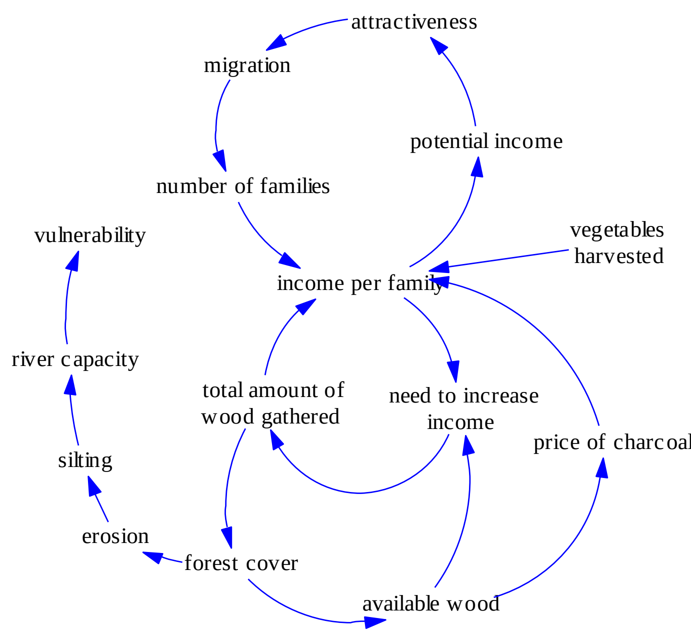

Figure 2. Causal map of the Marikina watershed system

The diagram explains the rate at which forest cover decreased over time. In the early years, when families were allowed to stay in the watershed, their basic source of income was vegetable growing. As their family needs grew, with additional expenditures, including water supply, their income from unstable vegetable farming became inadequate. The families began to rely more and more on wood gathering for charcoal production, which required less time to produce. This increased their income but also affected forest cover.

As their income stabilized, the area became attractive to others in the city. The current residents could sell the land at low prices but also the forest provided opportunity to generate income (potential income). This led to more families migrating to the area, resulting to more competition for wood gathering. The income per family was less than what it used to be but total wood gathered by all families increased. At the same time, available wood diminished raising the effort to collect more wood and go deeper into the forest.

With constant need to maintain income, the potential income observed by potential migrants became attractive. This led to more migrating families as well as increased effort to collect more wood and reduced forest cover and the need for more income and wood. The cycles themselves suggest that the families in the watershed became victims of the system – they will not be able to stop gathering wood as reduced available wood puts more pressure to increase their income.

4. SIMULATION RESULTS

From the above causal map, a mathematical model was built using Stella software. As detailed data is not available, this theoretical model reconstructs what happened over the 30-year period and shows how the interaction of the suggested factors in the Marikina watershed system led to higher vulnerability over time.

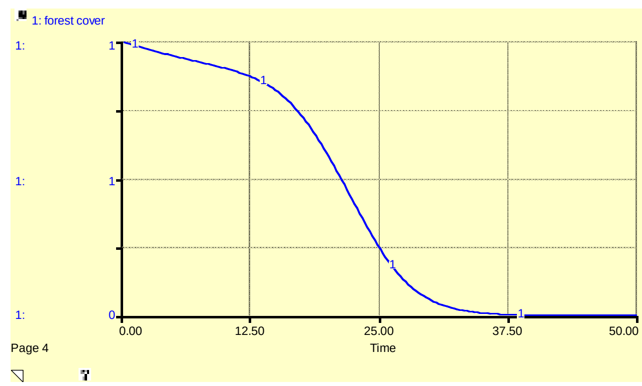

Figure 3. Simulated forest cover.

Figure 3 shows the simulated graph of the forest cover over the 30-year period. It closely replicates the known available data where the fastest deforestation rates happened in the 1990s (middle period).

The rapid decline of the forest cover is explained by the increased effort required to generate the minimum family income. The higher effort needed is a result of more competition for woods in the forest as more families now migrated into the area.

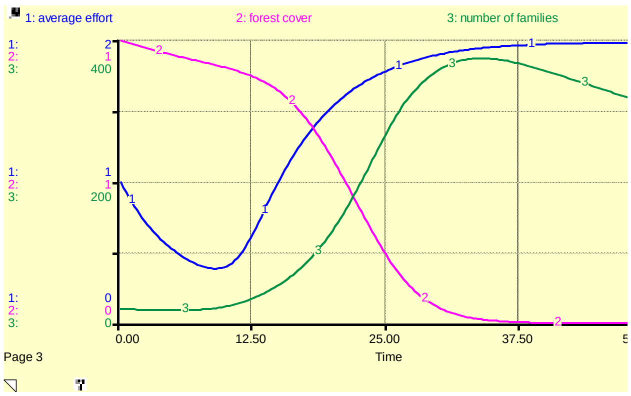

Figure 4. Simulation of wood gathering effort and population in the area.

Figure 5. Simulation of migration rate, potential income and number of families in the area

Figure 5 shows that the expected (potential) income of migrating families was immediately rising in the early 10 years. This possibility of a stable income in the watershed area attracted many families but this occurred after some delay. This delay is due to natural information lags to other people. This same delay can be seen in the fall of potential income that other people did not know. That is, even as the potential income fell by the tenth year, new families were still arriving as they were not aware of declining incomes and increased efforts.

The simulations suggest that the rate of deforestation if it is not controlled could continue until the forest is totally depleted. The simulation shows that there are still families in the watershed who can continue to cut trees.

In fact, the government has built roads in schools in the area. This development, coupled with the settlers building concrete houses, suggests that the families can stay permanently in the area and that they will not be easily dislodged. Even with current efforts for reforestation, the families living in the area can still profit from the new trees that will grow.

While indeed the deforestation was directly caused by migrating families, the tree cutting and clearing activities were triggered by need for income and livelihood. Thus, even with current efforts to train and extend help through livelihood programs are implemented, the forest can provide the easy additional income necessary for these families' needs.

As for disaster vulnerability, it is indirectly related to forest cover. As the forest cover is depleted, vulnerability to disaster increases with higher rates of erosion. However, structural mitigation to prevent hazards will have limited success in conditions were the damage was not mitigated and controlled earlier. There is more pressure for structural solutions to prevent potential disasters even as the socio economic dynamics continue to affect natural solutions to the disasters.

5. CONCLUSIONS

This paper attempted to recreate the non-structural causes of the devastating floods caused by Ondoy in Metro Manila. As there is very little data available in the Marikina watershed system, the simulation model provided the insights to how the factors interacted over time.

The main point of the paper is that similar efforts should be made on non-structural mitigation interventions as their cumulative effects can render structural interventions meaningless if the non-structural factors continue to remain overlooked and unabated.

Indeed, the Marikina watershed case seems to indicate the difficulty of controlling these socio-economic factors. The economic need to find and generate income and the attraction for migration of potential for stable income cannot be controlled. The government in relocating families cannot rely on contracts in controlling their behavior. They need to be provided for with other opportunities for earning a living. And if they cannot actually be prevented from mindlessly using the forest, public policy should avoid using forests for residential purposes.

The challenge therefore in setting public policies is to have better foresight as to how people will act and behave when such policies are implemented. The question that may be needed is “Will such a policy lead to long term vulnerability to disasters?”

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