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Sustainable Land Resources Management Using Goal Programming MCDA Model: Evidence from Best Practices in Natural Resources Management

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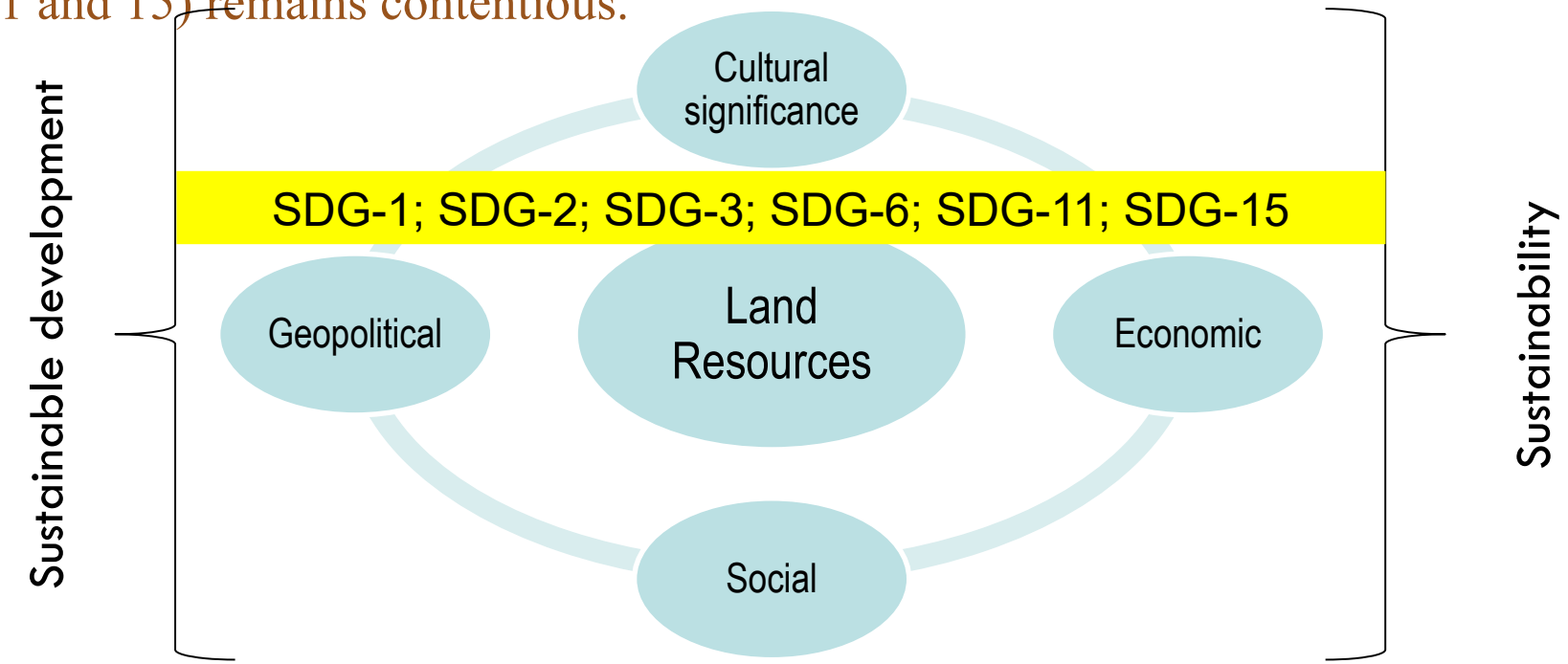
Presentation Outline

- Introduction
- Goal programming
- Research methodology
- Results and Discussion
- Conclusion and Limitations

