ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 16, Issue, 11, pp.30607-30613, November, 2024
DOI: https://doi.org/10.24941/ijcr.47753.11.2024

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

ENVIRONMENTAL MODELING FOR IDENTIFYING SUITABLE WASTE DISPOSAL SITES USING GEOSPATIAL ANALYSIS AND THE ANALYTIC HIERARCHY PROCESS IN BAMAKO

Tolidji Blaise DONOU[1]*, Olatondji Salomon CHABI ADIMI[2] Maman Sani ISSA[3] and Africa ESHOGBA-OLOJOBA[1]

[1]International Bank for Development and Reconstruction; [2]Laboratoire de Biogéographie et d'Expertise Environnementale, Bénin; [3]African Development Bank

ARTICLE INFO

Article History:
Received 24th August, 2024
Received in revised form
17th September, 2024
Accepted 29th October, 2024
Published online 30th November, 2024

Key Words:
Waste Deposit, Analytic Hierarchic Process.

Corresponding author:
Tolidji Blaise DONOU

ABSTRACT

World population growth, rapid urbanization, and economic development are causing profound changes to the environment and urban planning. This population increase and rapid urbanization have led to a rise in urban solid waste. These wastes, generated by industries and urban areas, create serious environmental management challenges. Waste management has become a major problem in African urban areas. This study aims to identify suiTable areas for waste disposal in the Bamako district. The methodology is based on multicriteria analysis and GIS, using the Analytic Hierarchy Process (AHP) for criteria weighting. The study reveals that 21% of the study area is not suiTable for waste disposal. Less suiTable areas represent about 9% of the study area, moderately suiTable areas account for 46%, suiTable areas make up 18%, and the most suiTable areas cover 4%."

Citation: Tolidji Blaise DONOU, Olatondji Salomon CHABI ADIMI, Maman Sani ISSA and Africa ESHOGBA-OLOJOBA. 2024. "Environmental modeling for identifying suitable waste disposal sites using geospatial analysis and the Analytic Hierarchy Process in Bamako". *International Journal of Current Research*, 16, (11), 30607-30613.

INTRODUCTION

World population growth, rapid urbanization, and economic development are causing significant changes in land use, with serious consequences for territorial planning and the environment (Nascimento *et al*., 2017). This population increase and urbanization lead to more urban solid waste (Laura, 2018). These wastes, generated by industries and urban areas, pose serious environmental management challenges (Sener *et al*., 2010). Waste management has become a major issue in African urban areas (Ouattara *et al*., 2021). Bamako, one of the largest urban centers in West Africa, with about 3 million people and a 5% growth rate, faces significant waste management challenges. Less than 45% of waste is collected, and in many neighborhoods, waste is dumped on roads, in open areas, or into gutters (Ouattara *et al*., 2021). Sustainable waste management is essential for a healthy environment, and a key part of this process is selecting appropriate waste disposal sites. This selection must consider various environmental factors, best addressed through multicriteria analysis (MCDA), which structures the problem to aid decision-making, rather than seeking an optimum solution (Sener *et al*., 2011). The Analytic Hierarchy Process (AHP) is used within this framework to compare and weigh each factor, with the aid of GIS.

MATERIALS AND METHODS

Study area: Bamako is divided into two distinct parts by the Niger River. To the north, the city extends between the Niger River and Mount Manding on an alluvial plain that is 15 kilometers long and covers 7,000 hectares, narrowing at both the eastern and western ends. To the south, the right bank occupies a 12,000-hectare area stretching from Sénou Airport (opened in 1974) and the Tienkoulou hills to the Niger River. The city is located in the southwestern part of the country. Originally, Bamako was settled on the left bank of the Niger River, in a plain about 4 kilometers wide, sloping towards the river. This initial site is dominated to the north by the Manding Plateau, which reaches an altitude of 485 meters at Koulouba.

Today, Bamako extends 22 kilometers from west to east and 12 kilometers from north to south, straddling both sides of the Niger River. Bamako is located between isohyets 700 to 1300 mm. The relief is little marked to influence the circulation of the lower atmosphere. The climate is of the Sudanian type, marked by the alternation of a rainy season with a rainfall of between 800 and 1200 mm/year, and a dry season.

