E. Fulajtar, L. Heng, M. Zaman, J. Halder, L. Mabit, J. Adu-Gyamfi

Use of nuclear techniques for enhancing climate smart agriculture

IAEA
International Atomic Energy Agency

- **October 1957, the First General Conference established the IAEA**
- **Headquarters in Vienna, Austria**
- **Opening the Vienna International Centre, August 1979**

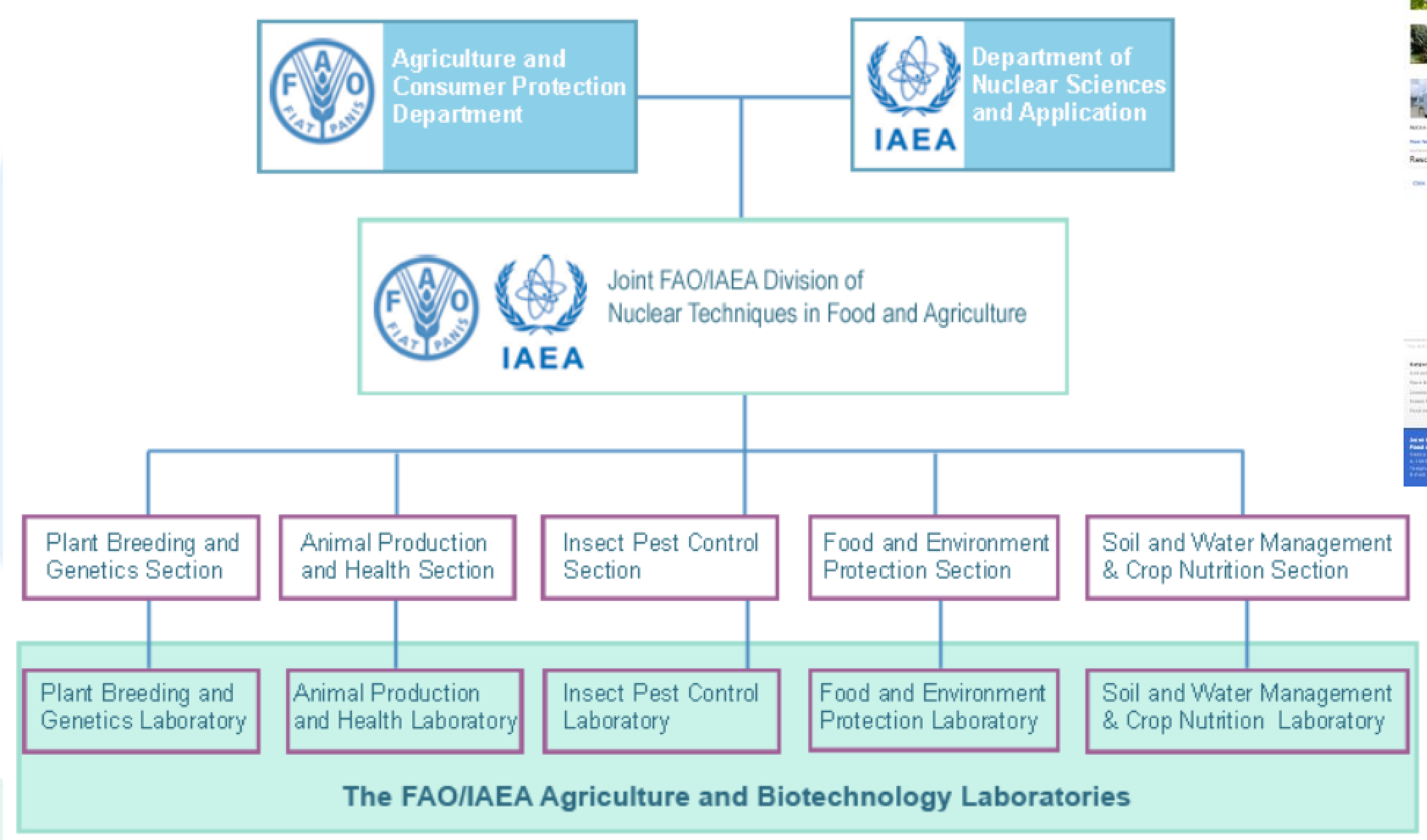
- Offices Reporting to the Director General
- Department of Management
- Department of Technical Cooperation
- Department of Nuclear Energy
- Department of Nuclear Safety and Security
- Department of Nuclear Sciences and Applications
- Department of Safeguards

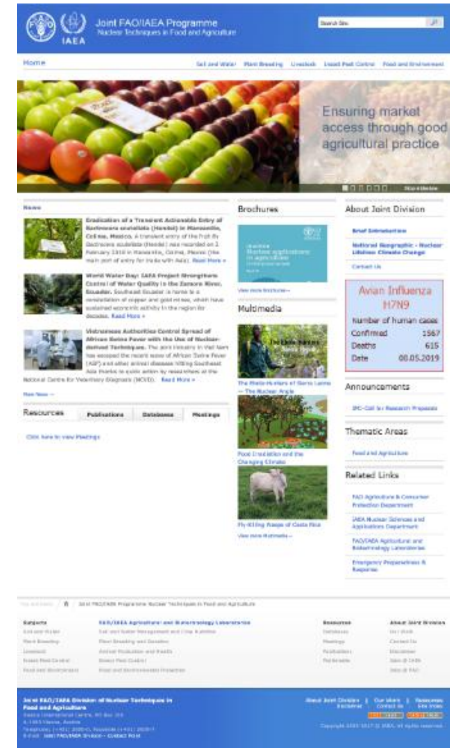
- Division of Human Health
- Division of IAEA Environment Laboratories
- Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
- Division of Physical and Chemical Sciences
- Seibersdorf laboratories
- Research Contracts Administration Section

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

The Joint FAO/IAEA Division of **Nuclear Techniques in Food and Agriculture**

Established on 1 October 1964





Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Use of nuclear techniques in soil science

Soil and Water Management and Crop Nutrition (SWMCN) Subprogramme

Soil Section

Soil Lab

Soils Newsletter

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture
http://www-naweb.iaea.org/nafa/index.html
http://www.fao.org/ag/portal/index_en.html
ISSN 1011-2650
Vol. 42, No. 1 July 2019

Contents

To Our Readers

Save soil for future generations: awareness rising bracelet from FAO's 'Global Symposium on Soil Erosion', 15-17 May, Rome

I am pleased to report that the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture through the Soil and Water Management and Crop Nutrition (SWMCN) Subprogramme co-organized the Global Symposium on Soil Erosion (GSER19), with FAO, the Intergovernmental Technical Panel on Soils (ITPS), the United Nations Convention to Combat Desertification Science-Policy Interface (UNCCD-SPI) in Rome, Italy recently. Lionel Mabit from the SWMCN Laboratory represented the Joint Division at the symposium, which aimed to bring science and policy together to review the status and challenges of soil erosion control for insuring food security and ecosystem services to fulfil the planned achievement of Sustainable Development Goals. The Joint Division also organized a side event on 'Soil erosion assessment: Making a difference with nuclear and isotopic techniques' at the Symposium to highlight the effectiveness of these techniques in evaluating soil erosion magnitude and in identifying the sources of sediments. This side event presented state-of-the-art nuclear and isotopic tools used to investigate soil erosion and recent methods development. Success stories from three colleagues from African Member States (Madagascar, Morocco and Zimbabwe) were also presented. The side-event generated great interest and positive feedback from the participants with more than 50 people attending.

A consultant's meeting was organized in February to develop a new coordinated research project (CRP) on "Assessing radionuclide uptake and dynamics for better remediation of radioactive contamination in agriculture", to replace the recently completed CRP D1.50.15 on 'Response to Nuclear Emergency affecting Food and Agriculture'. For the next 6 months, there will be another

Soil and Water Management and Crop Nutrition Subprogramme

Meeting the Challenges related to Climate Change

Activities

- Coordinated research projects
- Technical cooperation projects
- Research and Development
- Laboratory Services
- Publishing ativities

Meeting the Challenges related to Climate Change

Coordinated Research Projects

Main objective
- Developing new nuclear techniques and improving methods

Management
- Managed by Programme Officers from NSA
- Concept: cooperation of scientists from developed and developing countries
- Duration: 5 years
- Budget: 500 kEuro in total

Implementation tools
- Consultant meeting
- Research contracts: 7 kEuro/year + meeting attendance
- Technical contracts: 10 kEuro/year + meeting attendance
- Research agreements: meeting attendance
- 3 Research Coordination Meetings
- Support from Soil Lab

Technical Cooperation Projects

Main objective

- Disseminate nuclear technologies to Member Countries

Management

- Managed by Project Management Officers from TC
- Technical support by Technical Officers from NSA
- Concept: national or regional projects
- Duration: 2, 3 or 4 years
- Budget: 20 – 300 kEuro/year

Implementation tools

- Expert missions
- Fellowships and training courses (regional or national)
- Procurements
- Scientific visits
- Others (subcontracts, home based assignments)

Meeting the Challenges related to Climate Change

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Research and Development

- Research activities carried by Soil Lab (supporting CRPs)