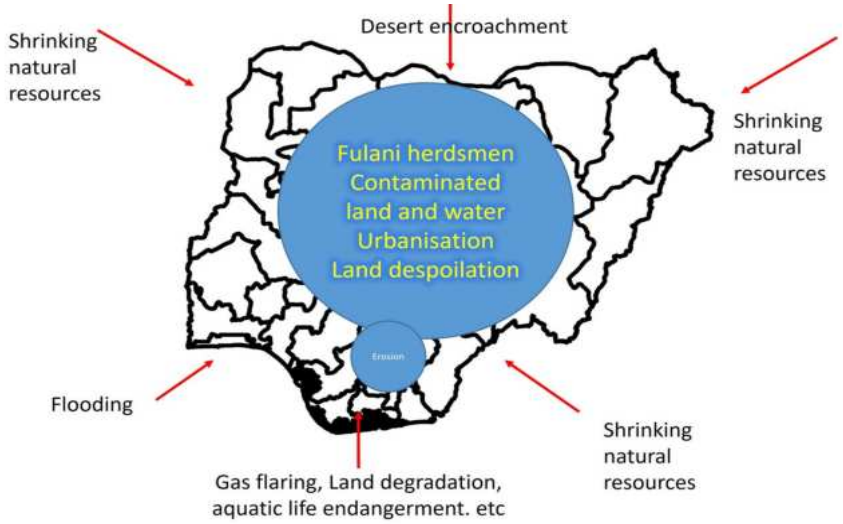
Introduction

- Land resources representation in the context of sustainability and sustainable development (specifically the SDGs 1, 2, 3, 6, 11 and 15) remains contentious.



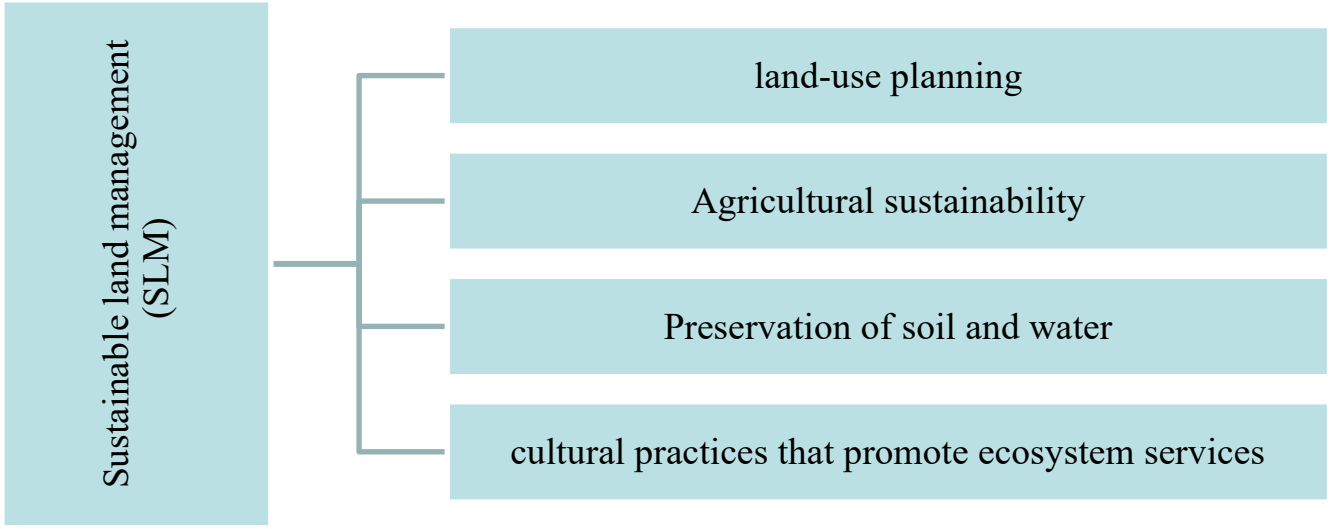
Introduction

- In developing countries such as Nigeria, land resources face an army of dire and refractory threats including land degradation, uncontrolled anthropogenic activities, and land ownership tussles.



