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

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Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

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

Coordinated Research Project (CRP)

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

Isotopic and Nuclear Techniques

^{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

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Water Isotope	Average Isotopic signature of water (‰)				
	Field (irrigation)	Wetland	Rain	River	Ground water
^{2}H	-79.6	-85.9	-81.5	-74.4	-95.2
^{18}O	-10.9	-11.7	-11.2	-10.1	-12.5

Wetland receive water mainly from runoff and rainfall

^{18}O and ^{2}H signatures TDS of different sources of water during rainy season in China

Property	Ground water	Surface water		
	Well	Field	Wetland	River
Sample Nos	29	8	1	1
δ^2H (‰)	-92.5	-79.6	-85.9	-74.4
$\delta^{18}O$ (‰)	-12.5	-10.9	-11.7	-10.1
TDS (mg/L)	187.1	100.5	27.6	48.2

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

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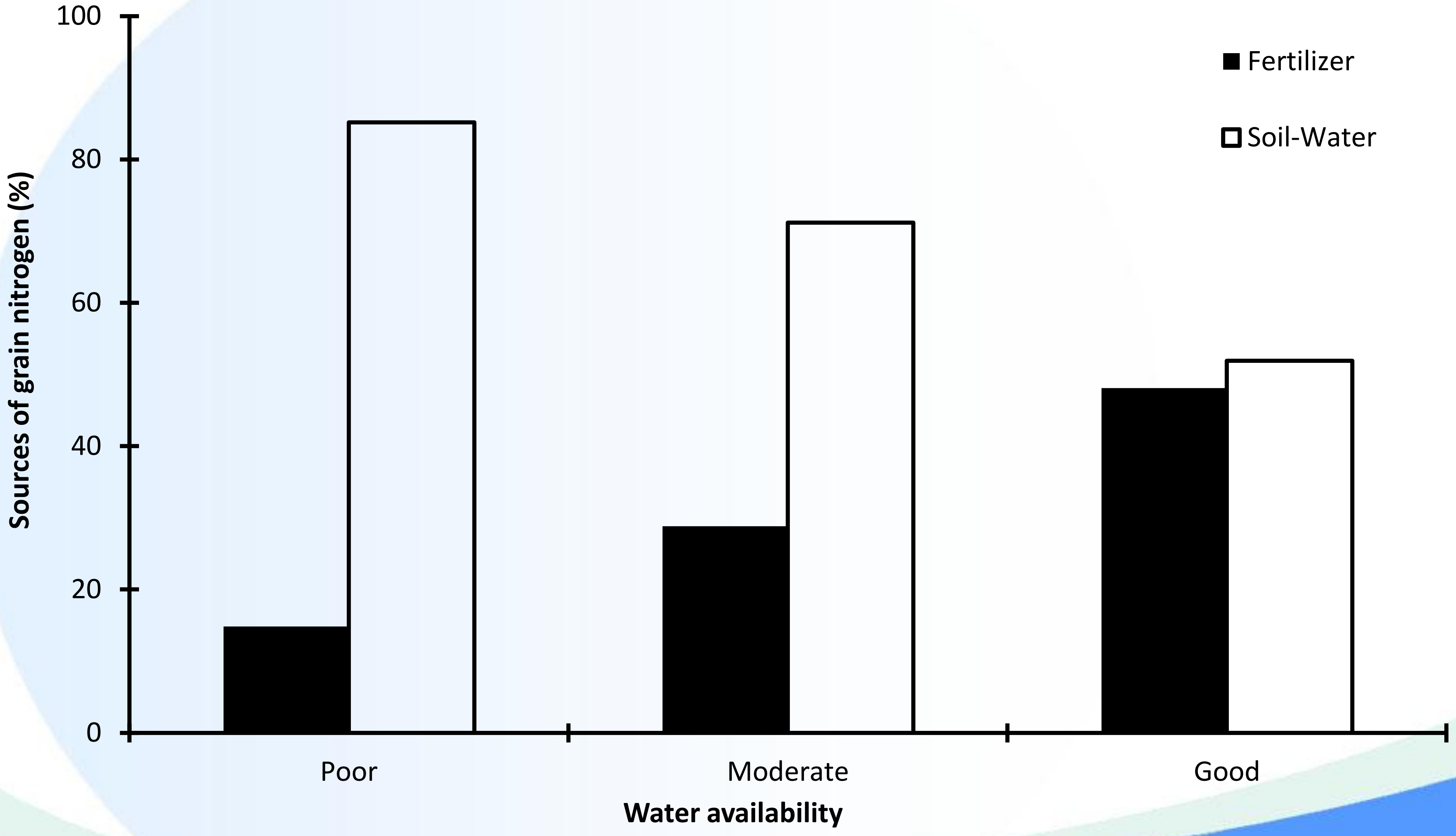
Source	No. of Samples	^{18}O Isotopic signature (‰)	
		Minimum	Maximum
Rainfall	30	-0.95	10.86
Runoff	25	-5.80	2.70
Farm pond	41	-4.00	2.50
Groundwater-Around the farm pond	24	-8.16	-7.19

