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Investigating potential mining induced water stress in Ghana's north-west gold province

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ABSTRACT

This study investigates the potential interactions of mining industry activities with water sources. The investigation identifies the socioeconomic impacts, as demands for water for domestic and industrial purposes are expected to increase. A case study was conducted in Ghana's North-West, one of the country's emerging gold provinces. Data were obtained from both primary and secondary sources. Socioeconomic and mean monthly rainfall data were integrated with data on 124 boreholes, and locations of 45 dams and ponds. The criticality ratio was modified and used to estimate groundwater stress indices (GWSI) for the region. A minimum of 0.008 and a maximum of 0.016 groundwater stress indices were obtained. Aridity indices were also estimated and used to develop an iso-aridity map for the area. It was found that a maximum of 229 and a minimum of eight rural households would potentially be affected due to growing water stress. With the emergent use of water in mine operations, conflicts may arise between local communities and companies, and between neighbouring states. The results of this study provide baseline information that could be useful to stakeholders for informed decision-making and the management of mining-related water use conflicts in developing countries.

1. Introduction

The spatial interactions between the increasing numbers of mineral resource development projects in Sub-Saharan Africa, and sources of water for domestic and industry uses are intricate. The character and fate of water resources in sub-Saharan Africa are shaped by its growing human population, residential expansions, and attendant land development. This has increased the demand for water, leading to stress on scarce sources. Water stress is defined as the reduction in the capacity of water resources, both underground or surface, to support physical, chemical or biological production for domestic, industrial and commercial purposes (UN-Water, 2009). This leads to water scarcity or the inability of sources to meet societal demands (UN-Water, 2007).

Water scarcity is among the most critical environmental problems in the twenty-first century. According to the United Nations Thematic Water Initiatives (UN-Water, 2007), approximately 1.2 billion people across the globe, mostly in developing countries, live in 'water scarce' areas. It is further projected that a further 500 million people will be at risk of water scarcity in the near future (UN-Water, 2007). Furthermore, approximately 1.6 billion people face water stress in countries where there is lack of capacity to take available water from remote rivers and aquifers, for purposes other than domestic usage (UN-Water, 2007). Further studies show that inhabitants of over 67% of rural communities in sub-Saharan Africa have no access to potable water sources (Assessment, 2005; UN-Water, 2015).

Water stress is caused by two main processes: natural and anthropogenic. Natural processes include climatic, physiographic, biological, and geological aspects of the environment (Peters and Meybeck, 2000). Natural disasters such as earthquakes, volcanic eruptions, landslides and floods can impact the availability of water and may lead to water scarcity. Anthropogenic processes, however, alter the rate and frequencies of these natural processes. Resource creation, via urbanisation, agriculture intensification, and mining activities, is the major anthropogenic factor that may initiate water stress. During resource creation, man modifies the landscape, potentially reducing its capacity for water sources and pathways at different spatial scales, and thereby degrading the quality and accessibility of the source. In addition, the quantity of available fresh water has a direct link with its quality. Once the quality of water is degraded, it becomes difficult to use for domestic, commercial and industrial purposes, particularly in arid and semi-arid areas (Peters and Meybeck, 2000). Agriculture and

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mining are the major anthropogenic activities that degrade water (World Bank, 2006). The negative impacts of agriculture on water stress have been discussed elsewhere (Peters and Meybeck, 2000). The impacts of mining industry activities on water stress, if not properly understood and managed, could also be pervasive, affecting not only local flow but also eventually regional flow systems (Sophocleous, 2002).

Due to the effects of substantial water use in mining operations, water stress and water-related conflicts may become inevitable in the associated regions. The UN-Water (2007) shows that shared ground and surface water systems could be a source of international governance cooperation. However, depletion of shared water systems, through mineral resource extraction, can be a source of conflict between neighbouring countries. For example, whereas Chile claims exclusive rights to the use of river Silala for copper mining, Bolivia argues for a mutual use and seeks to limit the activities of Chile's copper mines on the river (Toledano and Roorda, 2014). Another example is the dispute between the Netherlands on one hand, and France and Germany on the other, over pollution of the Rhine river (Haftendorn, 2000). The Rhine River serves as a major source of drinking water for communities in the Netherlands, and the quality of potable water was at stake.