Introduction

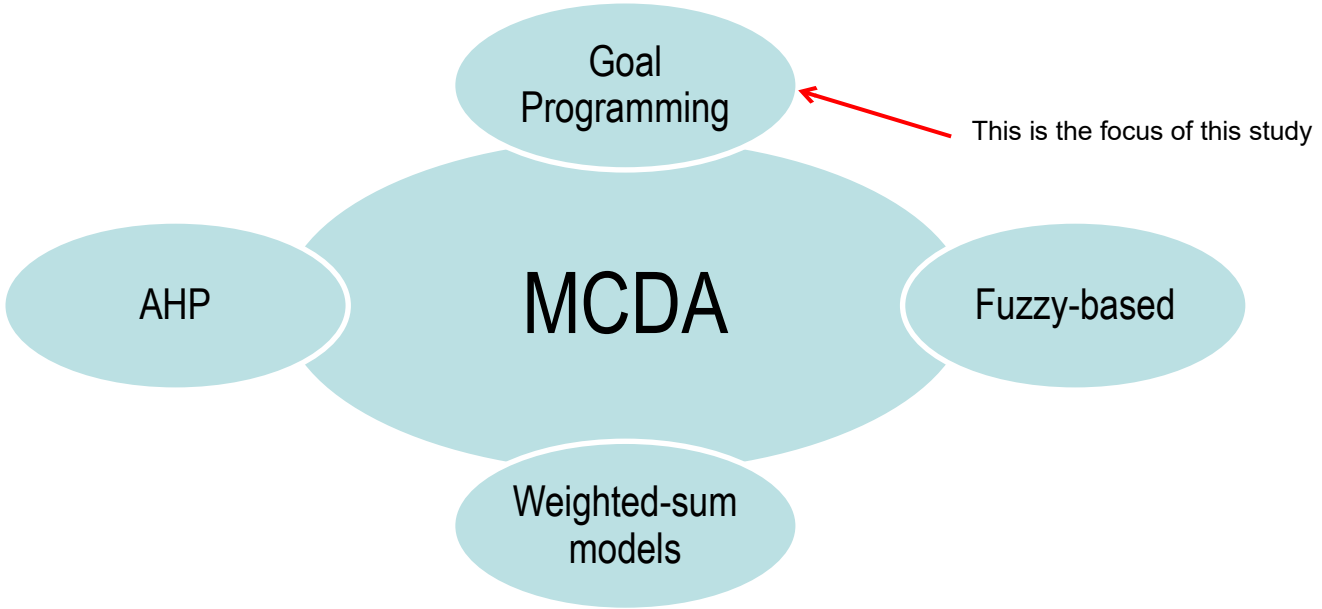
- Sustainable land management (SLM) is a major approach for assuaging land degradation. This encompasses land-use planning, agricultural sustainability, preservation of soil and water, and cultural practices that promote ecosystem services (Maisharou et al., 2015; Haregeweyn et al., 2023).



The UN's FAO defined SLM as "the use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions".

Introduction

- An MCDA (Multi-criteria decision analysis) tool can foster a more realistic SLM approach. Examples include fuzzy-based techniques, weighted-sum models, AHP, TOPSIS, Goal programming.



Study's aim and objectives

The main aim of this study is to describe an MCDA tool which can foster a more realistic SLM approach.

The objectives are:

- To describe the *Goal Programming* model, existing methods, and applications in SLM.

- To investigate how *Goal Programming* has been used to stimulate SLM in the focus areas in which SLM is being widely practiced.

Research Methodology

- The study's objectives are tailored towards a treatise on the applications of GP for SLM.
- The study is much of a theoretical discussion and draws extensively from evidence in the literature of natural resources management, to critically examine how the use of GP will impact positively on the overall ideology of SLM.

GOAL PROGRAMMING – Background

- *Goal Programming* was originally employed by Charnes *et al*. (1955) in a series of optimal estimation studies, although the first published volume in which it was mentioned is credited to Charnes & Cooper (1961).

- It is a multi-objective and multi-criteria decision tool which was developed and first applied in the 1950s.

- It is used to solve problems involving multiple criteria, multiple variables and with priorities which must not be overcome by decision maker's instincts and biases.