^{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 73,000m^3 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

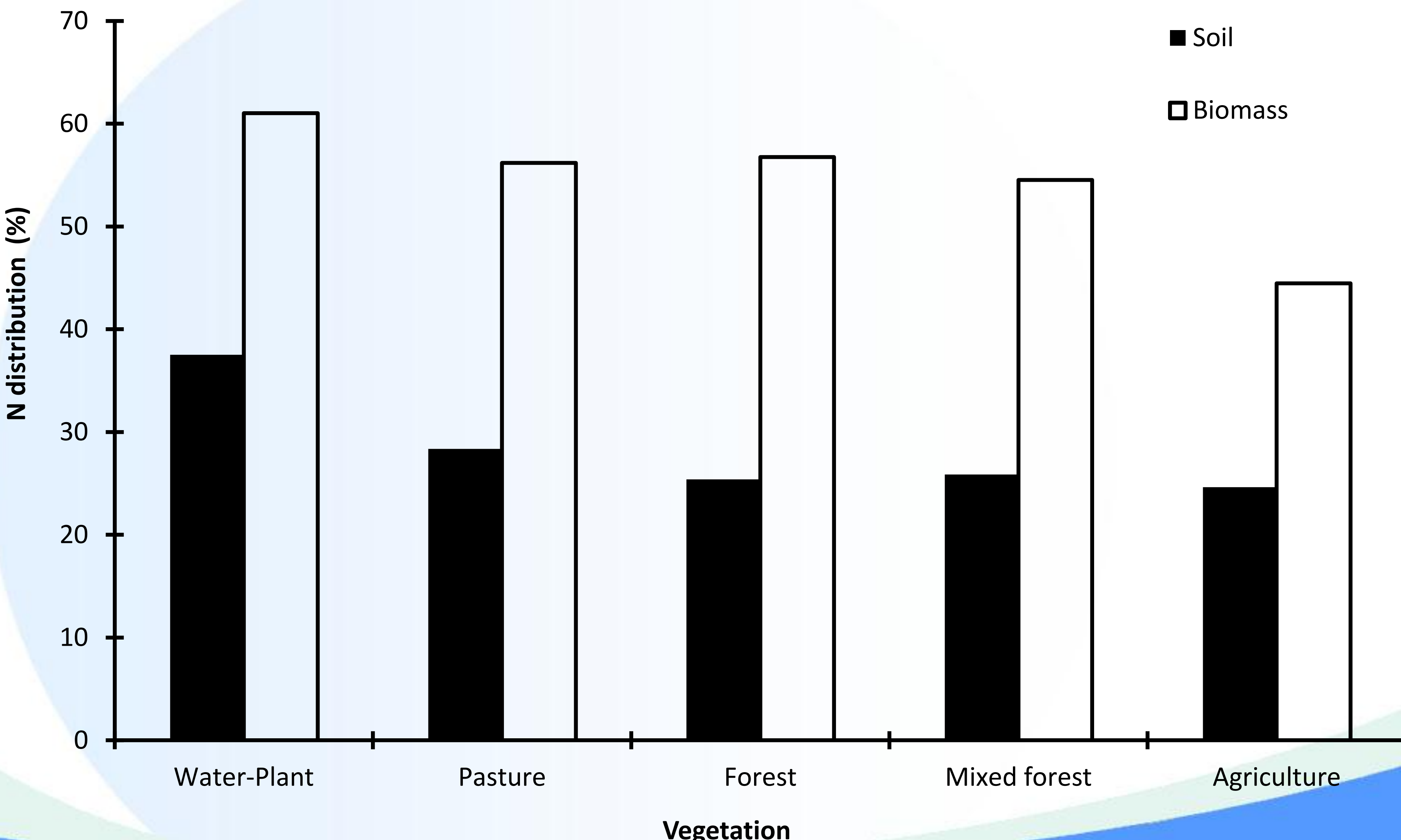


Total Biomass in water conservation zones and nitrogen uptake by biomass in Romania

