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Establishment of a monitoring system for mining activities and their spatial effects and environmental impacts in province Hoa Binh, Vietnam

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Abstract

In this proceeding paper the state of the work and the current findings of the establishment of a monitoring system for the spatial effects as well as the land-use-conflicts and environmental problems caused by the mineral extraction for building materials in province Hoa Binh will be presented. The main emphasis is put on how the spatial effects as well as the land-use conflicts and environmental impacts of mining activities are modeled, assessed and monitored by using an indicator system, GIS-based methods as well as remote sensing techniques. Land-use changes and especially the changes in mining areas in Hoa Binh were detected and analyzed using LANDSAT satellite images for the years 2000, 2007, 2009, 2011, 2013 and 2015. In addition monitoring data of several air, soil, surface water, groundwater and wastewater monitoring stations for the years 2014 and 2015 were evaluated and cartographically visualized for Hoa Binh. As the concentration of mining sites is especially high in the district Luong Son, more detailed analysis was done for this district on the basis of a high-resolution SPOT 6 image and further monitoring data for the year 2016. The analysis was fundamental for building a GIS-based monitoring system for environmental impacts based on monitoring data and land-use. The main findings and the self-established user-friendly GIS-tool for the monitoring of environmental impacts will be presented in this proceeding paper.

Key Words: environmental impacts, mining, monitoring system, remote sensing, GIS-Tool

1. Introduction

Vietnam is facing rapid urbanization during the last decades which is expected to continue in the future [1]. Along with this development, the demand for building materials in Vietnam increased due to the massive boom in the building sector, which has therefore lead to a massive increase in mining activities. Findings show that mining has influenced socio-economic well-being in Vietnam at the national level. Mining is associated with job creation and infrastructure development, but also with social and environmental conflicts and challenges [2].

Module 1 of the ongoing joint BMBF project Management of Mineral Resource Extraction in Hoa Binh Province – a Contribution to Sustainable Development in Vietnam (MAREX) deals with the monitoring of the environmental impacts and land-use conflicts associated with the mineral extraction of building materials in province Hoa Binh. A monitoring system for the spatial effects as well as the land-use conflicts and environmental problems causing by the mining activities will be developed. The responsible project partner for this module in Germany is the Department of Spatial Information Management and Modelling (RIM) of the Faculty of Spatial Planning, Technical University of Dortmund (TU Dortmund).

This paper describes the current state of the work of module 1. At first, the available materials and the applied methods for conducting the analysis will be explained. Then the current results and findings which are based on the analysis will be presented and discussed.

2. Materials and Methods

The basis for the work of module 1 is the analysis of the mining-environmental situation in Hoa Binh Province. To guarantee a comprehensive analysis, various data and methods were employed.

LANDSAT satellite images for the years 2000, 2007, 2009, 2011, 2013 and 2015 were classified using remote-sensing techniques to analyze the land-use changes in Hoa Binh Province. Furthermore, a high-resolution SPOT6 image of district Luong Son was analyzed for more detailed analysis. RIM used the remote-sensing software ENVI to classify the satellite images, to locate different land-use types and determine the changes.

Department of Natural Resources and Environment (DoNRE) provided monitoring data for the years 2014 and 2015 for Hoa Binh Province. Further monitoring data was provided by DoNRE and the Institute of Environment and Automation (IEA) for the year 2016 for the district Luong Son. The monitoring data includes coordinates of various numbers of monitoring stations (see table 1) and a wide range of measured parameters for air (e.g. TSP, noise, SO_2), soil (e.g. As, Cd, Pb, Zn), groundwater (e.g. NO_2-, Fe, As, coliform), surface water (e.g. pH, DO, TSS, coliform) and wastewater (e.g. pH, TSS, BOD_5, Pb, coliform) monitoring stations [3].

Table 1: Number of monitoring stations for the years 2014, 2015 and 2016

Monitoring data	Number of monitoring sites		
	2014 Hoa Binh province	2015 Hoa Binh province	2016 Luong Son district
Air	75	75	48
Soil	13	13	24
Groundwater	21	11	24
Surface water	57	30	24
Wastewater	113	150	24

Samples were taken in the field using current standard methods and equipment. For each type (air, soil, groundwater, surface water, wastewater) samples were gathered during two time periods – rainy and dry season – for the years 2014, 2015 and 2016. The weather

conditions during the sample taking should always be the same, e.g. no rain before and during the sample taking, and the operations at the mining sites take place normally [3].

