AFRICA TO ASIA: TESTING ADAPTATION IN FLOOD-BASED RESOURCE MANAGEMENT PROJECT
CURRICULUM REVIEW AND IMPROVEMENT WORKSHOP
24 to 28 February, 2020; Wad Medani and Kassala, The Sudan
FBLN – Yemen Chapter Participation
Dr. sharafaddin Abdullah Ahmed Saleh (FBLN – Yemen – Team leader
And Dr. Abraham Mahari)
Evaluating the potential of road rain water harvesting in Yemen– Rural Roads

A case study: A case study of the Maghrabah Manakah Bab Bahil Road, Sana'a Governorate

Study by:
Mohamed Abdullah Al-Abyadh (mabyadh@yahoo.com)
B.Sc in Civil Engineering
1st Supervisor: Dr. SharafAddin Abdullah Ahmed Saleh
2nd Supervisor: Dr. Abdullah Ahmed Maswari

Water and Environment Center (WEC)
Sana’a University 2015
Water scarcity, limited water resource and climate change is the main problems facing Yemeni farmers.

The challenge is how best to control and manage the replenishment and depletion of groundwater resources by improving water harvesting and raise the efficiency in water use.

Some of Yemen roads were located in mountainous rural areas; which had an adapted design for each environment - In Yemen surface water is estimated to be about 1,500 Mm3/year - Meanwhile, some roads is prone to severe damages and soil erosion as a result of floods events throughout the country in rainy season.

Manakha area as many of Yemen areas face recurrent droughts, and lack of green cover, where rainwater is the sole source of water, which exist annually in two seasons summer and autumn with an average of 400 mm, RRWH is not considered by road engineers during the design, construction and O&M
Main Objectives
Optimize the benefits of water harvesting from roads for the local communities in socio-economic development and for the environment protection focusing on the rural road (Maghrabah Manakah Bab Bahil Road and the linked road Jabal Ekbari and Jabal Awi Road Sana'a Governorate)

SUB-objectives
- To suggest alternative solutions in geometric road designs to manage water from roads due to Integrated Water & Roads Management.
- To induce the awareness of roads engineers on the importance of Integrated Water & Roads Management.
Methodology

1- Reconnaissance survey of RRWH structures
2- Stakeholders Interviews
3- Road Engineers Questionnaire
4- Data Analysis and Calculating the Potential RRWH
5- Literature Review
Field Work

1- Water Structures

- Bridges
- Culverts
- Side Ditches and Side Spillways
- Water Management Structures
- Mis-Improvement and Maintenance of Water Structures
2. Water Harvesting potential from Roads

- Water Harvesting from Side Ditches to Pond
- Water harvesting from culverts using earthen canal to the farm
- Water harvesting from culverts to the farm directly
- Water harvesting from road side shoulders and surface
Study Area and Study Road Sections
4.2 - Culverts location along the main study road

<table>
<thead>
<tr>
<th>No.</th>
<th>Sub-Catchment Category</th>
<th>Sub-Catchment Area (Km²)</th>
<th>Sub-Catchment Catchment Area (Km²)</th>
<th>Percentage of (2) from (1)</th>
<th>No. of Culverts</th>
<th>Culvert Type</th>
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<td>18.38%</td>
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</table>
4.3 - Main Road Natural Catchments Area

The road natural catchment area is 9,85 km² it represent a 18.38 % percent of the total study watershed sub catchments area which is 53.58 km².
Results
1- Reconnaissance survey of Road Rainwater Harvesting structures
Results

1- Reconnaissance survey of Road Rainwater Harvesting structures

<table>
<thead>
<tr>
<th>Item</th>
<th>Main Road</th>
<th>Sub-Road</th>
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</thead>
<tbody>
<tr>
<td>Open Tanks Ponds</td>
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<td>12</td>
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<tr>
<td>Roofed Tanks</td>
<td>14</td>
<td>21</td>
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<tr>
<td>Under Construction Tanks</td>
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<td>3</td>
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<tr>
<td>Cisterns</td>
<td>2</td>
<td>19</td>
</tr>
<tr>
<td>Under Construction Cisterns</td>
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<td>2</td>
</tr>
<tr>
<td>Total RRWH Structures</td>
<td>33</td>
<td>57</td>
</tr>
</tbody>
</table>
Results
Results
Results

2- Stakeholders Interviews Analysis
RRWH Techniques

- Humps: 47%
- Humps & Channels: 5%
- Side Ditch: 5%
- Side Ditch & Humps: 5%
- Side Ditch, Humps, Spillways and Channels: 5%
- Humps & Culverts: 5%
- Humps & Spillways: 5%
- None: 9%
Conclusions

- The estimated potential RRWH quantity from the main road surface is 60,769.8 m$^3$ for 36 km length and 10 m width, while the potential RRWH which generated from the road natural catchment is (9.85 Km$^2$) 1,662,729.25 m$^3$.

- The RRWH locations were observed at the culverts outlets, humps (rolling dips), channels, spillways, cascade steps and at the inner side of the road.

- The culverts catchment and outlets type vary according to the land use of the surrounding area, the landscape slope,. Moreover, the culverts catchment could be a sub-catchment, stream line, sub-stream or from the upper road section, while the culvert outlet could be a sub-catchment, stream line, sub-stream, road section, terraces, steep slope and tanks.
Conclusions

- All farmers consider rainwater running on the road their right.

- During road construction some claims raised by farmers such as: abandon water channels, water blockage, transmit sediments to farmlands, erosion, use of dynamite, road profile falling down farmland level and lack of communication with engineers.

- Several public and private tanks and ponds where used to harvest rainwater from road which need to give more attentions from locals in periodic maintenance for these structures.
Conclusions

- Engineers have practiced a number of possible drainage design procedures and consideration to the general road drainage structures such as culverts, ditches. However, the differences in road design are often forced by changes in geology & terrain, experience, use of typical drawings, lack of hydrologic and hydraulic studies, absence of integrated water resource approach, and cost restraint.

- More than half of Engineers response used typical drawings from MPWH in drainage structures.

- Some road geometric parameters such as vertical alignments, camber and (cross-slopes or superelevation), had effect on road drainage and consequence the rainwater harvesting system.

- Numbers of manuals mentioned the road rainwater harvesting in different ways and techniques, those ways and techniques should be generalized.
Recommendation

- Farmer’s initiatives should be encouraged and improved technically and institutionally, and also should be supported from government’s agencies and donor programs.

- The RRWH should be adapted by taking advantage of previous experience locally and across the World.

- Water rights along the road and in the downstream catchment should be considered to avoid social conflicts in case of RRWH.

- Capacity building for road engineers in integrating road design with RRWH.

- Social communication mechanism between engineers and stakeholders should be developed in all road projects in all phases.

- MPWH typical drawing should be updated and reviewed according to Yemen Hydrologic studies and RRWH integrated approach.
Recommendation

- Staged co-financed integrated approach (design and implementation) is suggested to cope with the cost factor (taking advantage of road construction equipment’s) to achieve the sustainable rainwater harvesting in the road vicinity.

- A Careful consideration of coordination and combination the horizontal and vertical alignments and drainage structures with reference to road catchment and natural drainage pattern which may be best indicated by:

  1. Contoured drawings of the required carriageway surface with water stream lines, culverts locations, land use map and potential RRWH locations.

  2. Details drawings of drainage structures (culverts, ditches, etc..) plan and profile especially when the cross section changed from cut to fill and at the outlet.

- Road drainage structures and protection works in roads should take in consideration rainwater harvesting, water rights, erosion control, environment sustainability and social and gender expectations.
Thank You for Your Attention