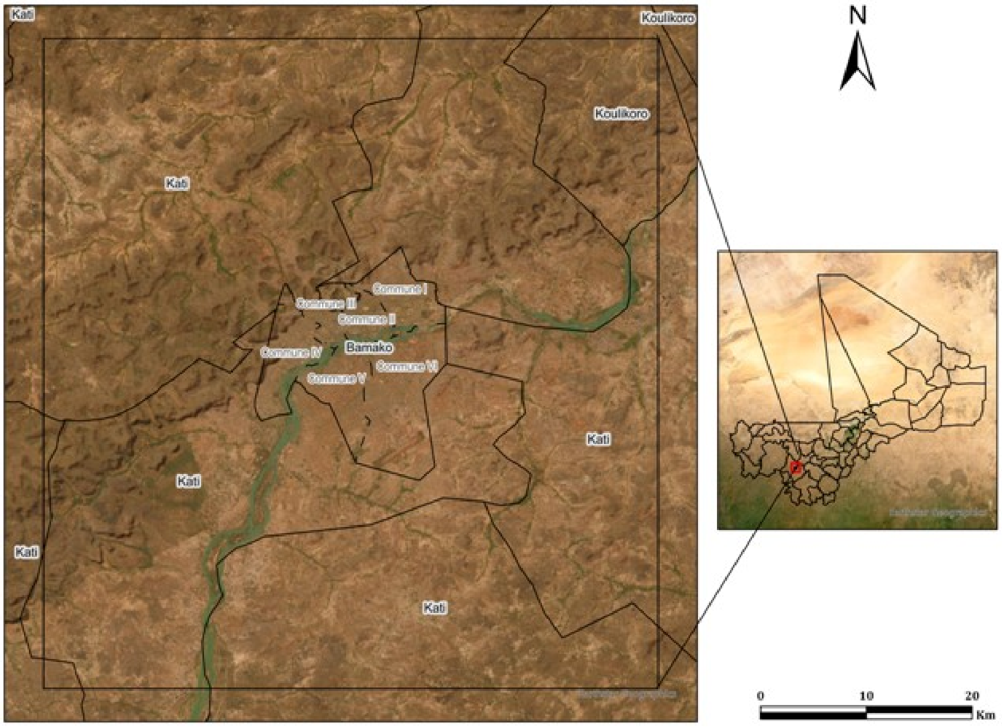


Figure 1. Location of the study area

The rainy season extends over 5 months, from June to October. A dry season divided into two periods, a cold period (from November to January) and a hot one (from February to May

Data collection and processing

The multi criteria analysis used in the research is based on specifical data contain in the Table below.

Table 1.data characteristics

Data	Format	Scale / Resolution	Date	Source	Utility
River layer	Shapefile			Diva-GIS	Proximity of river
Water body	Shapefile			Diva-GIS	Proximity of river
Geological layer	Shapefile		2011	British Geological Survey	Lithology
Road layer	Shapefile				Road proximity
Land use and land cover	Raster	10 m	2022	ESRI	Proximity of residential area, water and wetland
SRTM	Raster	30 m		USGS	Slope

Methods

The data used in this study represent the basis of the criteria. Thus:

- The river layer was integrated into ArcGIS to generate the proximity to the river.
- The water body was also used to generate the proximity to water body.
- The geological layer was used to generate the lithology, essential factor to avoid infiltration or contamination of groundwater.
- The road proximity is indispensable to access easily to the waste deposal; it was evaluated using road layer.
- The land use and land cover are important to avoid the population and water contamination by excluding residential area, water body and wetland area.

Standardisation: The standardization is an operation of reclassified criteria according to their suitability. There are two types of criteria for this research. The factor and constraints. The factor results from a linear classification of the criteria, while the constraints result from Boolean classification. For this research, the scale 0 to 10 was used for linear classification. When the value tends to 0, the suitability of the factor is low and when the value tends to 10, the suitability is high.

Weighting using AHP: The weighting is an operation of attribution of weight to each factor. The analytic hierarchic process of (Saaty, 2008) was used. It consists of comparing the criteria two by two in terms of relative importance (Table 2).