The chemistry and environmental analysis of the samples is done in the following weeks after the sample taking at the Research Centre for Environmental Monitoring and Modelling (CEMM) with the available laboratory equipment [3].

During a research stay in February 2017, 3D-Laserscanning data was taken from a mining site in the district Luong Son by RIM.

GIS-based methods were used to process the data, to carry out spatial analysis of the monitoring data and to connect the monitoring data with the land-use analysis.

Using open source QGIS and the programming language python, RIM establishes a GIS-Tool for processing monitoring data.

3. Results and Discussion

The detection and analyzation of the land-use as well as the geotagging of potential mining sites in the province Hoa Binh for the years 2000, 2007, 2009, 2011, 2013 and 2015, based on LANDSAT satellite images showed that the landscape in Hoa Binh dramatically changed as a consequence of the intensive and increasing mining activities (see figure 1).

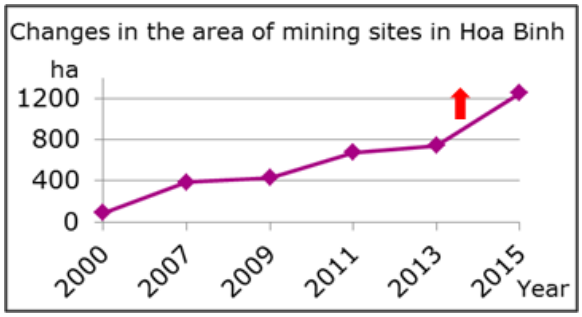

Figure 1. Changes in the area of mining sites in Hoa Binh; Source: Landsat 5 and Landsat 8 images, processed by RIM 2017 [4]

Additionally, the evaluation and cartographic visualization of the monitoring data of several air, soil, surface water, groundwater and wastewater monitoring stations for the years 2014 and 2015 pointed out the exceedances of limit values in Hoa Binh, especially for air parameters close to mining sites. Furthermore, land-use conflicts arise due to the high increase of the mining area in Hoa Binh. In the year 2015 the mining area was 12 times larger than in the year 2000. In the same time period, the forest area decreased about 12 %. A large amount of settlement areas is highly affected by mining activities which leads to conflicts with the inhabitants because of health issues occurring especially from the exceedances of limit values for air pollution and noise.

Especially the district Luong Son, where 60 of the 96 licensed mines of Hoa Binh were located in the year 2015, is highly affected by mining activities (see figure 2).

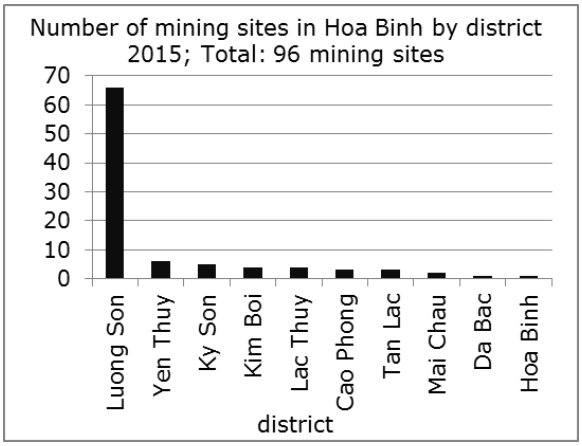

Figure 2: Number of mining sites in 2015; Source: data from DoNRE, processed by RIM 2017 [4]

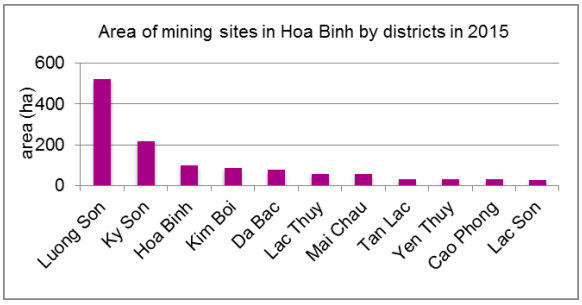

Figure 3: Area of mining sites in Hoa Binh by districts in 2015; Source: Landsat 8 image, processed by RIM 2017 [4]

Luong Son with a total of over 500 ha mining area in the year 2015 (see figure 3) has been heavily affected by mining activities. So, further research with SPOT 6 high-resolution satellite data together with additional monitoring data for the year 2016 was conducted for this district. Data for 48 air, 24 soil, 24 groundwater, 24 surface water and 24 wastewater monitoring stations close to mining sites in Luong Son were available for detailed analysis (see figure 4).