Laboratory services

- Laboratory intercomparison tests
- Training of fellows and training courses

Publishing

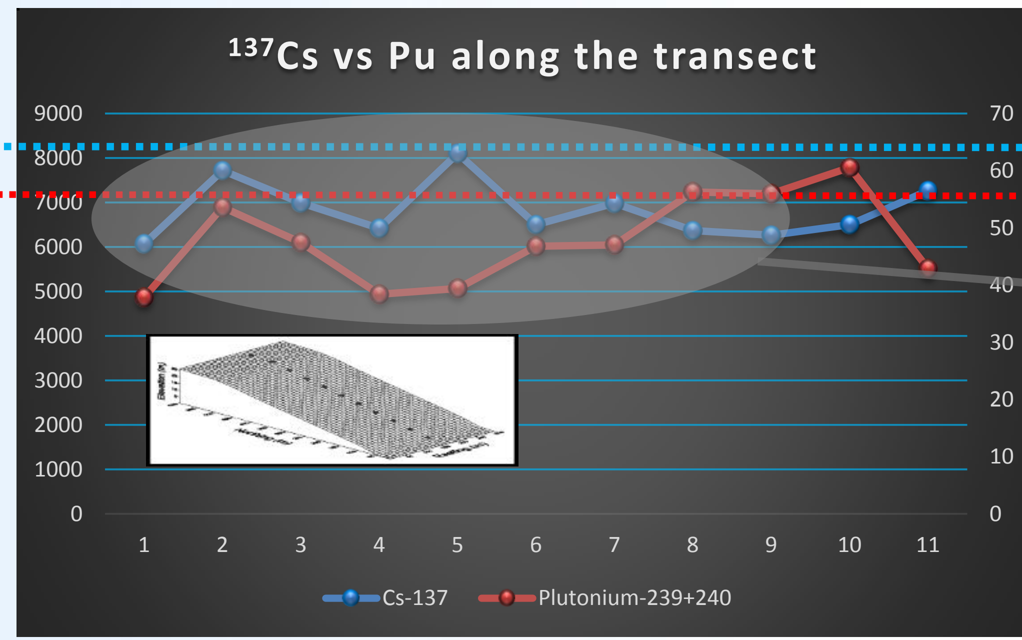
- Methodological handbooks
- Papers in scientific journals
- Presentations at conferences
- Awarenes rising and dissemination

Tests of the suitability of $^{239+240}$Pu for soil erosion assessment in Austria (Grabenegg agri. site) – Second year

- **Results of the test for the Grabenegg agricultural site**

11 bulk cores collected (2-3 increments) end Q4_2017 + pre-treatment ***24*** samples [*Q1_2018*]

24 *^{137}Cs analysis in Seibersdorf [Q2] +* ***24*** *$^{239+240}$Pu analysis at CNESTEN (Morocco) [Q3-Q4]*



[RS] ^{137}Cs = 8180 Bq/m^2

[RS] $^{239+240}$Pu = 56 Bq/m^2

Erosion rates ≤ 5 t/ha/yr

Coordinated Research Projects

1	D1.20.14	Enhancing agricultural resilience and water security using Cosmic-Ray Neutron Sensor
2	D1.50.16	Minimizing Farming Impacts on Climate Change by Enhancing Carbon and Nitrogen Capture and Storage in Agro-Ecosystems
3	D1.50.17	Nuclear Techniques for a Better Understanding of the Impact of Climate Change on Soil Erosion in Upland Agro-ecosystems
4	D1.50.18	Multiple isotope fingerprints to identify sources and transport of agro-contaminants
5	D1.50.19	Monitoring and predicting radionuclide uptake and dynamics for optimizing remediation of radioactive contamination in agriculture

Technical Cooperation Projects

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

	Country	Number	Title of Technical Cooperation Project
2	Afghanistan	AFG5008	Strengthening Climate Smart Agricultural Practices for Wheat, Fruits and Vegetable Crops
3	Algeria	ALG5031	Using Nuclear Techniques to Characterize the Potentials of Soils and Vegetation for the Rehabilitation of Regions Affected by Desertification
4	Azerbaijan	AZB5003	Determining of Radioactive Substances in the Environment with a Focus on Water and Soil
5	Bangladesh	BGD5033	Using Nuclear Techniques in Assessing River Bank Erosion
6	Burundi	BDI5001	Improving Cassava Productivity through Mutation Breeding and Better Water and Nutrient Management Practices Using Nuclear Techniques
7	Cambodia	KAM5005	Enhancing Soil, Water and Nutrient Management for Sustainable Rice Production and Optimized Yield
8	Central African Republic	CAF5012	Building Capacities in Developing Best Agricultural Practices for Enhanced Production of Maize and Its Quality – Phase I
9	Chad	CHD5009	Developing Sustainable Water Resources Management through the Use of Nuclear Isotopic Techniques in Drip Irrigation Systems
10	Costa Rica	COS5035	Building Capacity for the Development of Climate-Smart Agriculture in Rice Farming
11	Cuba	CUB5023	Strengthening National Capacities for the Development of New Varieties of Crops through Induced Mutation to Improve Food Security While Minimizing the Environmental Footprint
12	Gabon	GAB5003	Building National Capacities for Monitoring Sedimentation of Dams and Harbors and the Management of Remediation Operations
13	Gabon	GAB5004	Improving Soil Fertility Management for Enhanced Maize, Soybean and Groundnut Production
14	Haiti	HAI5008	Strengthening National Capacities for Enhanced Agricultural Crop Productivity
15	Indonesia	INS5043	Intensifying Quality Soybean Production in Indonesia to achieve self-sufficiency
16	Interregional project	INT0093	Applying Nuclear Science and Technology in Small Island Developing States in Support of the Sustainable Development Goals and the SAMOA Pathway
17	Interregional project	INT5156	Building Capacity and Generating Evidence for Climate Change Impacts on Soil, Sediments and Water Resources in Mountainous Regions

Technical Cooperation Projects

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

18	Iraq	IRQ5022	Developing Climate-Smart Irrigation and Nutrient Management Practices to Maximize Water Productivity and Nutrient Use Efficiency at Farm Scale Level Using Nuclear Techniques and Advanced Technology
19	Kuwait	KUW5004	Improving Production and Water Use Efficiency of Forage Crops with Nuclear Techniques
20	Laos	LAO5004	Enhancing National Capability for Crop Production and Controlling Trans-Boundary Animal Diseases
21	Lesotho	LES5009	Determining Soil Nutrient and Water Use Efficiency Using Isotope Techniques
22	Madagascar	MAG5026	Biocontrol of Striga asiatica (L.) Kuntze through the development of tolerant rice and maize lines and its impact on microbiological and ecological functioning of soil
23	Malawi	MLW5003	Developing Drought Tolerant, High Yielding and Nutritious Crops to Combat the Adverse Effects of Climate Change
24	Malaysia	MAL5032	Strengthening National Capacity in Improving the Production of Rice and Fodder Crops and Authenticity of Local Honey Using Nuclear and Related Technologies
25	Mali	MLI5030	Developing and Strengthening Climate Smart Agricultural Practices for Enhanced Rice Production — Phase I
26	Mauritania	MAU5006	Contributing to the Improvement of Rice Crop Yields through the Application of Nuclear Techniques to Water Management and Soil Fertility
27	Myanmar	MYA5027	Monitoring and Assessing Watershed Management Practices on Water Quality and Sedimentation Rates of the Inle Lake - Phase II
28	Namibia	NAM5017	Improving Crops for Drought Resilience and Nutritional Quality
29	Pakistan	PAK5051	Developing Isotope-Aided Techniques in Agriculture for Resource Conservation and Climate Change Adaptation and Mitigation
30	Panama	PAN5028	Improving the Quality of Organic Cocoa Production by Monitoring Heavy Metal Concentrations in Soils and Evaluating Crop Water Use Efficiency
31	Peru	PER5033	Application of Nuclear Techniques for Assessing Soil Erosion and Sedimentation in Mountain Agricultural Catchments
32	Qatar	QAT5008	Developing Best Soil, Nutrient, Water and Plant Practices for Increased Production of Forages under Saline Conditions and Vegetables under Glasshouse Using Nuclear and Related Techniques
33	Regional project Africa	RAF5079	Enhancing Crop Nutrition and Soil and Water Management and Technology Transfer in Irrigated Systems for increased Food Production and Income Generation (AFRA)
34	Regional project Africa	RAF5081	Enhancing Productivity and Climate Resilience in Cassava-Based Systems through Improved Nutrient, Water and Soil Management (AFRA)