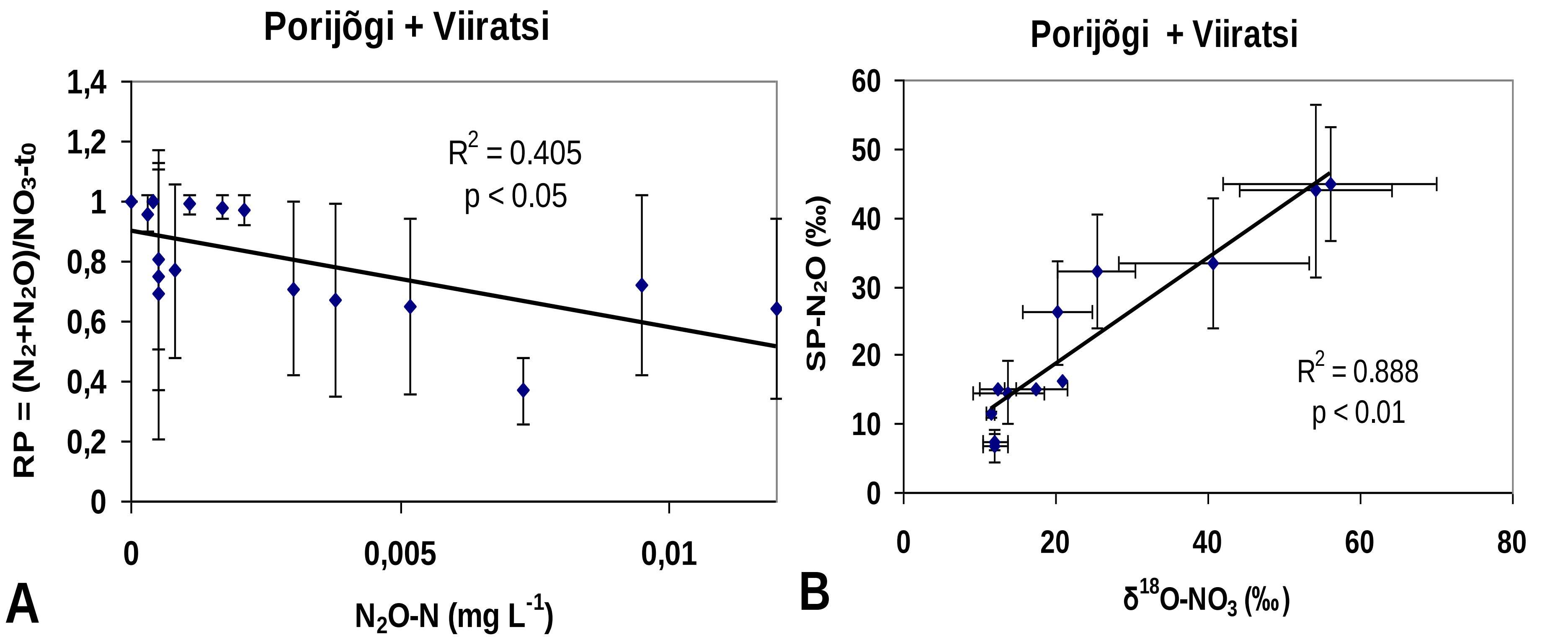
Vegetation Type	Biomass in the system (tonnes/ha)	Nitrogen removed by biomass (kg/ha/year)
Wetland vegetation	14.7	295
Pasture	108.4	184
Forest	75.5	259
Mixed Forest	7.4	89
Agricultural Crops	33.1	276

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 Porijogi and Viiratsi catchments, Estonia.



Denitrification of 51.7 and 48 kg N ha^{-1} yr^{-1} from Porijõgi and Viiratsi catchments

^{15}N and ^{13}C distribution in wetland soils in Lesotho

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Sites	Toposequence	^{13}C (‰)	^{15}N (‰)
Butha-Buthe (BB)	Upper slope	-28.84	-2.52
	Middle slope	-28.90	-2.97
	Lower slope	-28.13	-2.93
Ha-Matela (HM)	Upper slope	-12.12	2.00
	Middle slope	-11.77b	2.61
	Lower slope	-13.85	6.18

The enrichment of ^{15}N indicate that the HM wetland is a sink for nitrogen from the catchment (including fertilizer and animal excreta)

Water Balance for water conservation zones in Iran and Tunisia

Country	Catchment Area (ha)	Size of water conservation zone (ha)	% of catchment	Water Captured (MCM)	Area used for irrigation (ha)
Iran	10388	339	3.3	7.55	1640
Tunisia	265	4	1.5	0.144	6-9

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

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Catchment area (ha)	14,600
Irrigated rice area (ha)	4700
Water available (MCM)	7.552
Nitrogen captured (tonnes)	86
Rice nitrogen requirement (tonnes)	76
Phosphorus captured (tonnes)	17.2
Rice phosphorus requirement (tonnes)	13.1

There is enough N and P in the water for rice crop requirement

Interim findings from the Project

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- **Within the water conservation zones similar ^{2}H and ^{18}O signatures of surface water and ground water indicated their importance for groundwater recharge**
- **^{2}H and ^{18}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**