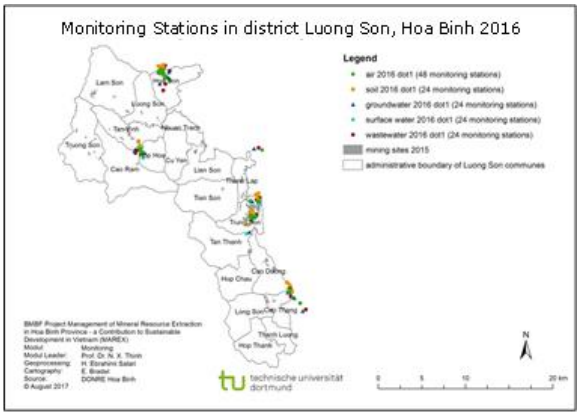

Figure 4: Monitoring Stations in district Luong Son 2016; Source: data from DoNRE, processed by RIM 2017 [4]

Different mining sites were visited on a research field trip in spring 2017 and 3D-laserscanning data was taken. Thus, more detailed environmental impacts in the context of mining sites and other land-uses were detected. In Luong Son 183 ha settlement area is located in the 200 m distance from mining sites in the year 2016 (see figure 5) which leads to conflicts between the mining sector and inhabitants especially due to air pollutants such as total suspended particulate (TSP) and extreme noise impacts which can cause serious health problems for humans [5, 6, 7].

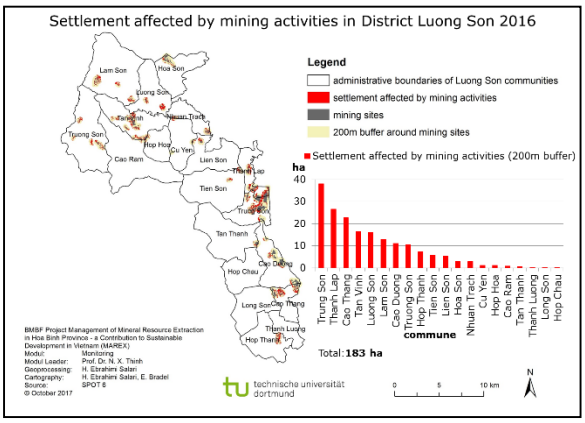

Figure 5: Settlement affected by mining activities in district Luong Son 2016; Source: SPOT 6, processed by RIM 2017 [4]

Furthermore, 509 ha of farmland was situated in the 200m area around mining sites in district Luong Son in the year 2016 (see figure 6). Farmland close to mining sites can be negatively affected by mining activities. Air pollution can highly influence the agricultural production. For instance, the dust resulting from mining activities negatively influences the nutrients, photosynthesis and production of plants which leads to reduced yields. Especially in economies depending on the agricultural sector this can result in serious economic and social problems [8].

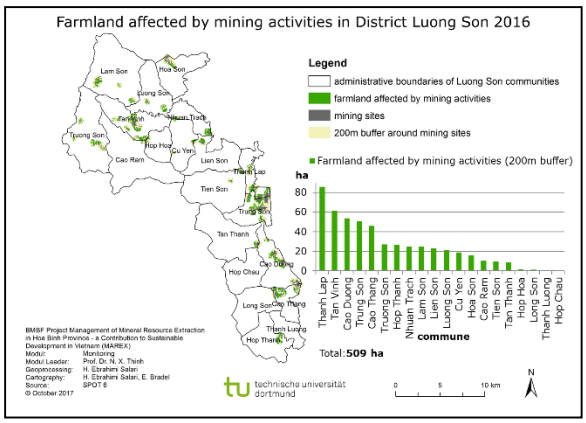

Figure 6: Farmland affected by mining activities in district Luong Son 2016; Source: SPOT 6, processed by RIM 2017 [4]

The analysis of monitoring data from the surrounding areas of six mines in the district

Luong Son for the year 2016 showed that there are exceedances of limit values of different parameters. At air monitoring stations, the comparison samples for TSP are below the limit values, but residential areas are affected by TSP at two mining sites (see figure 7) [3].