Technical Cooperation Projects

34	Regional project Africa	RAF5081	Enhancing Productivity and Climate Resilience in Cassava-Based Systems through Improved Nutrient, Water and Soil Management (AFRA)
35	Regional project Asia	RAS5073	Climate Proofing Rice Production Systems (CRiPS) Based on Nuclear Applications, Phase II
36	Regional project Asia	RAS5080	Developing Sustainable Agricultural Production and Upscaling of Salt-Degraded Lands through Integrated Soil, Water and Crop Management Approaches - Phase III
37	Regional project Asia	RAS5083	Reducing greenhouse gas emissions from agriculture and land use changes through climate smart agricultural practices
38	Regional project Asia	RAS5084	Assessing and improving soil and water quality to minimize land degradation and enhance crop productivity using nuclear techniques
39	Regional project Asia	RAS5089	Enhancing the Sustainability of Date Palm Production in States Parties through Climate-Smart Irrigation, Nutrient and Best Management Practices (ARASIA)
40	Regional project Latin America	RLA5076	Strengthening Surveillance Systems and Monitoring Programmes of Hydraulic Facilities Using Nuclear Techniques to Assess Sedimentation Impacts as Environmental and Social Risks (ARCAL CLV)
41	Regional project Latin America	RLA5077	Enhancing Livelihood through Improving Water Use Efficiency Associated with Adaptation Strategies and Climate Change Mitigation in Agriculture (ARCAL CLVIII)
42	Regional project Latin America	RLA5078	Improving Fertilization Practices in Crops through the Use of Efficient Genotypes in the Use of Macronutrients and Plant Growth Promoting Bacteria (ARCAL CLVII)
43	Regional project Latin America	RLA5084	Developing Human Resources and Building Capacity of Member States in the Application of Nuclear Technology to Agriculture
44	Rwanda	RWA5001	Improving Cassava Resilience to Drought and Waterlogging Stress through Mutation Breeding and Nutrient, Soil and Water Management Techniques
45	Senegal	SEN5041	Strengthening Climate Smart Agricultural Practices Using Nuclear and Isotopic Techniques on Salt Affected Soils
46	Serbia	SRB5003	Strengthening the Capacities for Soil Erosion Assessment Using Nuclear Techniques to Support the Implementation of Sustainable Land Management Practices
47	Seychelles	SEY5011	Supporting Better Sustainable Soil Management as Climate Change Adaptation Measures to Enhance National Food and Nutrition Security
48	Sierra Leone	SIL5021	Improving Productivity of Rice and Cassava to Contribute to Food Security
49	Slovenia	SLO5004	Improving Water Quality in Vulnerable and Shallow Aquifers under Two Intensive Fruit and Vegetable Production Zones
50	Sudan	SUD5037	Application of nuclear and related biotechnology techniques to improve of crop productivity and lively hood of small scale farmers drought prone areas of Sudan
51	Togo	TOG5002	Improving Crop Productivity and Agricultural Practices Through Radiation Induced Mutation Techniques
52	Zambia	ZAM5031	Improving the Yield of Selected Crops to Combat Climate Change

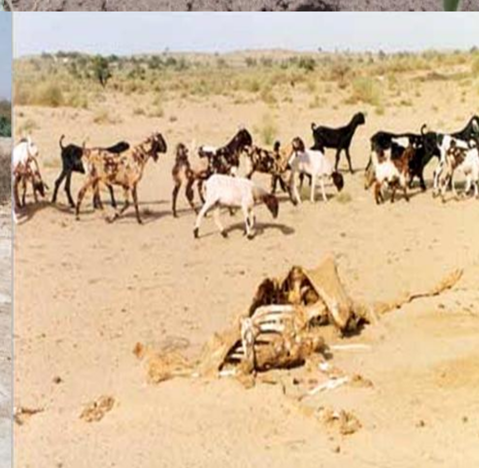
Soil-related problems to be addressed

IAEA
Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Soil Erosion and soil conservation

Salinity and Nutrient Toxicities

Water Scarcity and Low Water Use Efficiency



Low Soil Fertility and Poor Crop Nutrition

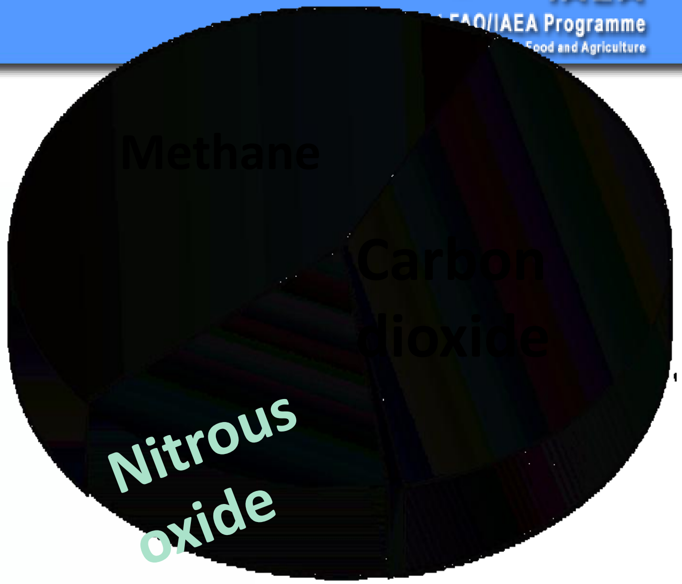
Meeting the Challenges related to Climate Change

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

1. **Minimising impact of agriculture on climate change**
   - Agriculture contributes to GHG emissions by 30%; therefore they need to be reduced.
   - Nuclear techniques help to reduce the agricultural greenhouse gas (GHG) emissions and thus reduce the temperature increase and impact of extreme weather events (drought and flood).

2. **Achieving food security under the conditions of climate change**
   - Rising human population (current 7.3 billion, will reach 9 billion by 2050) requires more food.
   - Food security problem affects especially developing countries.
   - Nuclear techniques help to achieve food security.

Greenhouse gases (GHGs)



Carbon dioxide (CO_2):

- Mainly from fossil fuel burning (57%), land use changes and deforestation (17%). Can stay for 40 years in atmosphere.

Nitrous oxide (N_2O):

- N_2O is a powerful GHG as well as ozone depleting gas, mainly originate from N fertilizer, animal manure and urine. Its half life 120 years and 300 times more powerful than CO_2 in Global Warming.

Methane (CH_4)

- CH_4 originate from animals (cow, sheep, goat, buffalo, deer, camel), paddy (rice) soil and wetland, half life 12 years.

Agriculture: The victim or the source of GHGs?

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Agriculture is the victim of climate change but it also contributes 24% to the total GHGs due to:

- Increasing demand of food and animal protein for growing human population
- Increased nitrogen fertilizer use (112 million t/year)
- Increasing number of dairy animals (260 million worldwide; majority in developing MS)
- Conversion of peatland into farming (in Asia and Africa)

Greenhouse gases (GHGs) continued

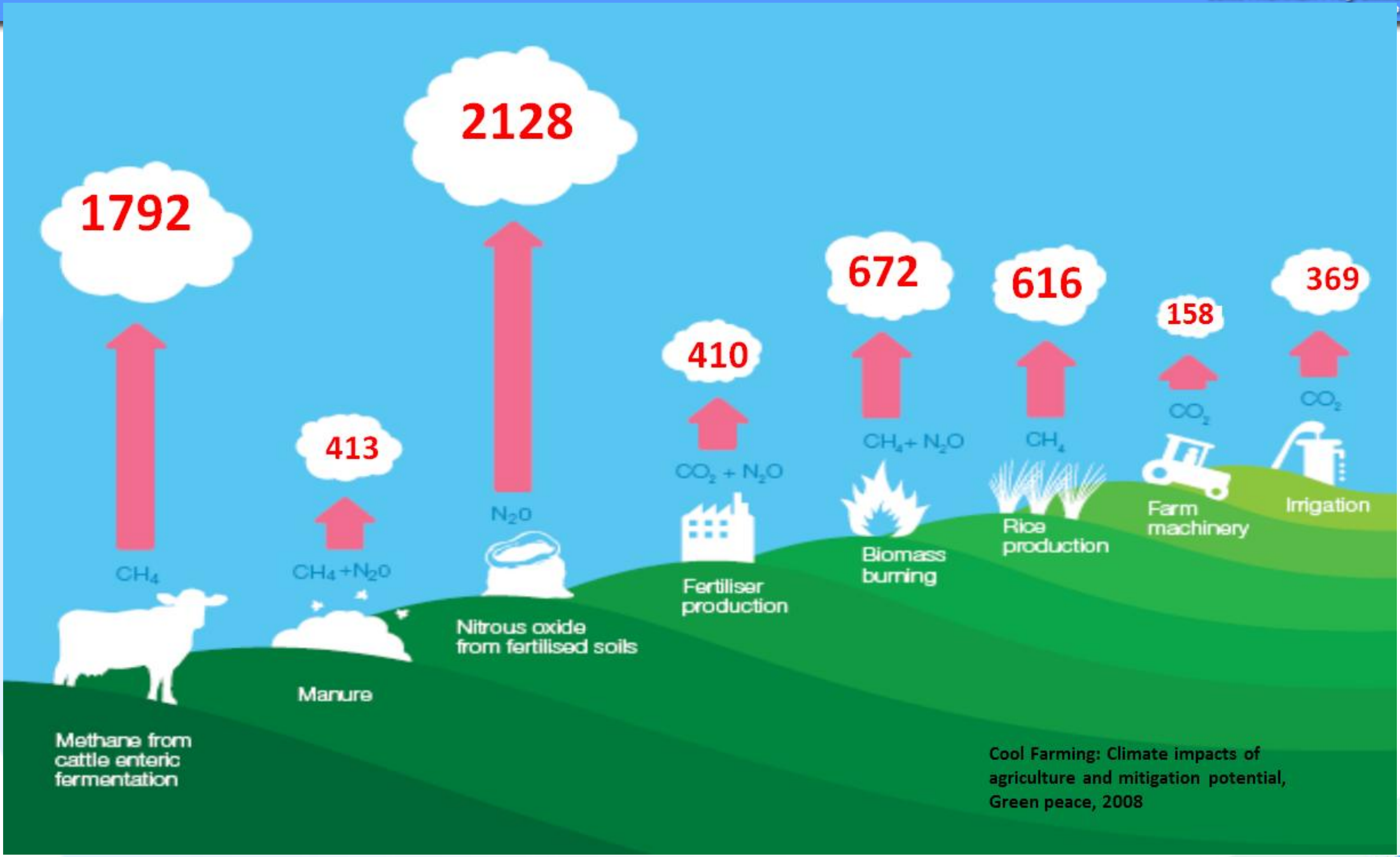
Joint FAO/IAEA Programme

Deforestation:

- The world's forests continue to shrink due to conversion into agriculture land

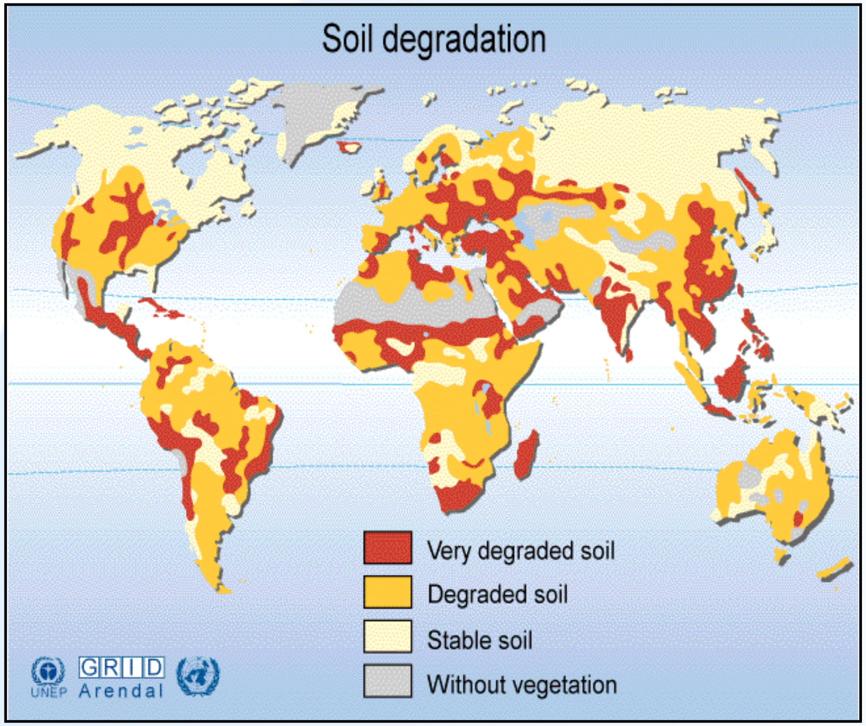
- 130 million hectares of forest - an area almost equivalent in size to South Africa - have been lost since 1990
- Africa and South America are the most affected areas

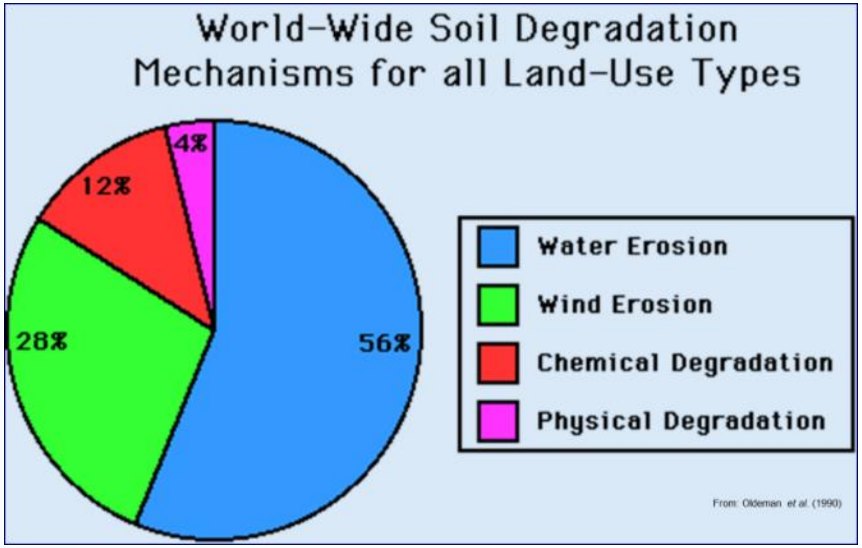
Sources of agricultural greenhouse gases (Mt CO2-eq)



Cool Farming: Climate impacts of agriculture and mitigation potential, Green peace, 2008

Soil Degradation





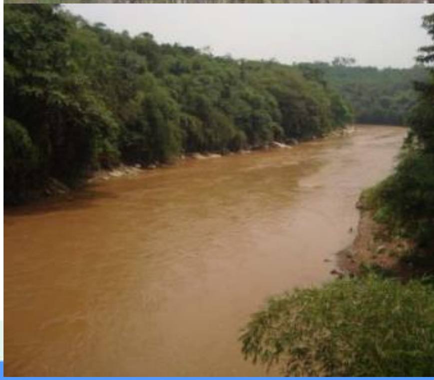
80% of degraded land is located in developing countries!

Soil Erosion

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

- Harsh arid climate, extreme rainfalls and inappropriate land management are making the soil more prone to erosion.
- Soil erosion affects 1.9 billion ha (65% of global soil resources; 80% in developing countries) and the affected area increases at alarming rate.
- Worldwide economic cost of soil erosion is US $400 billion y^{-1} (on and off-farm). This includes essential plant nutrient losses, poor water quality with reduced aesthetic value, deposition of sediments in dams and water reservoir.
- Slow soil formation rate: for 1 cm of fertile soil to develop, it takes about 100 to 300 years.





Salinity

- Globally about 250,000 to 500,000 ha of arable land is lost to production every year due to salinization
- Salinization can cause yield decreases of 10 to 25 % for many crops and prevent cropping altogether when it is severe

Nutrient Imbalance

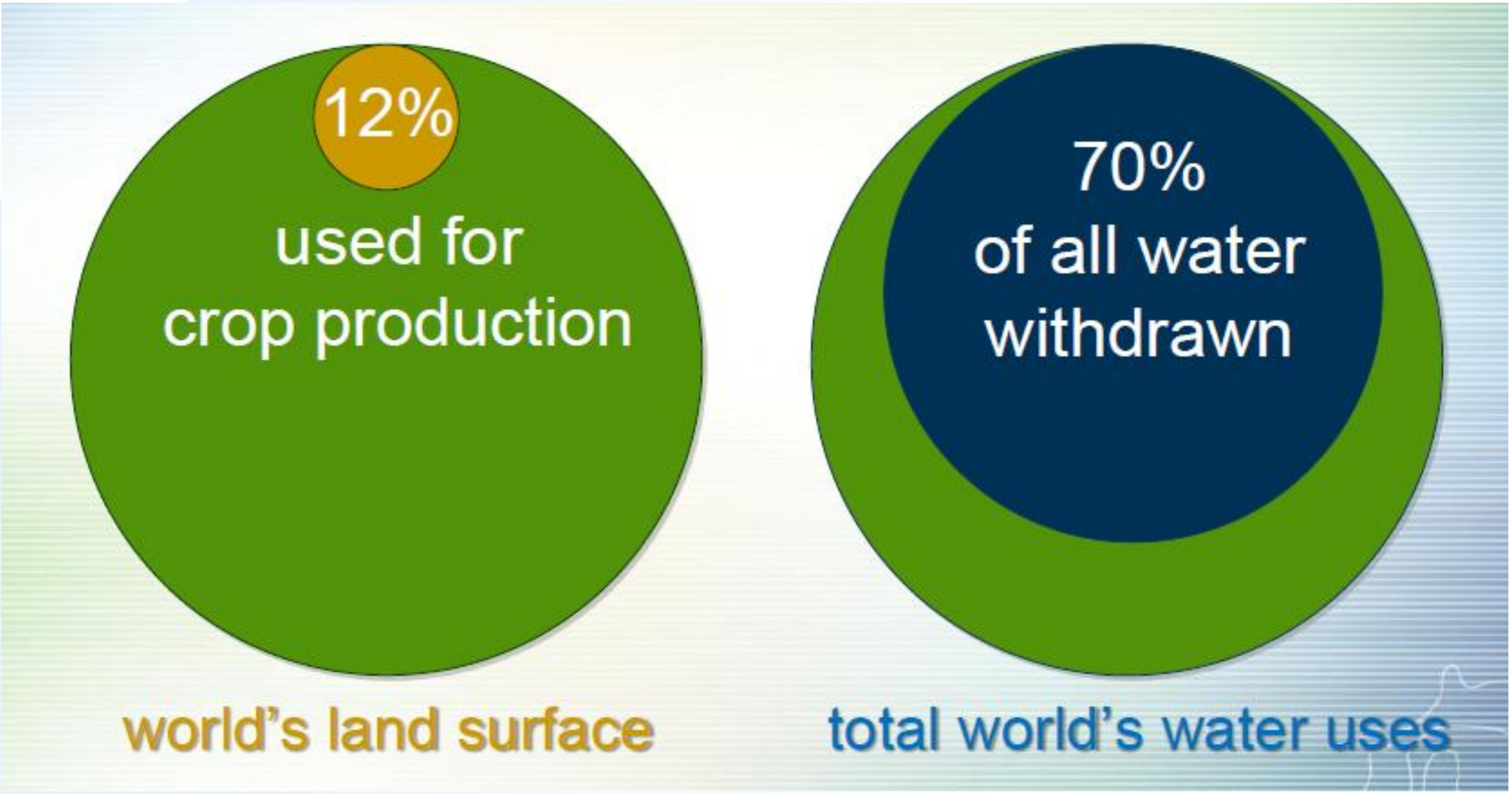
- Strongly weathered tropical soils (oxisols, etc.) have poor fertility and low nutrient content.