Table 2. Scales for pairwise comparison

Description	Intensity of importance
Equal importance	1
Moderate importance	3
Strong or essential importance	5
Very strong or demonstrated importance	7
Extreme importance	9
Moderately less important	1/3
Significantly less important	1/5
Very much less important	1/7
Extremely less important	1/9

Table 3. Pairwise comparison of factors

Criteria	Slope	Geology	Water body proximity	Road proximity	River proximity
Slope	1	1	0.333	1	0.333
Geology	1	1	0.333	1	0.333
Water body proximity	3	3	1	3	1
Road proximity	1	1	3	1	3
River proximity	3	3	1	3	1
∑	**9**	**9**	**5.666**	**9**	**5.666**

Table 4. Weight determination

Criteria	Slope	Geology	Water body proximity	Road proximity	River proximity	Weight
Slope	0.111	0.111	0.059	0.111	0.059	0.090
Geology	0.111	0.111	0.059	0.111	0.059	0.090
Water body proximity	0.333	0.333	0.176	0.333	0.176	0.271
Road proximity	0.111	0.111	0.529	0.111	0.529	0.278
River proximity	0.333	0.333	0.176	0.333	0.176	0.271

Consistency Ratio

In order to test the coherence of the different comparison, the **consistency** ratio (Saaty, 2008) was calculated through the below formulas:

- Consistency index (CI)/Random Consistency Index (RI)
• CI = (λmax – n)/n – 1
• λmax is the Principal Eigen Value; n is the number of factors
• λmax = Σ of the products between each element of the priority vector and column totals.

According to the number of criteria we have the valour of RI in the below table.

Table 5. Consistency Index

Number of criteria	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

λmax = 4.99879973
CI= 0
CR < 0.1 acceptable, so there is coherence between the different comparison.

Aggregation

After the definition of different criteria, they will aggregate using weighted linear combination equation.
$S = \sum_{wi\ xi} \times \prod c_j$
Where:S- is the composite suitability score.
xi- factor scores (cells)
wi- weights assigned to each factor.
Cj- constraints (or Boolean factors)
∑- sum of weighted factors
∏- product of constraints (1-suitable, 0-unsuitable)

The figure 2 present the resume of methodology.

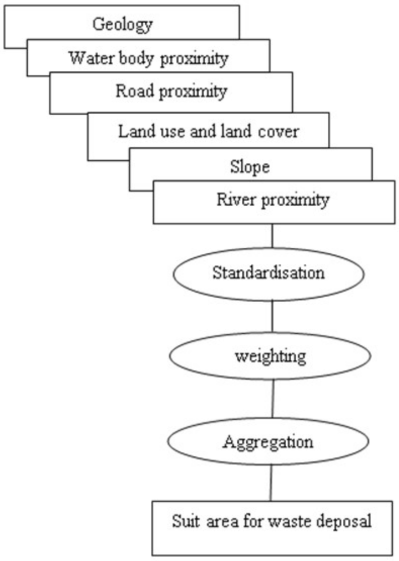
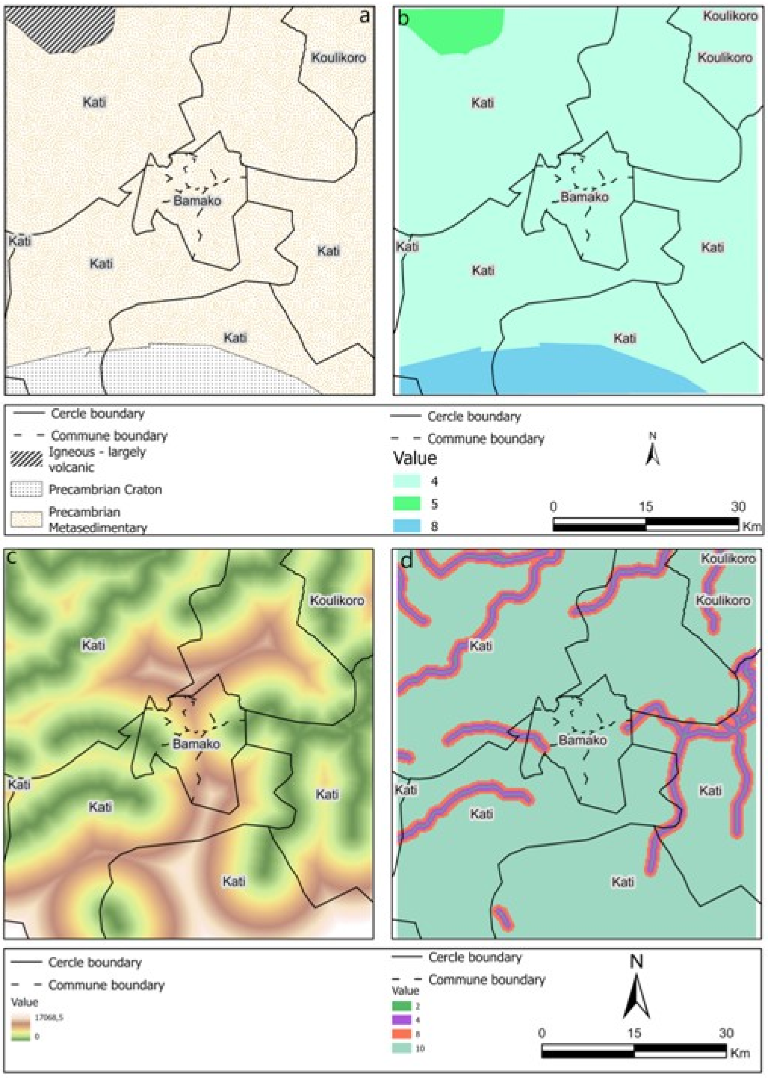


