WASCAL
West African Science Service Center on Climate Change and Adapted Land Use

# A stakeholder-based approach for assessing agricultural land use scenarios on Ecosystem Services in Northern Ghana


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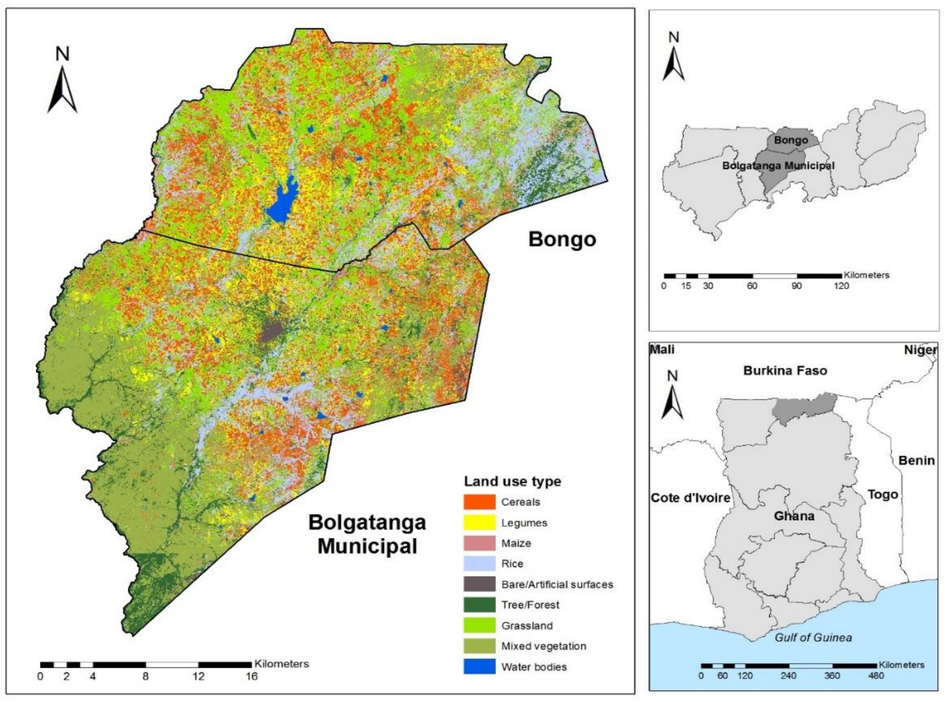
## Background

Increasing climate variability combined with land pressures due to population growth threatens the capacity of social-ecological systems in supplying sufficient ecosystem services in Northern Ghana.




## Objective

This study aims to suggest a stakeholder-based assessment framework for estimating the potential capacity of land use scenarios in supplying regionally relevant ecosystem services in Northern Ghana.

* Stakeholder : Agricultural Extension Agents (Agricultural field officers), Bolgatanga-15, Bongo-11

## Methods

### ✓ Ecosystem services perceived importantly by stakeholders

| Ecosystem services | Proxy | Criteria/indicators |
|---|---|---|
| Food | Benefits of agricultural land use related to food | Proportion of land use products consumed as food by households [%] |
| Fodder | Benefits of agricultural land use related to fodder | Proportion of land use products used for animal feed [%] |
| Energy | Benefits of agricultural land use related to energy | Proportion of land use products used for fuel [%] |
| Construction material | Benefits of agricultural land use related to construction materials | Proportion of land use products used for construction purposes (roofs, pillars) [%] |
| Market value | Benefits of agricultural land use related to market value | Proportion of land use products sold on the market for income [%] |
| Water | Water volumes that flow into water bodies | Potential water yields determined by subtracting evapotranspiration from precipitation [$\mathrm{mm\ cell^{-1} yr^{-1}}$] |
| Erosion control | Surface run-off prevention | Potential soil erosion level according to the RUSLE model [$\mathrm{t\ cell^{-1} yr^{-1}}$] |

### ✓ Scenario matrix

| | Name | Description |
|---|---|---|
| **Crop intercropping** | | |
| 1 | Cereal intercropping | Conversion of cereal fields into cereal-legume intercropping fields |
| 2 | Maize intercropping | Conversion of maize fields into maize-legume intercropping fields |
| 3 | Legume intercropping | Conversion of legume fields into legume-cereal/maize intercropping fields |
| **Afforestation and agroforestry** | | |
| 4 | Grassland afforestation | Conversion of grassland into forest |
| 5 | Mixed vegetation afforestation | Conversion of mixed vegetation into forest |
| 6 | Intercropping with fruit trees | Introduction of Mango trees into cereal fields |
| 7 | | Introduction of Mango trees into maize fields |
| 8 | | Introduction of Mango trees into legume field |
| 9 | Intercropping with fodder trees | Introduction of Leucaena to cereal fields |
| 10 | | Introduction of Leucaena to maize fields |
| 11 | | Introduction of Leucaena to legume field |
| **Soil conservation** | | |
| 12 | Stone and soil bunding | Introduction of bunds to cereal fields with the possibility of soil loss |
| 13 | | Introduction of bunds to maize fields with the possibility of soil loss |
| 14 | Wind break | Establishment of wind break though planting trees in cereal fields |
| 15 | | Establishment of wind break though planting trees in maize fields |

