Water Conservation Zones in agricultural catchments for biomass production, food security and environmental protection

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Water Management Issues in Agriculture

• More than 2 billion people are currently living in areas affected by water stress throughout the world.

• Climate change further exacerbates this situation and affects water availability for agriculture.

• On-farm water conservation zones (farm ponds, wetlands and riparian areas) are important for saving water for crops.
Main objective: to assess and enhance ecosystem service provided by water conservation zones for optimizing water and nutrient storage, biomass production and food security in agricultural catchments

Specific objectives:
1. To optimize water and nutrient storage in water conservation zones for downstream irrigation use
2. To maximize the use of water conservation zones for crop production
3. To regulate water and nutrient cycling in water conservation zones to improve biomass production and downstream water quality
Member States Participated

Research Contracts
1. China
2. Estonia
3. Iran
4. Lesotho
5. Nigeria
6. Romania
7. Uganda
8. Tunisia

Technical Contracts
1. United Kingdom
2. United States of America

Research Agreement
1. France
2. United States of America
$^{18}$O and $^2$H measurements in water are used to identify sources of water to water conservation zones.

$^{15}$N is used to quantify denitrification and the sources of biomass N in water conservation zones.
RESULTS: Isotopic Signatures of different sources of water from April to September in China

<table>
<thead>
<tr>
<th>Water Isotope</th>
<th>Average Isotopic signature of water (‰)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Field (irrigation)</td>
</tr>
<tr>
<td>$^2$H</td>
<td>-79.6</td>
</tr>
<tr>
<td>$^{18}$O</td>
<td>-10.9</td>
</tr>
</tbody>
</table>

Wetland receive water mainly from runoff and rainfall.
18O and 2H signatures TDS of different sources of water during rainy season in China

<table>
<thead>
<tr>
<th>Property</th>
<th>Ground water</th>
<th>Surface water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Well</td>
<td>Field</td>
</tr>
<tr>
<td>Sample Nos</td>
<td>29</td>
<td>8</td>
</tr>
<tr>
<td>δ2H (‰)</td>
<td>-92.5</td>
<td>-79.6</td>
</tr>
<tr>
<td>δ18O (‰)</td>
<td>-12.5</td>
<td>-10.9</td>
</tr>
<tr>
<td>TDS (mg/L)</td>
<td>187.1</td>
<td>100.5</td>
</tr>
</tbody>
</table>

Isotopic signatures and groundwater depth data suggest that rain water is the main contributor to groundwater recharge.
Isotopic signatures of water from different sources in Kamech Catchment, Tunisia

<table>
<thead>
<tr>
<th>Source</th>
<th>No. of Samples</th>
<th>$^{18}$O Isotopic signature (‰)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Minimum</td>
</tr>
<tr>
<td>Rainfall</td>
<td>30</td>
<td>-0.95</td>
</tr>
<tr>
<td>Runoff</td>
<td>25</td>
<td>-5.80</td>
</tr>
<tr>
<td>Farm pond</td>
<td>41</td>
<td>-4.00</td>
</tr>
<tr>
<td>Groundwater-Around the farm pond</td>
<td>24</td>
<td>-8.16</td>
</tr>
</tbody>
</table>

$^{18}$O isotopic signatures and mass balance studies showed that

1. Run off from the catchment is the main source of pond water (>90%) and < 10% comes from seepage mainly during dry season
2. Farm dam recharging the groundwater (up to 73,000m³ annually) during high dam volumes
Grain N (%) from fertilizer and wetland soil and water as influenced by water under rice in Manafwa catchment, Uganda based on $^{15}$N results.
### Total Biomass in water conservation zones and nitrogen uptake by biomass in Romania

<table>
<thead>
<tr>
<th>Vegetation Type</th>
<th>Biomass in the system (tonnes/ha)</th>
<th>Nitrogen removed by biomass (kg/ha/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wetland vegetation</td>
<td>14.7</td>
<td>295</td>
</tr>
<tr>
<td>Pasture</td>
<td>108.4</td>
<td>184</td>
</tr>
<tr>
<td>Forest</td>
<td>75.5</td>
<td>259</td>
</tr>
<tr>
<td>Mixed Forest</td>
<td>7.4</td>
<td>89</td>
</tr>
<tr>
<td>Agricultural Crops</td>
<td>33.1</td>
<td>276</td>
</tr>
</tbody>
</table>

*Biomass production is a major sink for nitrogen in water conservation zones*
N distribution in soil and biomass under five different vegetation types based on $^{15}$N results in Arges Catchment, Romania,
Denitrification as determined from $^{15}$N and $^{18}$O in Porijõgi and Viiratsi catchments, Estonia.

Denitrification of 51.7 and 48 kg N ha$^{-1}$ yr$^{-1}$ from Porijõgi and Viiratsi catchments.
The enrichment of $^{15}\text{N}$ indicate that the HM wetland is a sink for nitrogen from the catchment (including fertilizer and animal excreta)
<table>
<thead>
<tr>
<th>Country</th>
<th>Catchment Area (ha)</th>
<th>Size of water conservation zone (ha)</th>
<th>% of catchment</th>
<th>Water Captured (MCM)</th>
<th>Area used for irrigation (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iran</td>
<td>10388</td>
<td>339</td>
<td>3.3</td>
<td>7.55</td>
<td>1640</td>
</tr>
<tr>
<td>Tunisia</td>
<td>265</td>
<td>4</td>
<td>1.5</td>
<td>0.144</td>
<td>6-9</td>
</tr>
</tbody>
</table>

86 tonnes of nitrogen (N) and 17 tonnes of phosphorus (P) annually are captured by water conservation zones and used for rice production in Iran.
Nitrogen and Phosphorus captured by Ab-bandons and contribution to rice production in Iran

<table>
<thead>
<tr>
<th>Catchment area (ha)</th>
<th>14,600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated rice area (ha)</td>
<td>4700</td>
</tr>
<tr>
<td>Water available (MCM)</td>
<td>7.552</td>
</tr>
<tr>
<td>Nitrogen captured (tonnes)</td>
<td>86</td>
</tr>
<tr>
<td>Rice nitrogen requirement (tonnes)</td>
<td>76</td>
</tr>
<tr>
<td>Phosphorus captured (tonnes)</td>
<td>17.2</td>
</tr>
<tr>
<td>Rice phosphorus requirement (tonnes)</td>
<td>13.1</td>
</tr>
</tbody>
</table>

There is enough N and P in the water for rice crop requirement
Interim findings from the Project

- Within the water conservation zones similar $^2\text{H}$ and $^{18}\text{O}$ signatures of surface water and ground water indicated their importance for groundwater recharge.
- $^2\text{H}$ and $^{18}\text{O}$ signatures of water in runoff, rainwater and stream water and water balance calculations showed that more than 90% of water captured is by surface runoff during rainy periods.
- Nitrogen captured is a major N source for in-situ biomass production (up to 295 kg N/ha/year).
- Water conservation zones are a major source of water, nitrogen and phosphorus to rice production.
- Denitrification is an important pathway of N removal in water conservation zones.