- Approximately 40% of the world's arable soils are acidic leading Al, Mn and Fe toxicities, with P, Ca, Mg, and K deficiencies.

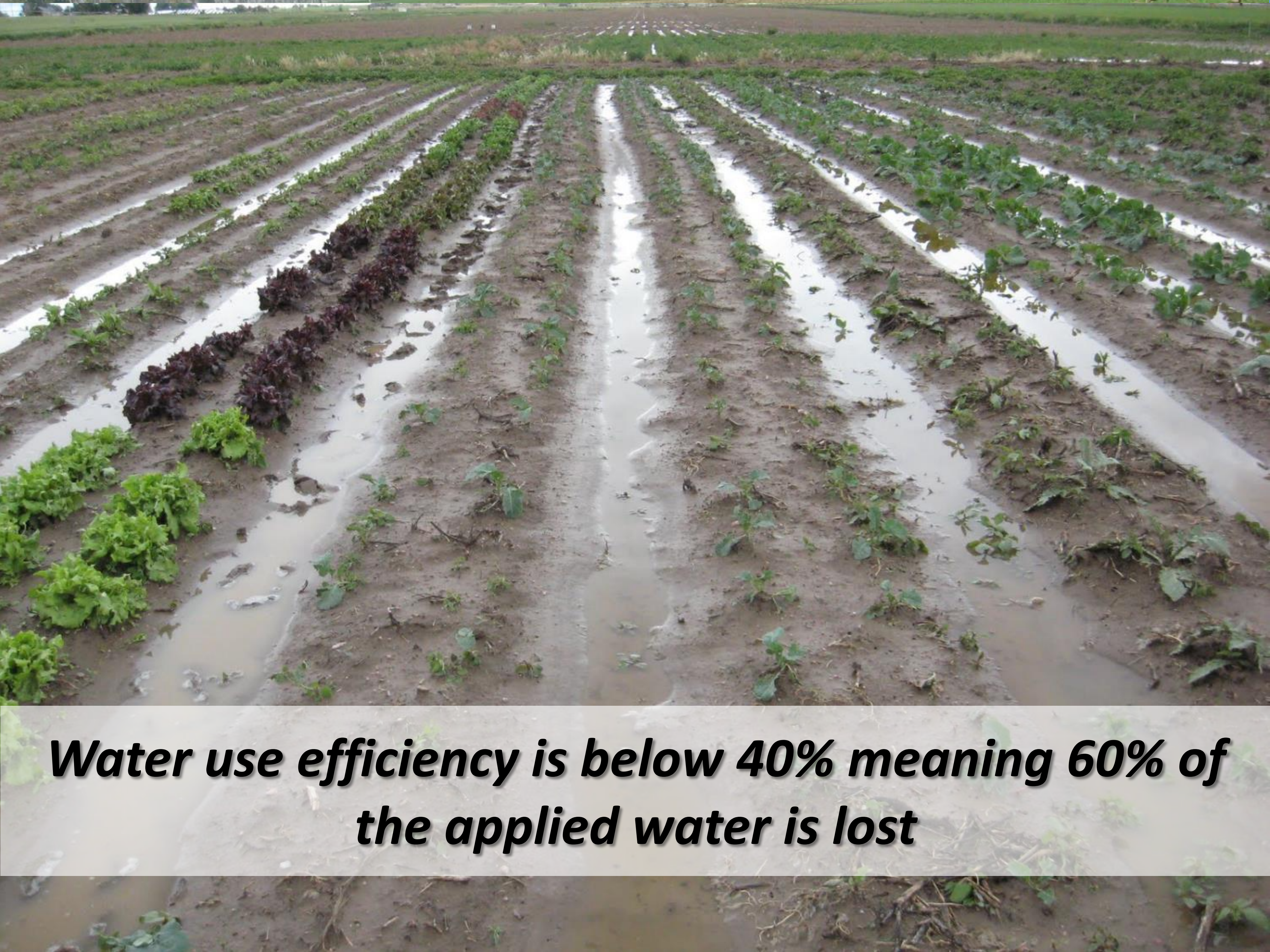
- Acidic soils mobilize many of toxic heavy metals and results in increased plant uptake of toxic substances which end up in human and animal food chains.

- Regular lime applications can correct most soil acidity problem and improve soil health.

Water Scarcity and Low Water Use Efficiency




70% of global freshwater is used by agriculture


Water use efficiency is below 40% meaning 60% of
the applied water is lost

Depleting Soil Fertility and Nutrient Mining

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

- Subsistence family farming in developing countries is lucking balanced chemical fertilizers due to high cost.
- Low nutrient use efficiency on farm is always a challenge (NUE <40%; PUE<20%).
- Climate change worsen nutrient depletion, deterioration of soil fertility, loss of crop productivity and income decrease.

General principles

- Wide range of nuclear techniques can be used
- Isotopes, neutrons and X-rays are used
- Two groups of isotopes can be used:
  - Stable isotopes
  - Radionuclides
- Two approaches are used:
  - Observation of independent environmental processes (natural abundance of isotopes and neutrons)
  - Man-designed experiments (isotopic labelling techniques, emitting neutrons and X-rays)

General principles of isotopic techniques

1. Comparing proportion (expressed as isotope signature) of 2 or more isotopes of the same element in the same substance or chemical compound, (used mostly for stable and for few radioactive isotopes of major biogenic elements: Carbon, Hydrogen, Oxygen, Nitrogen, Sulphur, Phosphorous) to trace chemical processes of environmental circulation of these elements
   - Two isotopes of one element differs in number of neutrons and consequently in their atomic weight.
   - Isotopes of one element differing by their weight have different capability to enter into chemical reactions and physical processes.
   - Mutual proportion of two isotopes in compound entering into chemical reaction or into physical process is different than their proportion resulting from the chemical reaction or physical process.
   - Investigating the differences in isotope signatures of environmental objects such as air, water, soil, plant tissues, etc. we can trace the circulation of biogenic elements and water.

Nuclear Techniques Used in Soil Science

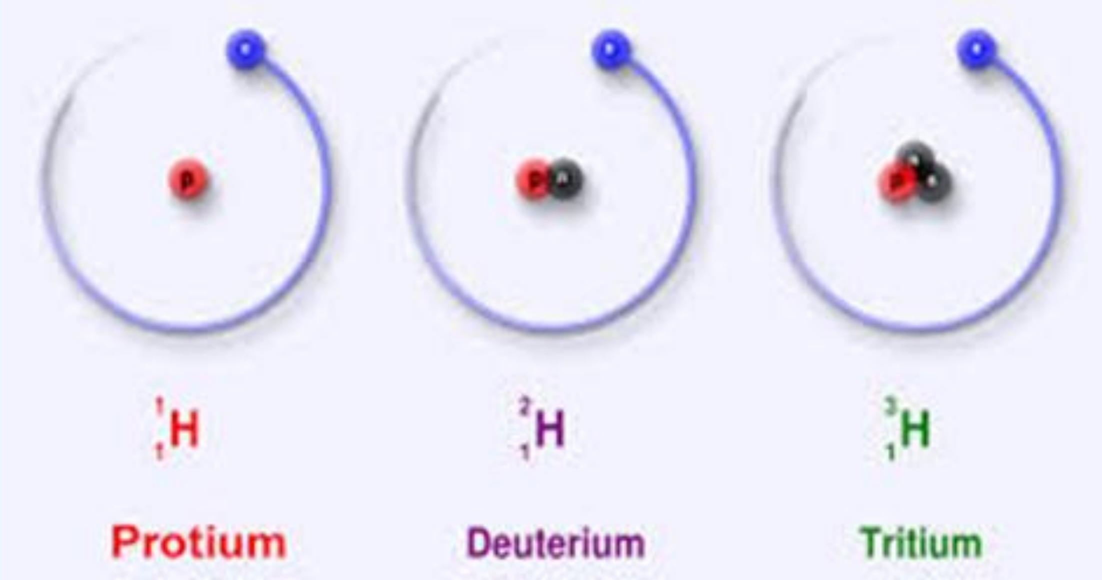
2. Comparing amounts of one isotope at two different places
    - Fallout radionuclides used as erosion tracers
    - Physical processes of transport

