

## Article

# A Systematic Approach of Optimal Land-Use Planning by Applying Geo-Environmental Techniques: A Case Study

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**Abstract:** This article demonstrates the capabilities and integrity of the environmental geological and geophysical techniques for planning the suitability of the extension of Helwan city for construction and engineering purposes. The geological and topographical mapping were utilized as well as environmental geophysical techniques (seismic refraction, ground penetrating radar (GPR), and resistivity soundings) for optimal land-use planning. The seismic refraction profiles were conducted to evaluate the geotechnical characteristics of the bedrock, GPR was applied to define the main subsurface reflectors, and the geoelectrical resistivity survey was used to identify the subsurface stratigraphic sequence and the distribution of main structural elements impacting the investigated area. The integrated results and findings of the environmental geological and geophysical survey inferred two major distinctive subsurface layers: a thin surface layer represented by highly weathered limestone, with an average thickness of 3 m, and a bottom layer equivalent to the bedrock composed of hard limestone. In addition, GPR performed an analysis of two remarkable subsurface layers, which supported the generated model of other geophysical surveying techniques. Finally, all the geological and various geophysical techniques were integrated and merged to generate the optimal land-use plan of the extension of Helwan city for construction and engineering purposes and to avoid high-risk areas to reserve the sustainability of the new urban communities.

**Keywords:** integrity; environmental; geological; geophysical; sustainability



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## 1. Introduction

As populations grow, available land will become a scarce natural resource, especially for the already-existing urban communities. As more land is planned to be developed, effective planning will counteract the negative effects of its use and development. The numerous benefits of effective land-use planning can include the following: creating a generic framework for the proposed urban project, aiding the anticipation of the future plan of the investigated site, implementing sustainable infrastructure utilities, direct positive impact on the local urban economy, optimal use and conservation of natural resources along with protection of the environment, minimizing the associated risks of the natural hazards, and avoiding land-use conflicts [1–3].

For an optimal planning and effective development of the investigated site, a suggested joint integrated approach of geophysical methods including the electrical resistivity, seismic refraction methods, ground penetrating radar, and geological mapping were implemented throughout the study area. Geophysical indicators, including electrical resistivity, seismic velocity, and electromagnetic signature, give a clear image about the subsurface layering sequence and the degree of rock weathering or fracturing [4,5].

The investigated site is situated at the southeastern sector of Cairo, Egypt, which was designated for a proposed residential extension of the already-existing Helwan city, to reduce/minimize the random distribution of the unplanned urbanization in addition to providing millions of job opportunities, which takes into account the provision of a

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