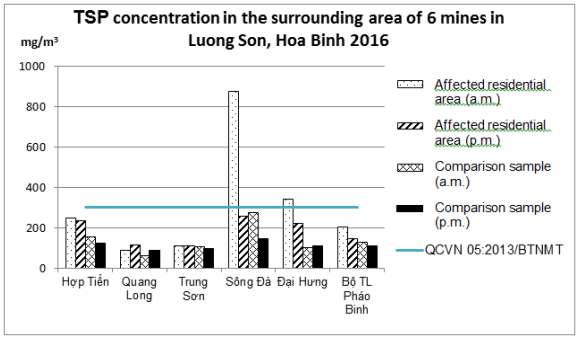

Figure 7: TSP concentration in air in the surrounding area of 6 mines in the district Luong Son, Hoa Binh; Source: DoNRE and IEA 2017 [3]

Further exceedances of limit values were detected for the year 2016 at surface water monitoring stations in comparison to QCVN 08-MT:2015/BTNMT National Technical Regulation on surface water quality. The analysis has shown some low exceedances of NH4+, COD (see figure 8) and Fe and high exceedances of TSS and Hg as well as some exceedances in grease and oil [3].

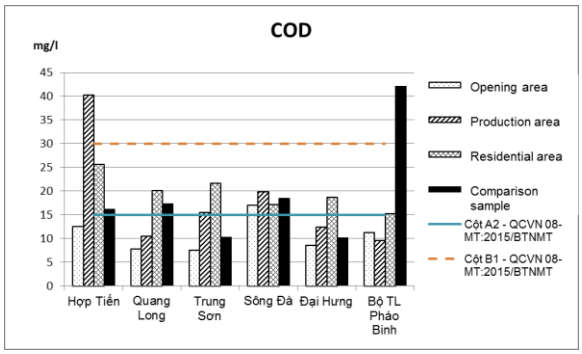

Figure 8: COD concentration in surface water in the surrounding area of 6 mines in the district Luong Son, Hoa Binh; Source: DoNRE and IEA 2017 [3]

Reasons for the environmental impacts of mining activities are especially associated with the management of the building sector and the legal framework for mining. Spatial planning in Vietnam meets serious challenges. Urban planning in Vietnam has several lacks, especially on the land development and zoning level. In most areas of Vietnam, urban and land use planning is not effective due to a lack or disregarding of existing zoning plans which leads to urban development into exposed areas [1, 9].

A GIS-based monitoring system for environmental impacts and land-use conflicts due to mining activities was established based on the described analysis of environmental impacts and land-use conflicts between mining and settlement areas. The self-established GIS-Tool can be used in QGIS as a plugin (see figure 9).

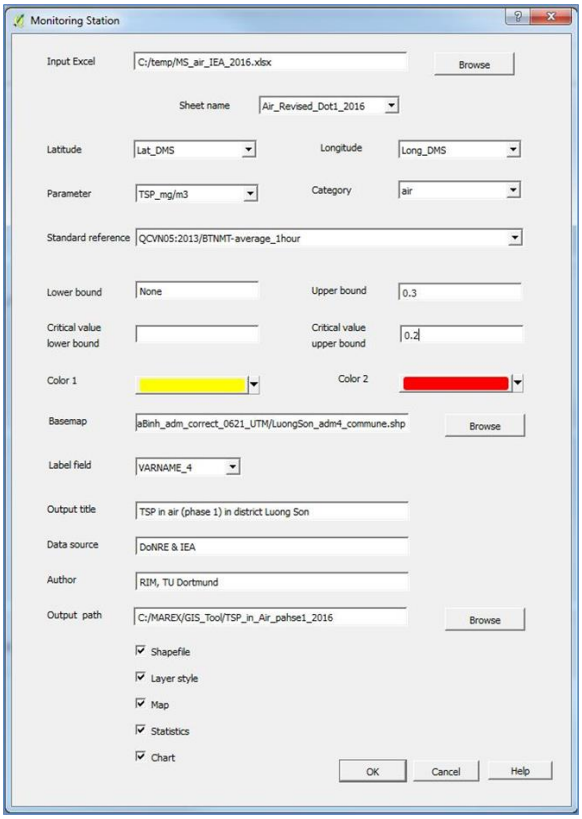

Figure 9: GIS-Tool for the analysis of monitoring data; Source: RIM 2017 [4]