3. Measuring the energy of free neutrons in environment
    - Used for soil water measurements
    - Emitting own neutrons
    - Measuring naturally occuring neutrons (cosmic rays)

4. Bombarding elements by X-rays (X-ray fluorescence)

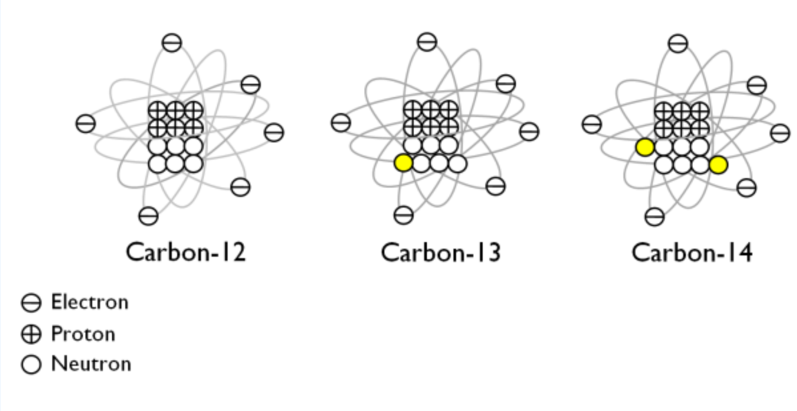
Isotopes

- The chemical properties of a single element are nearly identical (exception isotopes of hydrogen)
- The physical properties of isotopes are different from each other since these properties often depend on mass



Isotopes

- Isotopes are samples of an element with different numbers of neutrons in their atoms



- 275 isotopes of the 81 stable elements
- 800 radioactive isotopes (natural and synthetic)

Nuclear Techniques Used in Soil Science

^{15}N

To quantify biological nitrogen fixation to save N fertilizers

^{15}N ^{32}P

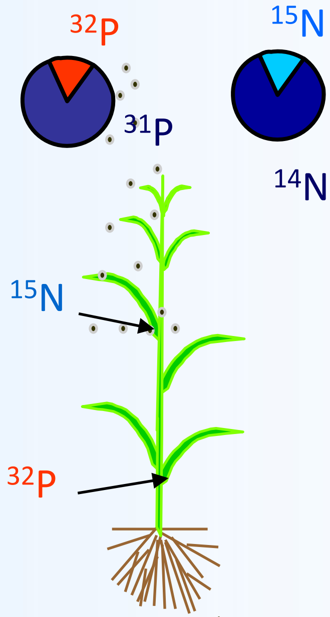
To quantify the flow and fate of N fertilizers to improve fertilizer use by crops

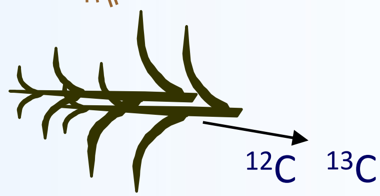
^{13}C

To assess adaptation of crop tolerance to drought and salinity

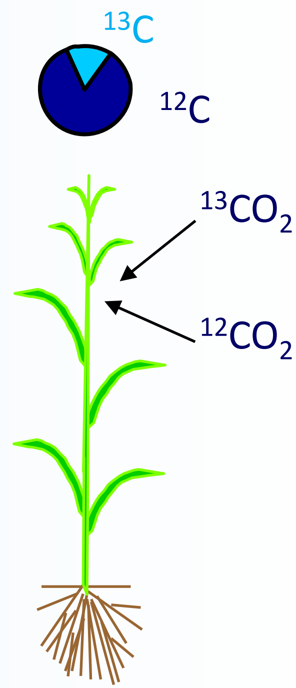
^{18}O ^{2}H

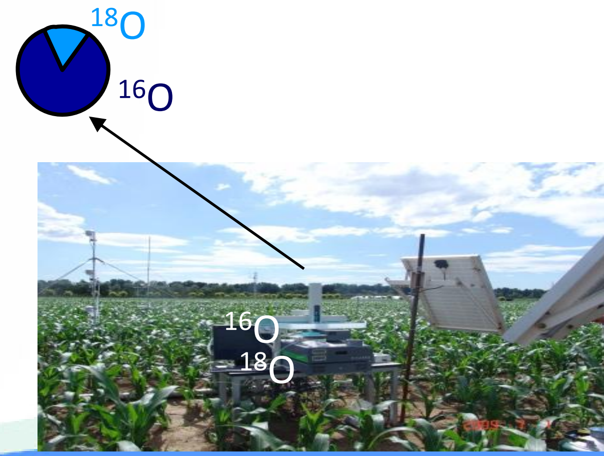
To estimate sources and fluxes of water to improve WUE





To assess soil organic carbon storage ‘sequestration’