Figure 2. Flow chart of model applied for suitability for waste deposal.

RESULTS

The Figure 3 presents the map of the different criteria.



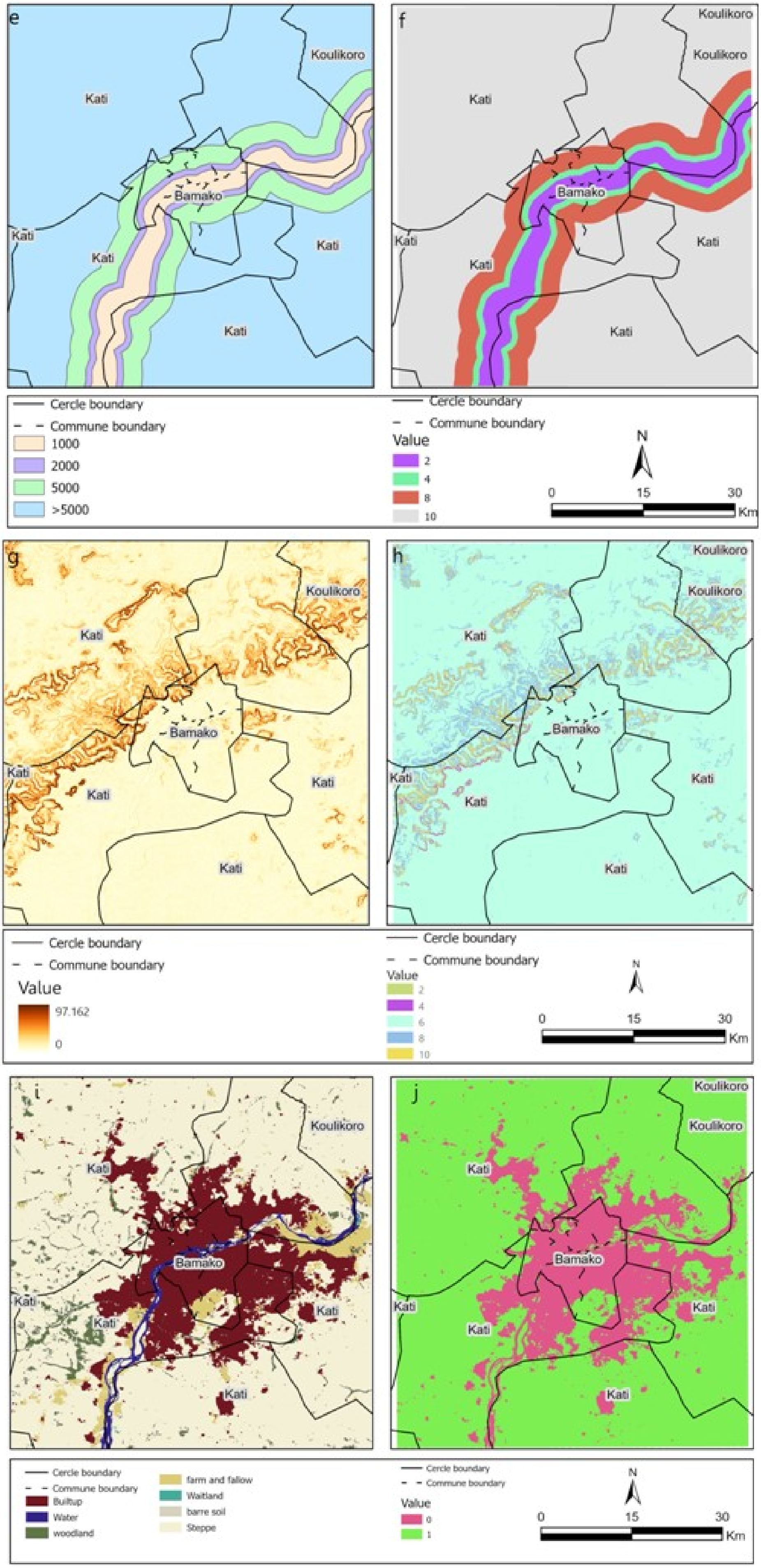


Figure 3. Input criteria: a geology, b Geological suitability c- river proximity d- river proximity suitability e- Water body proximity f- Water body proximity suitability g- slope h- slope suitability i- Land use and land cover j- land use and land cover suitability

Among the five criteria identified, four is factor (geology, proximity of road, proximity of water body, proximity of river and slope) and one is constraints (Land use and land use) the combination of all them using linear weighting combination, described in the methodology allow to identify the suitability area for waste deposal. The result of this analysis showed in Figure 3:

