CALCULATION OF MINING ANTHROPOGENIC DISTURBANCE USING REMOTE SENSING IN CARAGA REGION, PHILIPPINES

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1. Introduction

Material Flow Analysis (MFA) has emerged to be a useful tool in various disciplines for evaluation, management, and decision-making, among others. In this research, we use the concept of MFA to understand the flow of mineral resources as material input in the socio-economic environment and the less attended overburden material.

In the context of mining, anthropogenic disturbance (AD) is the land resources excavated which contain the valuable minerals from the earth. Generally, anthropogenic disturbance is broken-down into domestic extraction (DE) and hidden material flow (HMF). DE is the mineral ore like nickel, copper, gold, and chromites which have economic value while HMF is the overburden which is the by-product of the mining operation like rock, soil, and vegetation which have no economic value in the mining process. In most cases, there is more volume of overburden materials compared to the extracted mineral ore that is in there. According to the World Bank, the global ratio of overburden to the amount of mineral removed ranges from 2:1 to 8:1. The overburden ratio (waste-to-ore) defines the productivity of the mining operation. A higher ratio means that the mining operation is less productive. Overburden implies the extent of environmental pressure, which the economy did not benefit and the wasted energy resources in mining operation.

Caraga region, which is located in the southern part of the Philippines, is considered as one of the main mining areas of the country with major mineral such as nickel, gold, silver, chromite, copper, and zinc, among others. Every year the approved mining coverage is rapidly increasing, making it one of the major growth drivers of the region's economy. In effect, the Regional GDP is increasing due to the contribution of mining sector in the economy. However, this also results in the increase of anthropogenic disturbance (AD) in the area. AD is inevitable in a mining site and destructive to some extent to the environment if not properly managed.

Specifically, the study use ArcGIS 10.3 software as a tool in locating mining spots in Caraga region and estimate the total volume of mining anthropogenic disturbance (AD) from 2000 to around 2010 using satellite imageries. The study also determined the domestic extraction from 2000-2010 using historical data sources and calculates the overburden ratio of the mining development in the region.

2. Data Source and Methodology

We based our methodology (Figure 1) from previous research such as the calculation of overburden in urban development using GIS by Tanikawa and Imura (2001); mapping landslide susceptibility using aspect and slope, among others by Quan and Lee (2012); and assessing the vulnerability and inundation to Tsunami using parameters such as elevation and slope, among others by Sambah and Miura (2013).

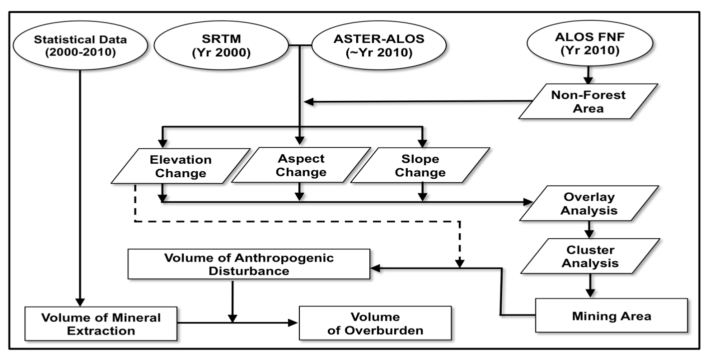

Figure 1 Framework of the Study

In this research, we will be using similar parameters such as the elevation, aspect and slope; however, we are the first to apply it in calculating the anthropogenic disturbance and overburden using GIS in a mining spots at regional scale. We used digital elevation model (DEM), a digital representation of terrain's surface in an equally spaced grid of elevation points such as SRTM 30m (2000), ASTER GDEM 30m (~2010), and ALOS 5m (~2010). We also used the ALOS Forest/Non-Forest (FNF) Map (2010) and statistical data of mineral production from the period 2000 to 2010.

Initially, we merged the ALOS 5m DEM to ASTER 30m DEM. We then extracted the non-forest boundary from ALOS FNF 25m, which potentially covered the mining spots in the region. With the non-forest boundary, we used it to extract the boundary of non-forest boundary of ASTER-ALOS and SRTM, and then get their elevation change. The same process was done in getting the aspect and slope change. Aspect change is defined to be as the direction of slope. We then applied weighted overlay analysis on the three parameters using 80% for elevation, 10% for aspect, and 10% for slope (Figure 2).

Using ArcGIS software, we then do aggregate analysis to eliminate those small contiguous areas. In mining development, the assumption is that the mining spot generally have wide coverage of extraction. Then, we verify the mining spot by overlaying in the ArcGIS World Imagery. The volume of anthropogenic disturbance is then calculated as the summation of the elevation change multiplied by the resolution of the DEM.