The GIS-tool uses Excel-data with monitoring data as an input together with a basemap to produce a map, diagram as well as statistics about user-defined parameters. The output

shows for the chosen parameter, where exceedances of limit values occur and which monitoring stations show critical high values of the parameter. This is a helpful tool for authorities as it offers the possibility to prematurely intervene when measured parameters at mining sites are critically high or exceed the limit values. This can help to detect and prevent negative environmental impacts of mining activities. Furthermore, the GIS-tool makes it possible to put the monitoring data into context with the existing land-use to show the impacts of the mining activities on different land-uses. The usage of the GIS-Tool offers an easy and standardized method for the monitoring of environmental impacts of mining activities as well as for the evaluation of monitored data. As it is developed in QGIS, the free availability of the GIS-Tool is guaranteed. A help function in html-format makes it easy to understand the program and to use it efficiently.

4. Conclusion

The processing of high-resolution satellite images as well as the analysis of the data of various monitoring stations shows that negative environmental impacts of mining activities occur in Hoa Binh. As the findings of the analysis show, the development of settlement area close to mining sites can have serious impacts. This makes it necessary to develop strategies which help local authorities to control and monitor the mining activities. The GIS-tool for the monitoring of environmental impacts and land-use conflicts is one option in finding a way to prevent environmental impacts and to improve the situation in Vietnam. The established open-source GIS-Tool offers standardized monitoring and evaluation methods and thus helps to build an efficient network for the management of environmental impacts of mining activities.

The further work of module 1 of the ongoing joint research project MAREX will concentrate especially on the development and improvement of the GIS-tool, which will be an important output of this module. The aim is to establish a user-friendly GIS-tool which enables local authorities to monitor and control the mining activities of mining enterprises and to take conservation measures when environmental impacts seem to occur. The comparable outputs of the GIS-tool such as statistical data and maps should help to construct an effective monitoring system of the environmental impacts of mining activities.

Acknowledgments

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References

[1] Sudmeier-Rieux, K.; Fra.Paleo, U.; Garschagen, M.; Estrella, M.; Renaud, F. G.; Jaboyedoff, M. (2015): Opportunities, incentives and challenges to risk sensitive land use planning. Lessons from Nepal, Spain and Vietnam. In: International Journal of Disaster Risk Reduction 14, pp. 205–224. DOI: 10.1016/j.ijdrr.2014.09.009.

[2] Nguyen, Nhi Ba; Boruff, Bryan; Tonts, Matthew (2017): Mining, development and well-being in Vietnam. A comparative analysis. In: The Extractive Industries and Society. DOI: 10.1016/j.exis.2017.05.009.

[3] DoNRE (Department of Natural Resources and Environment) and IEA (Institute of Environment and Automation) (2017): Report of Phase I. Tasks: "Investigation, survey and analysis of environmental quality in mining sites in Luong Son district, Hoa Binh Province"

[4] RIM (Department of Spatial Information Management and Modelling) (2017), Faculty of Spatial Planning, TU Dortmund, Germany

[5] Patra, Aditya Kumar; Gautam, Sneha; Kumar, Prashant (2016): Emissions and human health impact of particulate matter from surface mining operation—A review. In: Environmental Technology & Innovation 5, pp. 233–249. DOI: 10.1016/j.eti.2016.04.002.

[6] Parker, Anthony W.; Tones, Megan J.; Ritchie, Gabrielle E. (2017): Development of a multilevel health and safety climate survey tool within a mining setting. In: Journal of safety research 62, pp. 173–180. DOI: 10.1016/j.jsr.2017.06.007.

[7] Li, Xiaodong; Song, Ziyang; Wang, Tao; Zheng, Yu; Ning, Xin (2016): Health impacts of construction noise on workers: A quantitative assessment model based on exposure measurement. In: Journal of Cleaner Production 135, pp. 721–731. DOI: 10.1016/j.jclepro.2016.06.100.

[8] Hota, Padmanabha; Behera, Bhagirath (2015): Coal mining in Odisha: An analysis of impacts on agricultural production and human health. In: The Extractive Industries and Society 2 (4), pp. 683–693. DOI: 10.1016/j.exis.2015.08.007.

[9] Du Huynh (2015): The misuse of urban planning in Ho Chi Minh City. In: Habitat International 48, pp. 11–19. DOI: 10.1016/j.habitatint.2015.03.007.

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