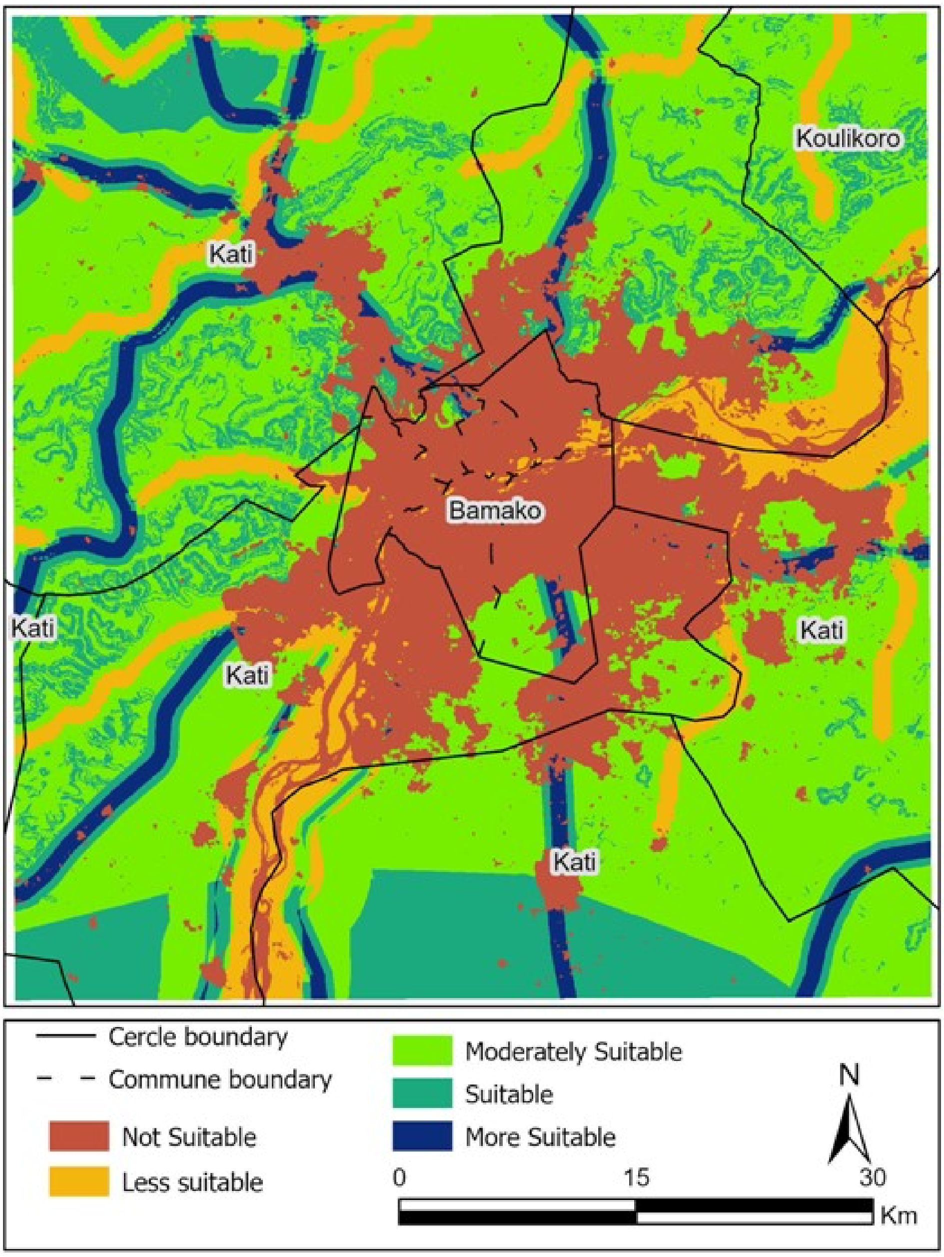


Figure 4. Waste deposal suitability map

This model excluded the area not suiTable for waste deposal in the base of constraints (Land use and land cover). The not suiTable areas are composed of the built-up area, the water body and wetland. These areas were excluded to avoid the water pollution and contamination, and to preserve the population living environment. This area represents 21 % of the study area. As for the less suiTable area, they represent about 9% of the study area, the moderate suiTable 46 %, the suiTable 18 % and the more suiTable are a 4 %.

DISCUSSION

This study is a significant contribution in identification of suiTable area for waste deposal at Bamako. GIS and multicriteria analysis are very useful, because this ability to quantify, weighting and combine all of the factors indispensables for environmental protection (surface water, groundwater residential area and wetland contamination) rentability and accessibility of waste collection operation (proximity to road). The importance of this model is testified through the works (Paul et Gosh, 2022Ali Shah *et al*, 2019.) on solid waste dumping. The same model was also used for landslide susceptibility mapping (Feizizadeh *et al*, 2012), suitability analysis for maize production (Chabi adimi *et al*, 2018).

Competing interests: The authors declare that they have no competing interests

CONCLUSION

This study carries out the suitability area for waste deposit using GIS and multicriteria evaluation based on AHP.
The criteria used take in count the living environment, the surface and groundwater protection and the accessibility through the road network and slope.

REFERENCES

Ali Shah S., Abbas Musvi S. Y., Tameez A.; Alam M., Nawaz A. 2019. Analyzing site suitability for solid waste disposal through GIS multi-criteria decision-making hierarchy process. DOI: http://dx.doi.org/10.17993/3 ctecno.2019. specialissue.07