- The true value of *Goal Programming* lies in its contribution to the solution of decision problems involving multiple and conflicting objectives and criteria

GOAL PROGRAMMING – Mathematical formulation

(1)

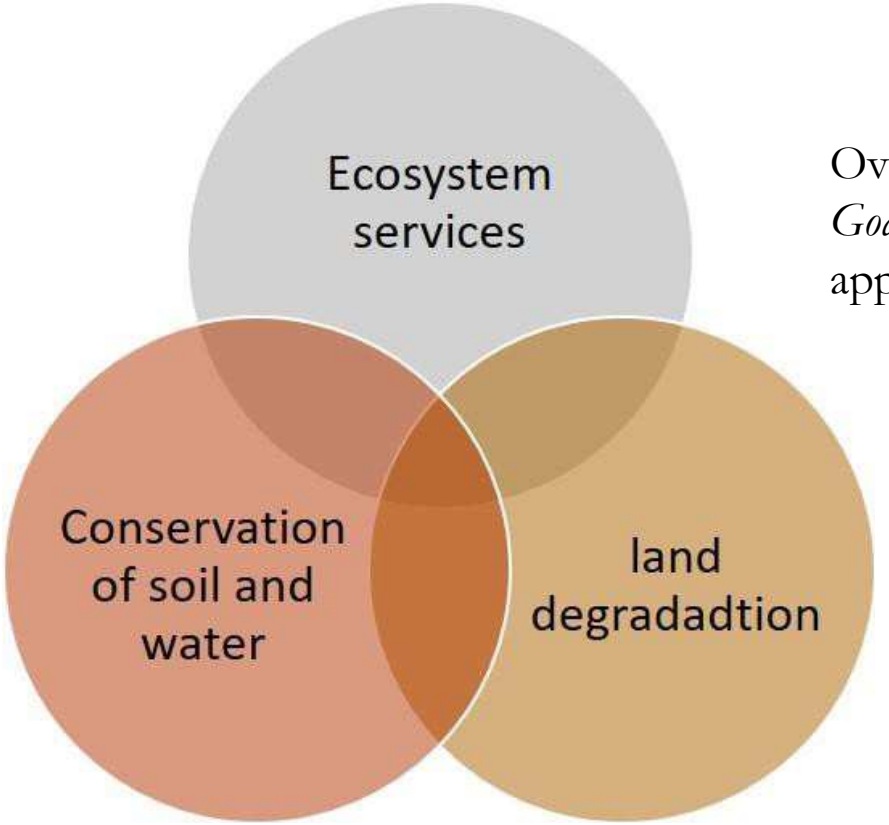
For $k = 1..., K; i = 1, ... L$

where there are N goals, and i is the index of constraints index, k is the priority rank index, and l is the index of the deviation variables within priority rank. In the objective function, Z is the summation of all deviations, the w kl are optional mathematical weights used to differentiate deviation variables within a kth. $di-$ = negative deviational variable from the *i*th goal, $di+$ = positive deviational variable from the *i*th goal

GOAL PROGRAMMING – Applications

S/No	Study	Goal programming model formulated	Land Use Planning	Agricultural Sustainability	Water and soil	Land degradation mitigation	Ecosystem services
1.	Srivastava & Singh (2017)	Weighted goal programming model		✓			
2.	Felix *et al.* (2019)	priority based fuzzy goal programming model.	✓				
3.	Nechi *et al.* (2020)	Coupled goal programming and satisfaction function	✓				
4.	Phinyoyang & Ongsomwang (2021)	Regional composite indicator, based on goal programming		✓			
5.	Najafabadi *et al.* (2023)	Designed a new interval meta-goal programming		✓			
6.	Joolaie *et al.* (2017)	Fuzzy multi-objective goal programming		✓			
7.	Musa (2021)	Integrated goal programming and demand function			✓		
8.	Petridis *et al.* (2018)	Weighted goal programming mixed-integer linear programming (WGP MILP)					✓
9.	Gosling *et al.* (2020)	Linear goal programming model				✓	
10.	Ren *et al.* (2018)	Multiobjective stochastic fractional goal programming model			✓		
11.	Bakhtavar *et al.* (2023)	Fuzzy cognitive-based goal programming					✓
12.	Xavier *et al.* (2018)	Coupled ecosystem services and regional composite indicator		✓			
13.	Corrigan & Nieuwenhuis (2016).	The biophysical linear goal programming model					✓
14.	Etemad *et al.* (2019)	Goal programming and fuzzy analytic hierarchy process					✓
15.	Kamaludin *et al.* (2021)	Multiple objective linear goal programming		✓			
16.	Ma & Zhao (2015).	multi-objective artificial immune optimization model	✓				
17.	Jana *et al.* (2016)	A hybrid probabilistic fuzzy goal programming approach		✓			
18.	Zhou *et al.* (2016)	Multilevel factorial fractional goal programming			✓		
19.	Aldea *et al.*, (2014)	Participatory goal programming					✓
20	Bagdon *et al.* (2016)	Simulation modelling with goal-programming					✓
21.	Sacchelli & Bernetti. (2019)	Multi-objective analysis and metaheuristic approach					✓
22	Zheng *et al.* (2017)	3-level multichoice goal programming					✓
23	Elliot *et al.* (2019)	A combined multi-objective integer goal programming and LULC performance scores					✓
24	Qu *et al.* (2019)	Weighted goal programming models			✓		
25	Groot *et al.* (2018)	Pareto-based multi-objective programming approach					✓