In addition, contamination of both ground and surface water can also result in conflicts between local communities and companies. For example, Bebbington and Williams (2008); Lin et al. (2005); Miranda and Kool (2003) found that the contamination of up and downstream water sources from mine water and acid drainage resulted in company-community conflicts in Peru, Southern China, and Papua New Guinea. Akabzaa et al. (2007) find in Ghana that surface waters were more exposed to pollution than groundwater. Besides, Mol and Ouboter (2004) find a link between stream-bed sedimentation in the Amazon drainage system and water-driven erosion that is caused by mining. Moreover, Company-community conflicts also result from the diversion, over-abstraction or stemming of water bodies by mining companies. For example, mine expansion and intensification of low grade ore extraction has led to the over-withdrawal of water from 852 rivers, 1181 lakes, and 2277 springs in Mongolia (Toledano and Roorda, 2014). Instances of company-community clashes because of water stress are also reported elsewhere (Comment, 2013).

Nevertheless, little geographic information exists to adequately appraise and understand the extents of Mining Induced Water Stress (MIWS) on local communities in sub-Saharan Africa. While Environmental Impact Assessments (EIAs) are in place in developing countries, the nature and amount of water resources for use by local communities and their spatial interactions with the mining industry's activities is poorly understood by governments, and local stakeholders. Likewise, not many studies have measured the cumulative social impacts of MIWS for mitigating potential conflicts as this study does.

The purpose of this study, therefore, is to understand the spatially-explicit interactions between mining industry activities and water sources. It identifies the potential socioeconomic impacts that may result as the demands for domestic and industrial water requirements increase. Specifically, the paper aims to: (1) provide an overview of water stress status in the study area; (2) assess the potential impacts of the mining industry's activities on water sources; and (3) provide a robust prediction of potential company-community conflicts and inter-state conflicts due to resource extraction in shared drainage basins.

2. Materials and methods

2.1. Study area

Ghana is a mineral rich country in Africa. The country is bordered by Burkina Faso, the Republic of Togo, the Gulf of Guinea, and Ivory Coast (Fig. 1). It has 10 administrative regions and Accra is the capital. The three administrative regions in the north of the country are: Upper East (UER), Upper West (UWR), and Northern (NR). Mean annual rainfall, temperature, and humidity across all these regions are 885 mm, 28.6 °C and 54%, respectively (EPA, 2003). The Potential Evapotranspiration (PET) in the three northern regions is between 1652 mm and 1720 mm, with an annual aridity index of 0.54-0.60 (EPA, 2003). Excepting the district in the north-eastern corner, all three regions are within the Guinea

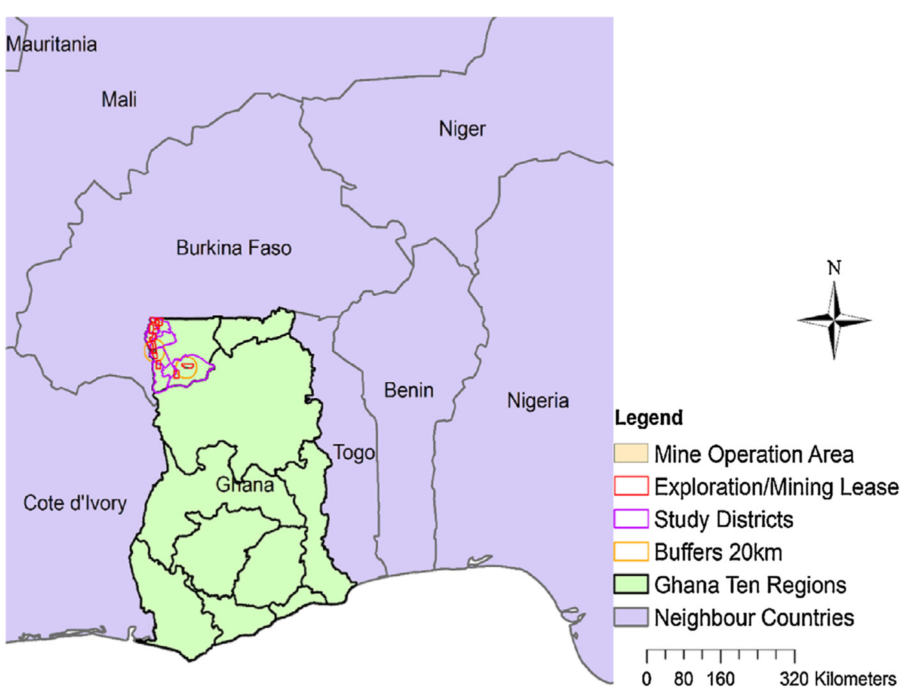

Fig. 1. Location of study area.