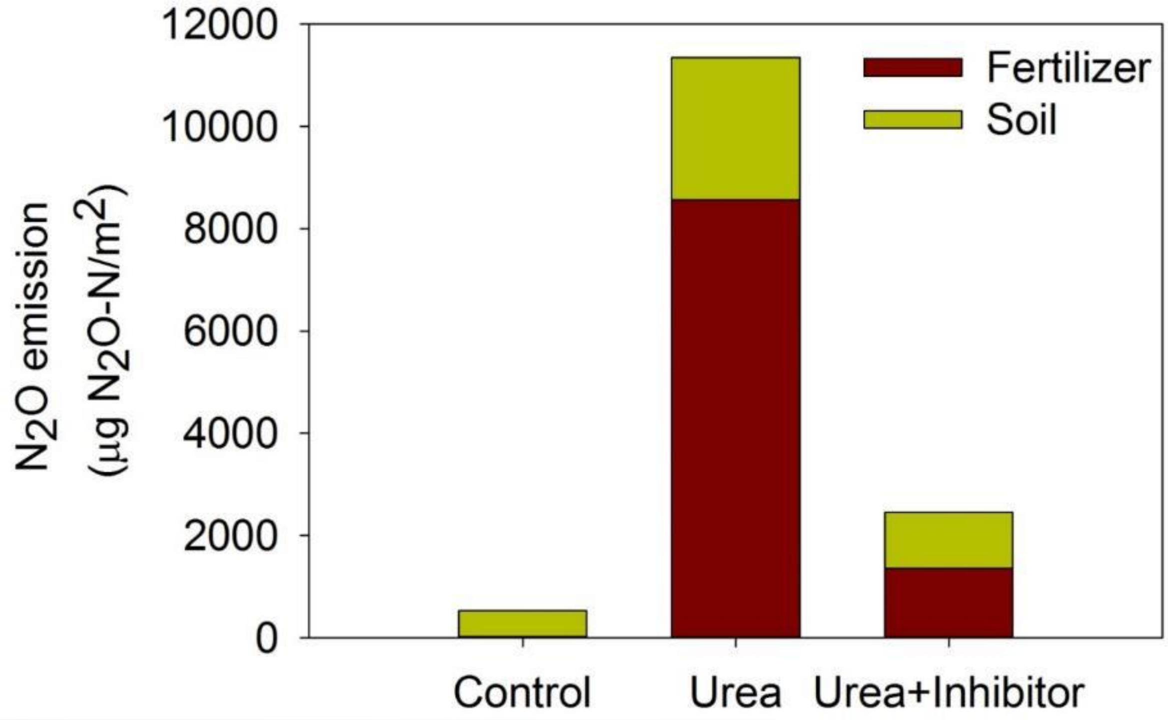




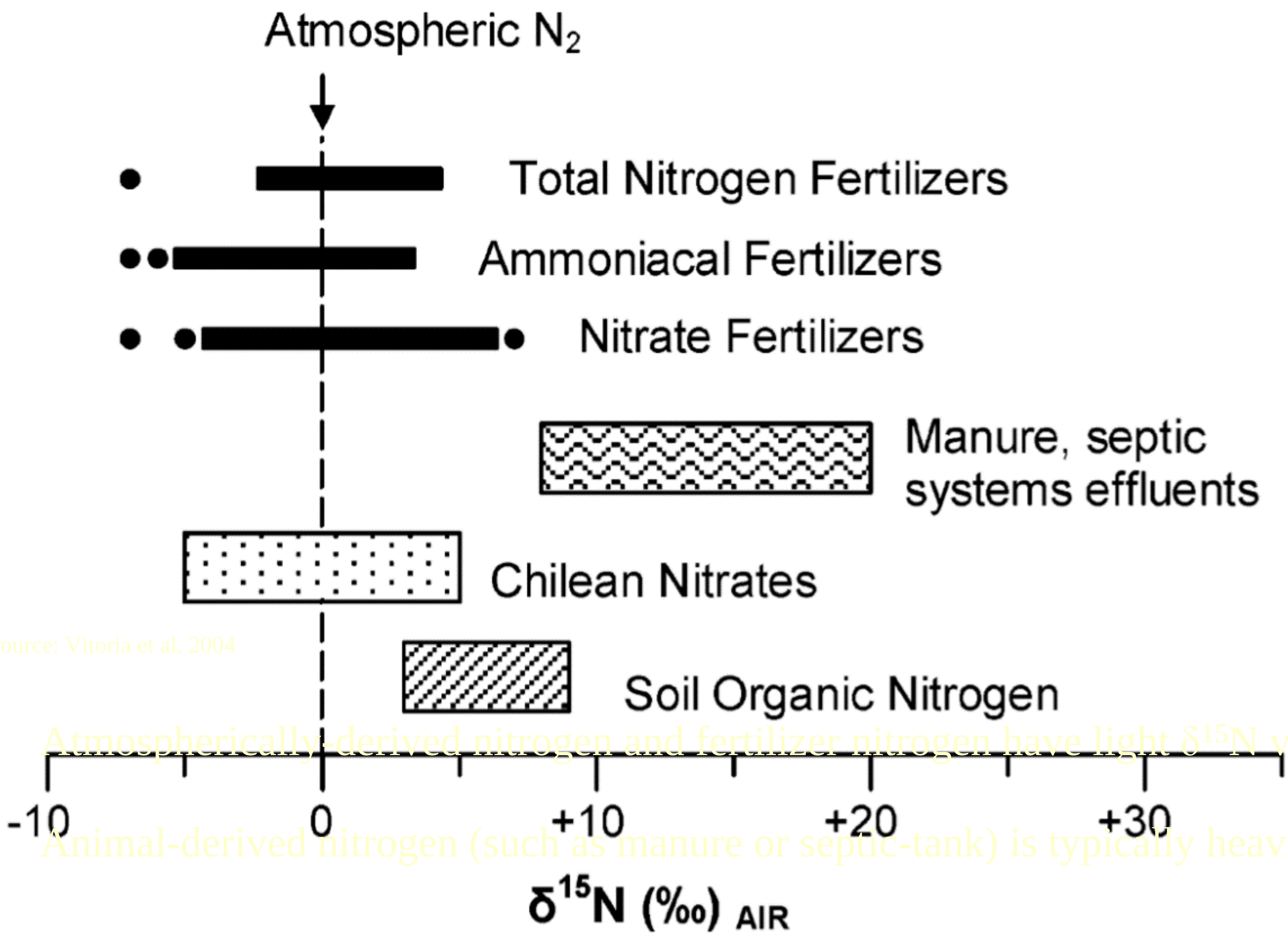
Role of Nuclear Techniques

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

N-15 technique precisely measure N_2O emissions and identify the Nitrogen source (fertilizer versus soil N) enable us to adjust fertilizer N rate to crop need and demand



Isotopic compositions of N



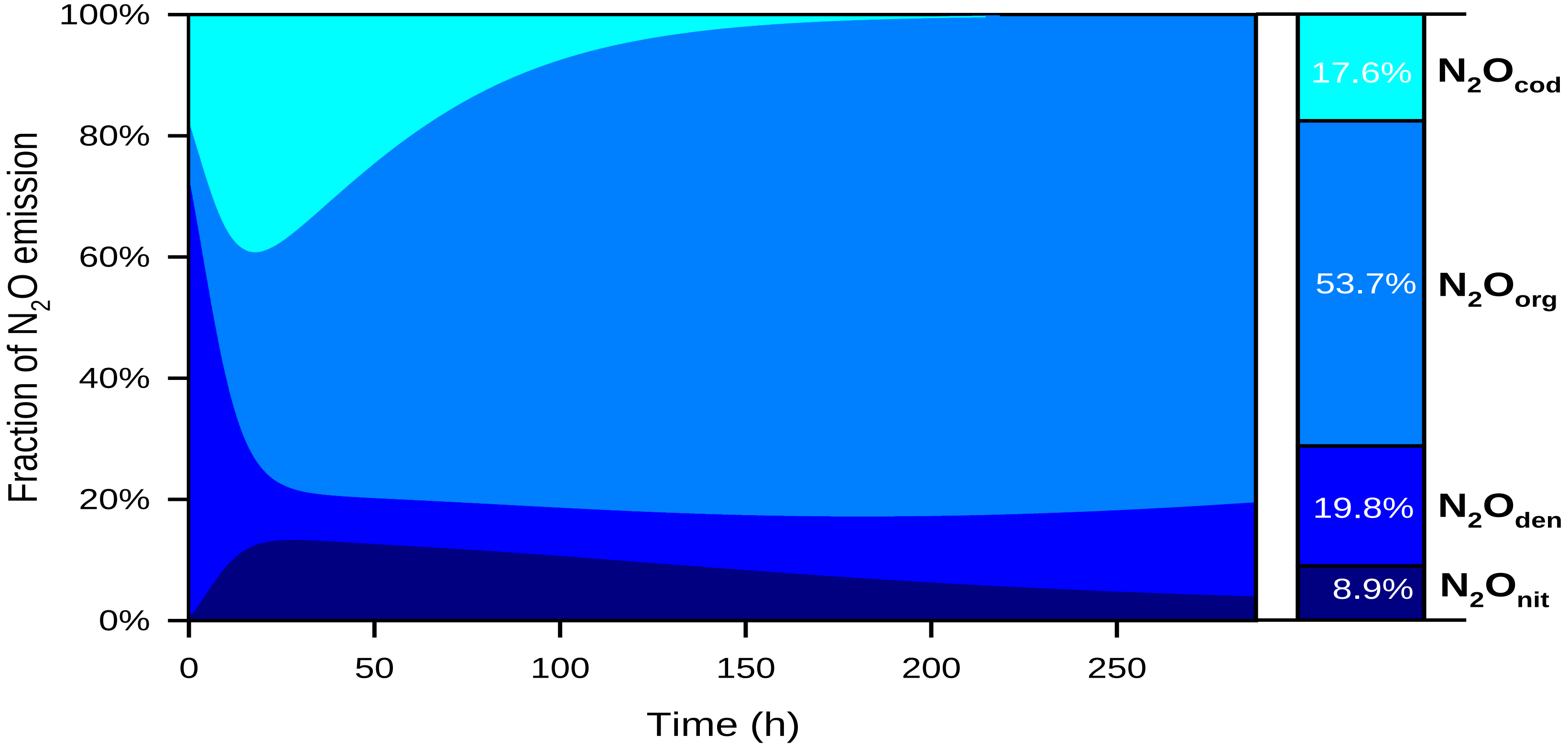
Source: Vitoria et al. 2004

- Atmospherically-derived nitrogen and fertilizer nitrogen have light $\delta^{15}N$ values
- Animal-derived nitrogen (such as manure or septic-tank) is typically heavier

Role of Nuclear Techniques continued

Nitrous oxide is produced from 4 different microbial processes.

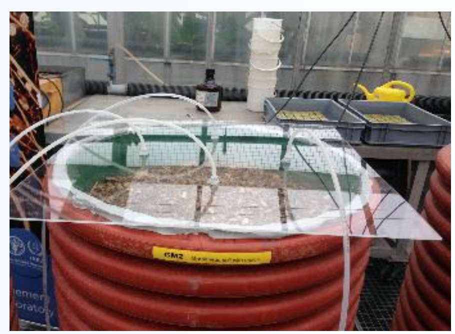
- N-15 technique identifies the exact microbial process which enables us to put more control on that process to reduce N_2O.