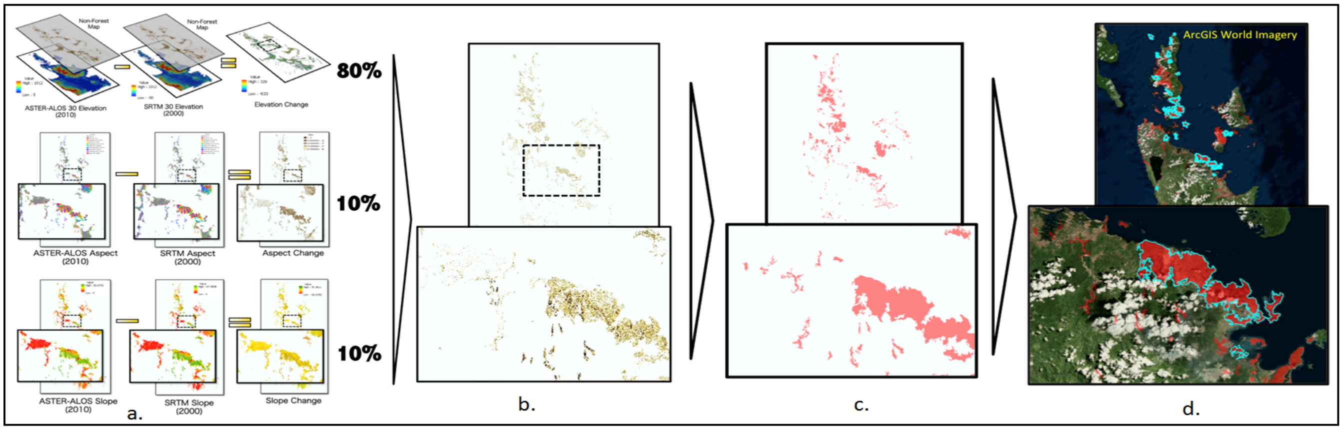

Figure 2 a) elevation, aspect, and slope change; b) weighted overlay analysis; c) aggregate analysis; d) verification of mining spot

Statistical data of mineral extraction of the region from 2000 to 2010 were compiled to calculate the domestic extraction. We categorized it by metal ores, construction minerals, industrial minerals, and fossil energy carriers. In this study, we are interested in the volume of metal ores from 2000 to 2010.

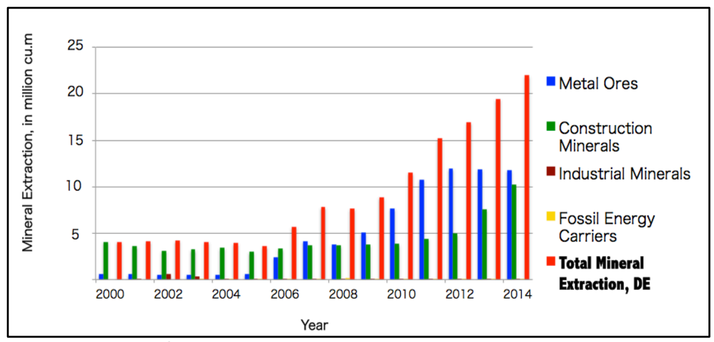

Figure 3 Mineral Extractions in Caraga Region, 2000 - 2014

3. Results and Discussion

The total volume of anthropogenic disturbance is found to be 518 million cu.m. The mineral extraction for the metal ores from 2000 to 2010 reaches 26 million cu.m, which is 95% of the AD (Figure 3). Therefore, the amount of overburden (waste) reaches 492 million cu.m. Overburden ratio (waste-to-ore) calculation in the case of Caraga shows a value of 19:1, which is higher than the global overburden ratio at the range from 2:1 to 8:1 (Mine Wastes Management, 2009).

The result of the overburden ratio implies five (5) major concerns. First, is that there are abundant amount of material extraction that are not utilized in the economy. This may be attributed to the type of technology used and the enforcement of mining regulations in the region. The overburden ratio may also imply the vulnerability of the mining area to natural hazards and added adverse environmental impacts such as flooding and landslide, among others especially during heavy rainfall events. It may also imply that there is potentially more fuel energy, equipment and financial resources that are wasted in the mining operation to get the mineral in the ground. Along with that, it implies contribution of CO_2 emission in the environment. Lastly, it also imply that there is a need for practical improvement in the mining technology, enforcements of policies and creation of innovative ways to reduce the amount of overburden.

The findings of this study can also provide baseline information for development planners and decision-makers to balance ecological and socio-economic needs for the mining sector in the region.

Acknowledgements

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