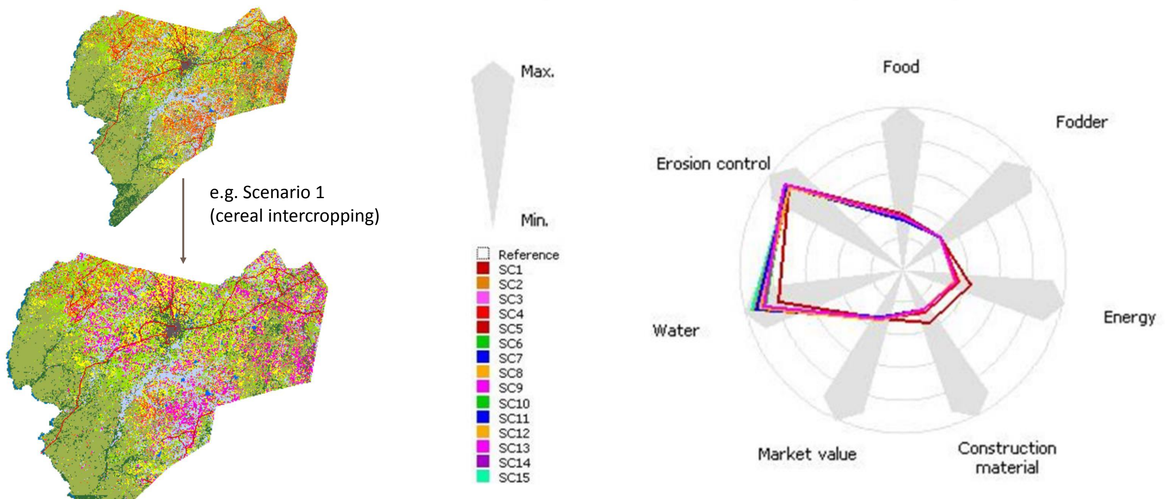
| ES ↔ ES | Food | Fodder | Energy | Construction material | Market value | Water | Erosion control |
|---|---|---|---|---|---|---|---|
| Food | ▪ | 1,2,6,7,12,13,14,15 | 3,4,5,9,10,12,13,14,15 | 3,4,5,8,9,10,12,13,14,15 | 1,2,3,5,8,9,10,11,12,13,14,15 | 9,10,11 | 1,2,3,4,5,6,7,8,12,13,14,15 |
| Fodder | 3,5,8,9,10,11 | ▪ | 12,13,14,15 | 12,13,14,15 | 2,12,13,14,15 | 3,4,5,6,7,8 | 1,2,9,10,11,12,13,14,15 |
| Energy | 1,2,5,6,7 | 1,2,3,4,5,6,7,8,9,10, | ▪ | 3,4,5,8,9,10,12,13,14,15 | 3,4,5,8,9,10,12,13,14,15 | 1,2,6,7,9,10 | 3,4,5,8,12,13,14,15 |
| Construction material | 1,2,5,6,7 | 1,2,3,4,5,6,7,8,9,10 | 6,7 | ▪ | 3,4,5,6,7,8,9,10,12,13,14,15 | 1,2,9,10 | 3,4,5,6,7,8,12,13,14,15 |
| Market value | 3,4 | 3,4,5,6,7,8,9,10,11 | 1,2,6,7 | 1,2 | ▪ | 9,10,11 | 1,2,3,4,5,6,7,8 |
| Water | 1,2,3,4,5,6,7,8,12,13,14,15 | 1,2,9,10,11,12,13,14,15 | 3,4,5,8,12,13,14,15 | 3,4,5,6,7,8,12,13,14,15 | 1,2,3,4,5,6,7,8,12,13,14,15 | ▪ | |
| Erosion control | 6,7,9,10,11 | 3,4,5,6,7,8 | 1,2,6,7,9,10 | 1,2,9,10 | 1,9,10,11 | 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15 | ▪ |