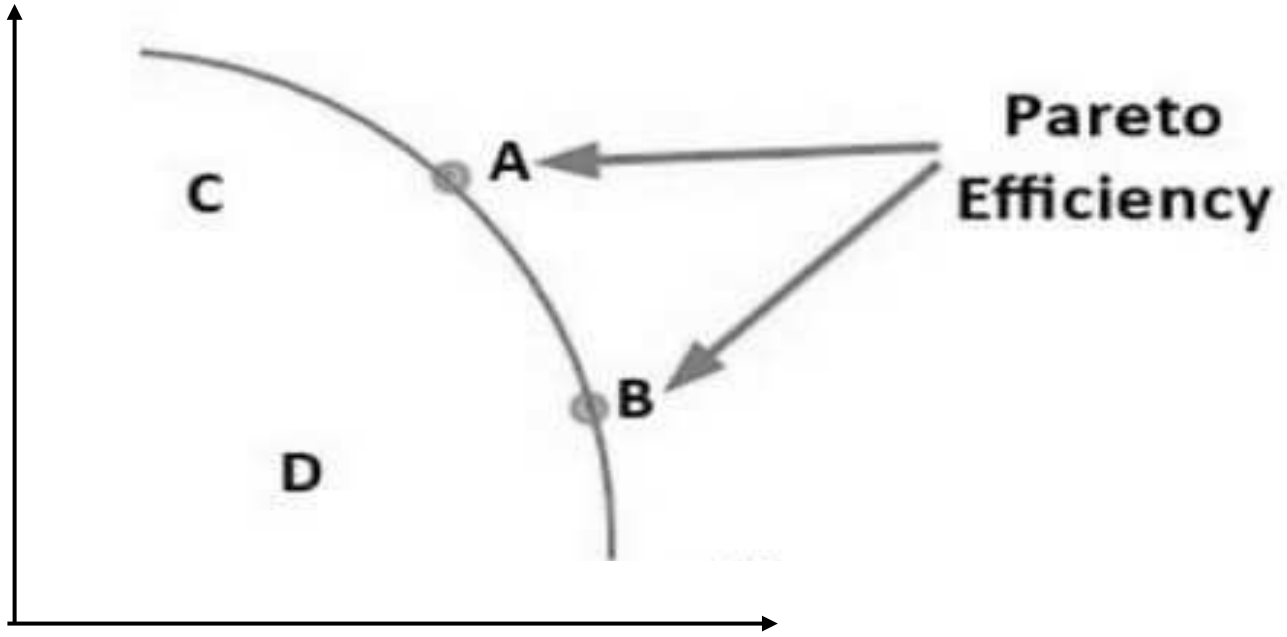
GOAL PROGRAMMING – Applications



Overlapping areas in *Goal Programming* applications

GOAL PROGRAMMING – Limitations

"Solutions are not *Pareto efficient*"



Conclusion and study limitation

- Land resources suffer a major threat that requires a sustainable approach to manage their assets.
- Sustainable land resource management guarantees the optimal use of land resources while *simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions,*,
- Multi-criteria decision analyses are being deployed for effective SLM, and of all the existing model goal programming, holds significant value to achieve the objectives of SLM.
- Goal programming takes the form of a linear programming function that limits bias and inconsistencies in driving a basis for multichoice and multi-decision problems such as SLM.
- The absence of realistic implementation is a major limitation of the present study.

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