Chabi Adimi O. S., Oloukoi J., Tohozin C. A. B. 2018. Analyse spatiale multicritère et identification des sols propices à la production du maïs à Ouessè au Bénin, pp. 1-18. Journals.openedition.org/vertigo/19885

Estoque R. C. 2011. GIS-based Multi-Criteria Décision Analysis (in Natural Resource Management), Note de cours, Université de Tsukuba, 24 p.

Feizizadeh B., Blaschke T. et Nazmfar H. 2012. GIS-based ordered weighted averaging and Dempster–Shafer methods for landslide susceptibility mapping in the Urmia Lake Basin, Iran. International Journal of Digital Earth, 7:8, 688-708, DOI: 10.1080/17538947.2012.749950

Jiang H, Eastman JR. 2000. Application of fuzzy measures in multi-criteria evaluation in GIS. *International Journal of Geographical Information Science*, **2**(14): 173-184.

Ouattara I., Diya A., Y Diarra Y., Dembélé O. et Konaté A. 2021. Acteurs et stratégies de gestion des déchets solides ménagers à Bamako. Revue Africaine des Sciences Sociales et de la Sante Publique, Volume (3) N 2 ISSN : 1987-071X e-ISSN 1987-1023.

Paul S. et Ghosh S. 2022. Identification of solid waste dumping site suitability of Kolkata Metropolitan Area using Fuzzy-AHP model. Cleaner Logistics and Supply Chain 3 (2022) 100030

Saaty T. L. 2008. Decision Making with the Analytic Hierarchy Process. International Journal of Services Sciences, 1: 83-98. DOI: 10.1504/IJSSCI.2008.017590

Saaty TL. 1980. The Analytic Hierarchy *Process, Planning, Priority Setting, Resource Allocation*. McGraw-Hill: New York.

Sener S., Sener E., Karagüzel R. 2011. Solid waste disposal site selection with GIS andAHP methodology: A case study in Senirkent-Uluborlu (Isparta) Basin. Turkey.Environ. Monit. Assess. 173 (1-4), 533–554.

Sener S., Sener E., Nas B., Karagüzel R. 2010. Combining AHP with GIS for landfill site selection: A case study in the Lake Beys¸ehir catchment area (Konya, Turkey). Waste Manag. 30 (11), 20372046.

****