Synergy

Trade-off

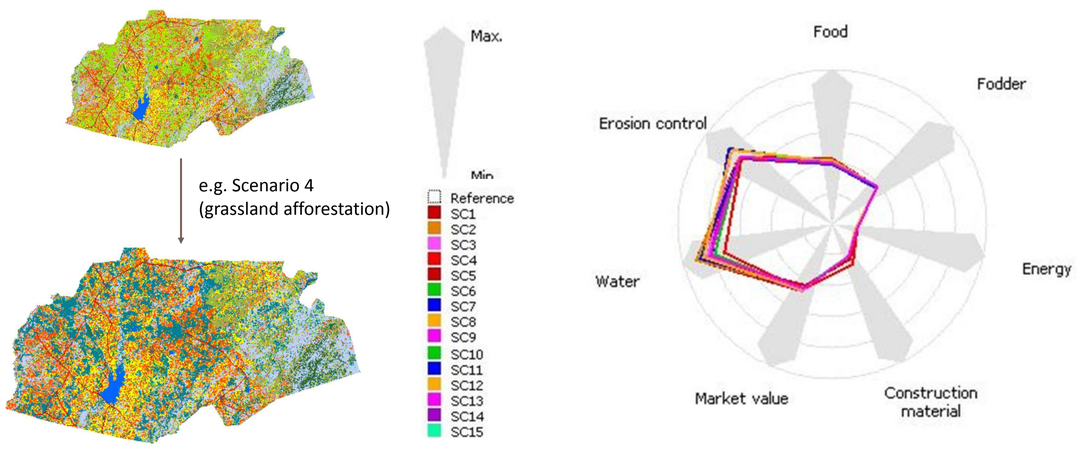
## Results and conclusion

### ✓ Scenario assessment using GISCAME in Bolgatanga




| | Land use class | Food | Fodder | Energy | Construction material | Market value | Water | Erosion control |
|---|---|---|---|---|---|---|---|---|
| | Initial | 30 | 31 | 33 | 27 | 32 | 95 | 85 |
| SC1 | Cereal intercropping | 34 | 31 | 34 | 27 | 33 | 90 | 88 |
| SC2 | Maize intercropping | 31 | 31 | 33 | 27 | 33 | 94 | 86 |
| SC3 | Legume intercropping | 33 | 31 | 33 | 27 | 34 | 91 | 85 |
| SC4 | Grassland afforestation | 31 | 31 | 35 | 29 | 33 | 88 | 85 |
| SC5 | Mixed vegetation afforestation | 33 | 31 | 43 | 36 | 33 | 78 | 85 |
| SC6 | Cereal+mango | 30 | 31 | 34 | 27 | 33 | 86 | 87 |
| SC7 | Maize+mango | 30 | 31 | 33 | 27 | 32 | 93 | 86 |
| SC8 | Legume+mango | 32 | 31 | 33 | 27 | 34 | 89 | 85 |
| SC9 | Cereal+leucaena | 32 | 31 | 34 | 27 | 33 | 87 | 88 |
| SC10 | Maize+leucaena | 31 | 31 | 33 | 27 | 32 | 94 | 86 |
| SC11 | Legume+leucaena | 31 | 31 | 33 | 27 | 34 | 89 | 86 |
| SC12 | Cereal+bunding | 33 | 31 | 34 | 27 | 33 | 91 | 87 |
| SC13 | Maize+bunding | 31 | 31 | 33 | 27 | 32 | 95 | 86 |
| SC14 | Cereal+windbreak | 32 | 31 | 34 | 27 | 33 | 92 | 87 |
| SC15 | Maize+windbreak | 31 | 31 | 33 | 27 | 32 | 95 | 86 |

### ✓ Scenario assessment using GISCAME in Bongo




| | Land use class | Food | Fodder | Energy | Construction material | Market value | Water | Erosion control |
|---|---|---|---|---|---|---|---|---|
| | Initial | 38 | 36 | 15 | 24 | 44 | 90 | 72 |
| SC1 | Cereal intercropping | 42 | 37 | 15 | 24 | 47 | 90 | 74 |
| SC2 | Maize intercropping | 38 | 36 | 15 | 24 | 45 | 90 | 73 |
| SC3 | Legume intercropping | 40 | 36 | 15 | 24 | 47 | 83 | 80 |
| SC4 | Grassland afforestation | 38 | 37 | 16 | 30 | 46 | 72 | 72 |
| SC5 | Mixed vegetation afforestation | 38 | 37 | 16 | 25 | 44 | 87 | 72 |
| SC6 | Cereal+mango | 40 | 36 | 15 | 24 | 46 | 78 | 73 |
| SC7 | Maize+mango | 38 | 36 | 15 | 24 | 45 | 87 | 73 |
| SC8 | Legume+mango | 40 | 37 | 15 | 24 | 46 | 85 | 80 |
| SC9 | Cereal+leucaena | 39 | 37 | 16 | 24 | 45 | 81 | 73 |
| SC10 | Maize+leucaena | 38 | 36 | 15 | 24 | 44 | 88 | 73 |
| SC11 | Legume+leucaena | 39 | 37 | 15 | 24 | 46 | 80 | 82 |
| SC12 | Cereal+bunding | 41 | 37 | 16 | 24 | 46 | 83 | 74 |
| SC13 | Maize+bunding | 38 | 36 | 15 | 24 | 44 | 89 | 73 |
| SC14 | Cereal+windbreak | 40 | 37 | 16 | 24 | 45 | 83 | 73 |
| SC15 | Maize+windbreak | 38 | 36 | 15 | 24 | 44 | 89 | 73 |

**→ Enhance applicability of assessing multiple ES via participation of stakeholders in actual agricultural land use and implementation**

**→ Identify effects of potential land use scenarios by considering trade-offs and synergies between ES**

**→ Suggest land use alternatives for the future based on comparison of benefits and risks between scenarios on ES**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