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# Restoration monitoring of rare earth element (REE) mines in southern Jiangxi, China

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Rare earth elements (REE) mines have an extremely high strategic value, especially, in national aerospace industry and military fields. The long-term open mining and extraction processing of REE in the weathered crust since 1970s have led to serious land degradation, e.g., vegetation degradation, soil loss, reduction of soil fertility, and especially, environmental pollution to subsoil and groundwater. Taking southern Jiangxi, where ion-type of REE mines are mainly located, as an instance, the total mining area is measured about 79 $km^2$ from 1291 mines, of which 56 $km^2$ have been or are being managed with restoration measures identified by comparison between multitemporal very high resolution images available on Google Earth. Visual interpretation revealed that large-scale mining activities occurred after 2000 and restoration management was not intervened until 2010, in particular, 2013. As implemented by different enterprises or companies, post-mining restoration has a strong spatial variability in both management approaches and effectiveness from mine to mine. Up to today, no systematic monitoring and assessment have been conducted for this restoration intervention. It is, therefore, the objective of our study to evaluate the effectiveness of such restoration efforts using multitemporal October Landsat data with scene path/row number of 121/42-121/43 from 2000 to 2017. Eight managed and seven unmanaged typical mines were selected for a comparative analysis and restoration assessment.

After atmospheric correction using COST model, NDVI and GDVI (Generalized Difference Vegetation Index) that is more suitable for low vegetation, as proxy of vegetation vigor and biomass production, were derived from all satellites images. The mean NDVI and GDVI values of each selected mine were calculated. The results show that NDVI of the managed REE mines has been increasing from 0.32 to 0.67 and GDVI from 0.55 to 0.90 year by year since 2010, indicating a vegetation recovery, especially, for those with effective management. In contrast, in the unmanaged mines, NDVI values remain low ranging from 0.20 to 0.40, and GDVI from 0.22 to 0.60, implying that the damaged vegetation cover caused by open mining and pollution has low capacity to recover without human intervention, where continue serious water loss and soil erosion. We also noted in some managed areas that planted grasses have survived but trees died

or are dying probably because of the residual pollution in subsoil. This means a holistic management should be implemented in both surface, subsoil and groundwater, and monitoring be conducted by remote sensing in combination with soil sampling. This will be our next task of research.