Identification of potential rain water harvesting areas in the Central Rift Valley of Ethiopia using a GIS-based approach

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Introduction

Background

- Ethiopia is located in the Horn of Africa
- 80 million population
- Agriculture is the backbone the economy
  - 60% of the GDP
  - 88% export earnings
  - majority of the employment
- well-endowed with water resources
  - Annual runoff = 110 billion m³
  - Groundwater = 2.6 billion m³
    - supports a far greater number of people
- Current use of this huge resource is very limited.
- Rainfed agriculture is still the backbone of the country’s economy and rural livelihoods
Problem statement

- Crop production in CRV - rainfed conditions
  - Major part of this crop production is in semi-arid areas
    - Low crop production and food insecurity
- To increase crop yields and improve food security
  - Effective planning and development of water resources
- The Ethiopian government together with NGO = RWH
- The implementation has been confined with a range of problems and its adoption is low
- Lack of scientific information to properly allocate and plan RWH interventions.
- Based on ad-hoc basis without much knowledge about the location-specific conditions
- A more systematic approach is required to the selection of feasible sites for RWH interventions
Ground survey is the best technique to identify suitable areas for RWH in relatively small areas. However, for larger areas like the CRV, ground survey is difficult, costly, and time-consuming. The application of GIS can be helpful for a first screening and identification of areas potentially suitable for RWH. However, the application of GIS for the identification of RWH potential areas in Ethiopia is almost not existing and there is no documented work. GIS is a powerful set of tools used to collect, store, retrieve, transform, and display spatial data from the real world for a particular purpose.
Objectives

- To identify potential areas for different types of rainwater harvesting in the entire CRV
- To identify and evaluate qualitatively selected existing rainwater harvesting interventions in the CRV
Material and methods

Study area

- The CRV - 38°00’-39°30’ E - 7°00’-8°30’
- 150 km southeast of the Addis Ababa
- Area - 1 million ha
- Population = 1.5 million
- Annual rainfall in CRV 600 mm -1250 mm
  - Variable in space and time
- About 70% of the rainfall precipitates in the short rainy season (July to September).
- Rainfed agriculture
Identifying and assessing existing RWH structures

- An inventory of the existing RWH interventions was conducted
  - review of the literatures
  - interviews with key stakeholders
  - field survey of RWH farmers

- The field survey focused on
  - type of RWH practiced
  - farmers’ experiences and constraints
  - duration of water storage, water uses and application methods

- The information generated from the survey helped to identify
  - bottlenecks and successes of RWH interventions
  - the type of RWH for which the suitability maps were developed
  - to fine tune the methodology and validate the derived suitability map
Methodology of RWH potential area mapping

- The identification of suitable areas for RWH is a multi-objective and multi-criteria problem
  - The objective is to map potential areas
    - Pond
    - *In-situ* RWH
  - Suitability criteria for ponds and *in-situ* were identified and selected
    - Based on
      - Literature review
      - Information from filed survey
      - Expert judgment
Flow chart In suitability model

Soil texture
- Clip & Re-projection
  - Soil textural map
    - Reclassification

Soil depth
- Clip & Re-projection
  - Soil depth map
    - Reclassification

DEM
- Clip & Re-projection
  - Surface analysis
    - Slope map
      - Reclassification

Rainfall
- Interpolation
  - Rainfall map
    - Reclassification
    - Rainfall surplus map
      - Reclassification

ETo point data
- Interpolation
  - ETo map
    - Land use/cover
      - Land cover map
        - Reclassification

Land use/cover
- Clip & Re-projection
  - ETo point data
    - Minus
      - Minus

Hydrology map
- Digitizing
  - Clip & Re-projection
    - Groundwater depth map
      - Reclassification

Potential suitable areas
- Overlay
Results

Survey result

- RWH practiced
  - ponds
  - concrete tanks
  - Community ponds

- Use of harvested water
  - drinking water for animals
  - watering vegetable
  - watering trees
  - washing cloths
  - cooking
  - making mud blocks
  - raising pepper seedling
Current situation

- Most of the observed RWH were not performing satisfactorily
  - high water losses
  - improper siting of the ponds
  - improper design
  - ponds and tanks were not repaired and maintained
  - Roofs and plastic sheets were stolen
  - Roofs and plastic sheets used for other purposes
  - ponds were left unprotected
Identification of potential RWH areas

- **Criteria selection**
  - Six -> pond
  - five -> *in-situ*

- **Weights**

- **Criteria maps**

<table>
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<th>No.</th>
<th>Criteria</th>
<th>Weights (%)</th>
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<td>2</td>
<td>Soil depth</td>
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<td>3</td>
<td>Rainfall surplus</td>
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<td>6</td>
<td>Land cover</td>
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<tr>
<td></td>
<td>Sum</td>
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</tbody>
</table>
Eastern and western part of the study area is in very high and high suitability category.

The central and northern part is mostly moderate suitable.

The northwestern and some central part has a low suitability.
- high suitability occurred in most part of the study area

- The northern and southern part is mostly moderately suitable

- The central part has a low suitability at few places.
Suitability vs Woreda area and land cover

Ponds
- Degeluna Tijo, Tiyo, Munessa, Limuna Bilbilo

In-situ
- Degeluna Tijo, Ziway Dugda
- Adami Tulu Jido Kom. Tiyo

Land cover

Highest suitability in cultivated areas for both ponds and in-situ
Validation

- From the proximity analysis result
  - 53% of the exiting surveyed RWH structures were within the moderately suitable areas
  - 43% are low suitable
  - 3% are with highly suitable areas.

- The validation results showed
  - The database
  - The methodology
  - The suitability levels for the criteria
  - The criteria’s relative importance weights have given good results.
Conclusions and recommendations

- The major problems of the existing RWH
  - improper site selection during implementation such as locating ponds in areas with less suitable soils
  - improper design
    - only one type of tanks and ponds are constructed everywhere
  - lack of farmer involvement during the planning and implementation
  - lack of materials like plastic sheet to reduce seepage in ponds
  - lack of maintenance
- But the RWH technology by itself may be the suitable
  - Bottleneck is the planning, implementation and management
    - Improving the implementation process may improve the performance in the future
The suitability model used a MCE process that combined different biophysical factors. However, socioeconomic factors—market access, Infrastructure, and population density—were not considered due to lack of readily available data for this large area.

It is therefore recommended to include such socio-economic factors in future studies to improve the suitability assessment.

GIS =>
- flexible
- time-saving
- cost-effective tool to screen RWH suitability in larger area like CRV
The suitability maps provide an easy to understand source of information to quickly identify areas that are more promising for RWH intervention. The information is helpful for decision-makers and planners.

It is recommended however that one should be careful in the interpretation of the generated information. Actual RWH implementation should always be supported by a field survey.

Apart from this, on-the-ground work is also needed for getting the socio-institutional setting of the areas.
Thank you