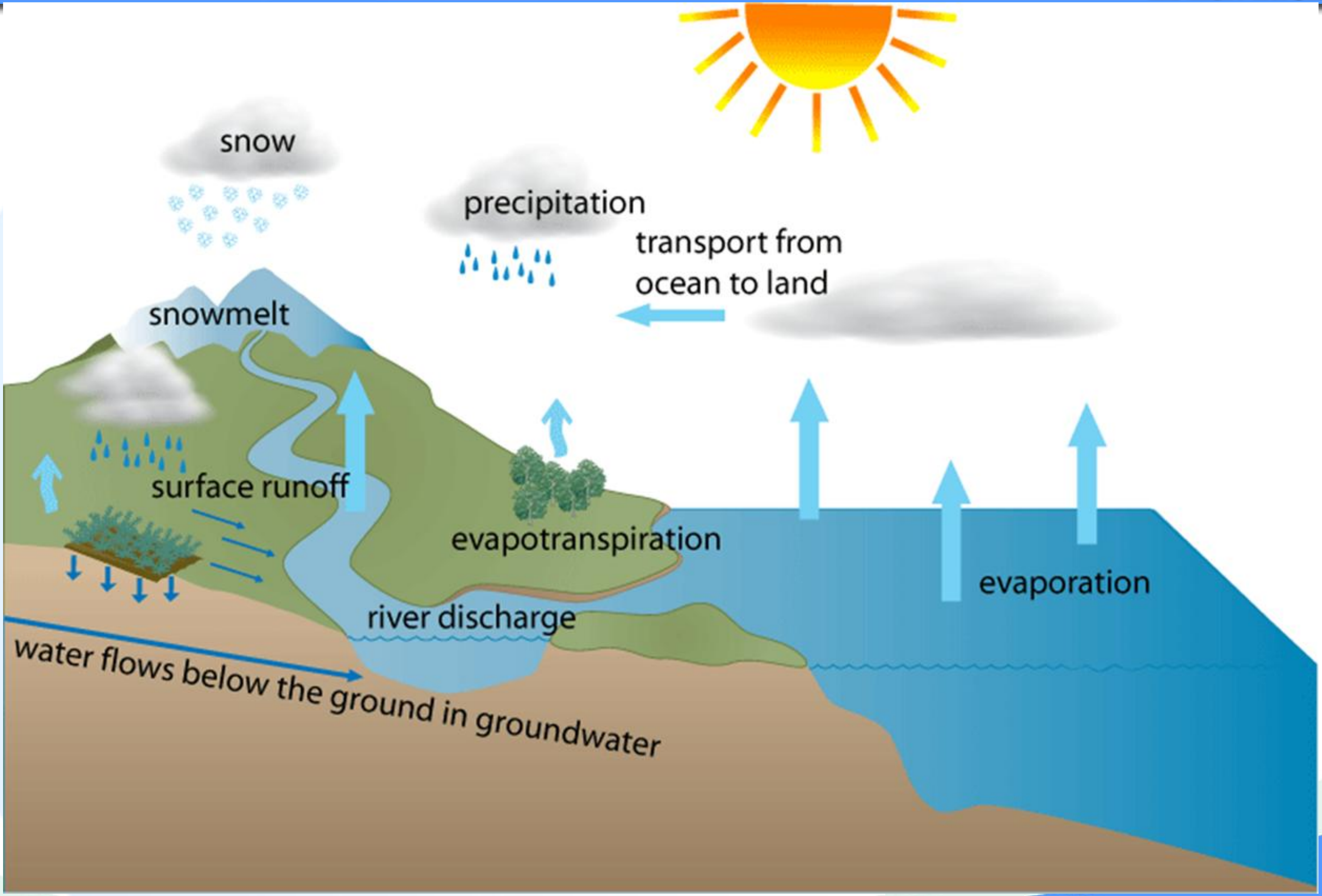
Role of Nuclear Techniques continued

Carbon-13 techniques

- Precisely measure both CO_2 and CH_4 emissions from different agroecosystems
- Identify their exact sources (different plant residues and organic matter in soil)
- Determine C storage (sequestration) in soil
- Labelling plant materials with carbon-13



Simplified Water Cycle



The δ notation

Isotopic ratios are reported in standard "δ" notation as deviations in per mil (‰) from the Vienna-SMOW (Standard Mean Ocean Water)

Is defined as: $\delta^{18}O$ (or δD) = $1000(R_{sample}/R_{VSMOW} - 1)$

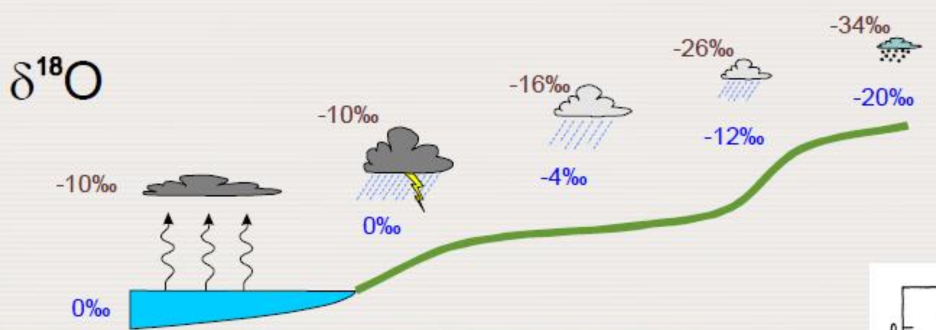
$R \equiv [^{18}O]/[^{16}O]$ (or $R \equiv [D]/[H]$)

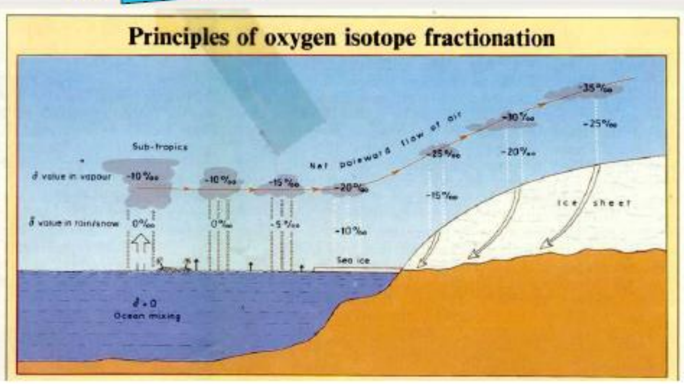
Stable isotope variability in precipitation

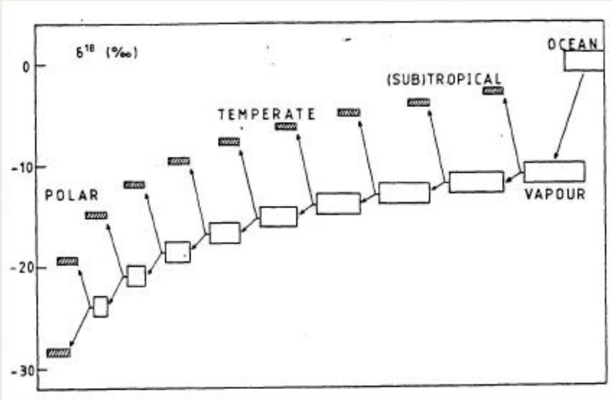
Warm → Cold

Low elevation
Low latitude

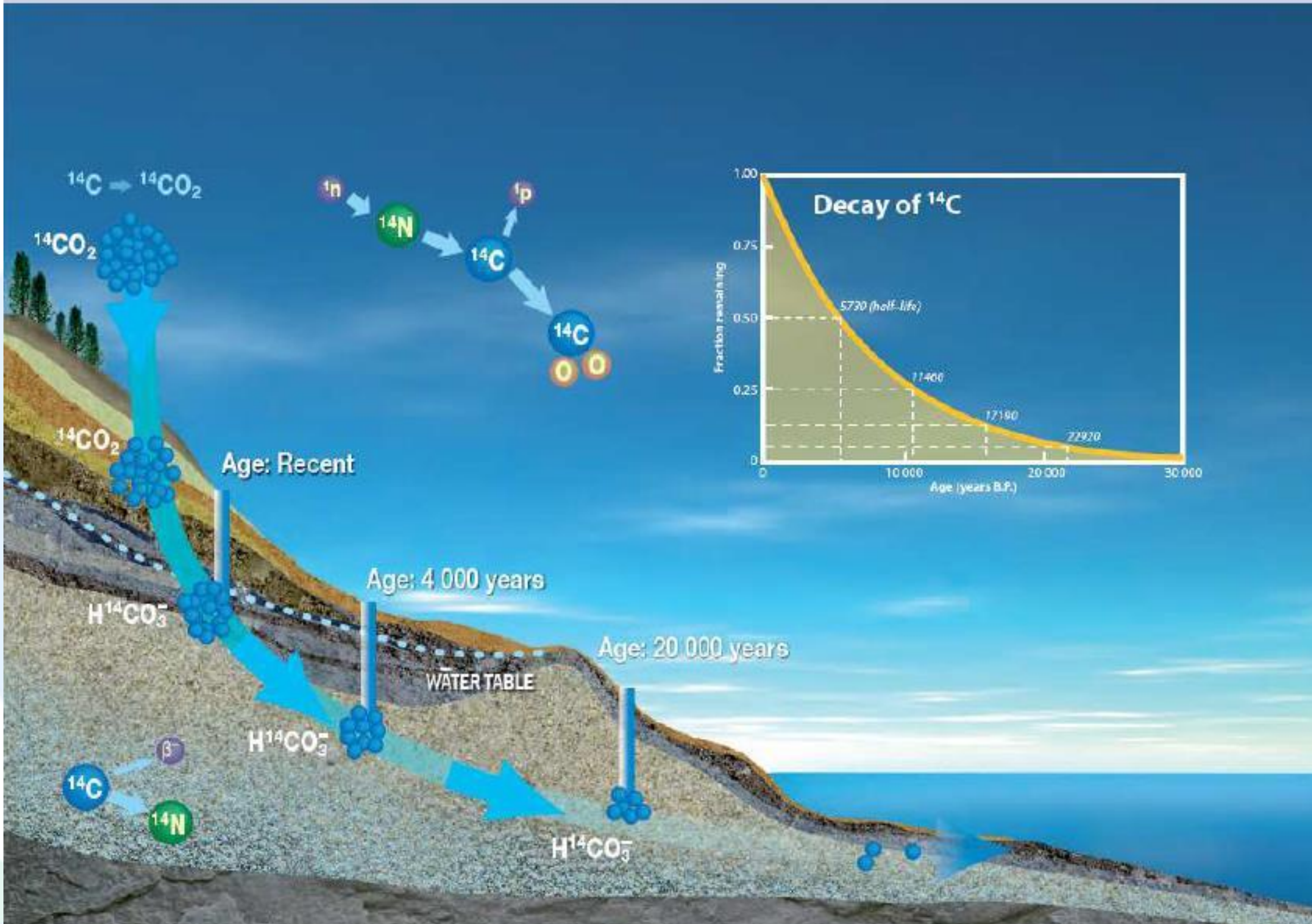
High elevation
High latitude



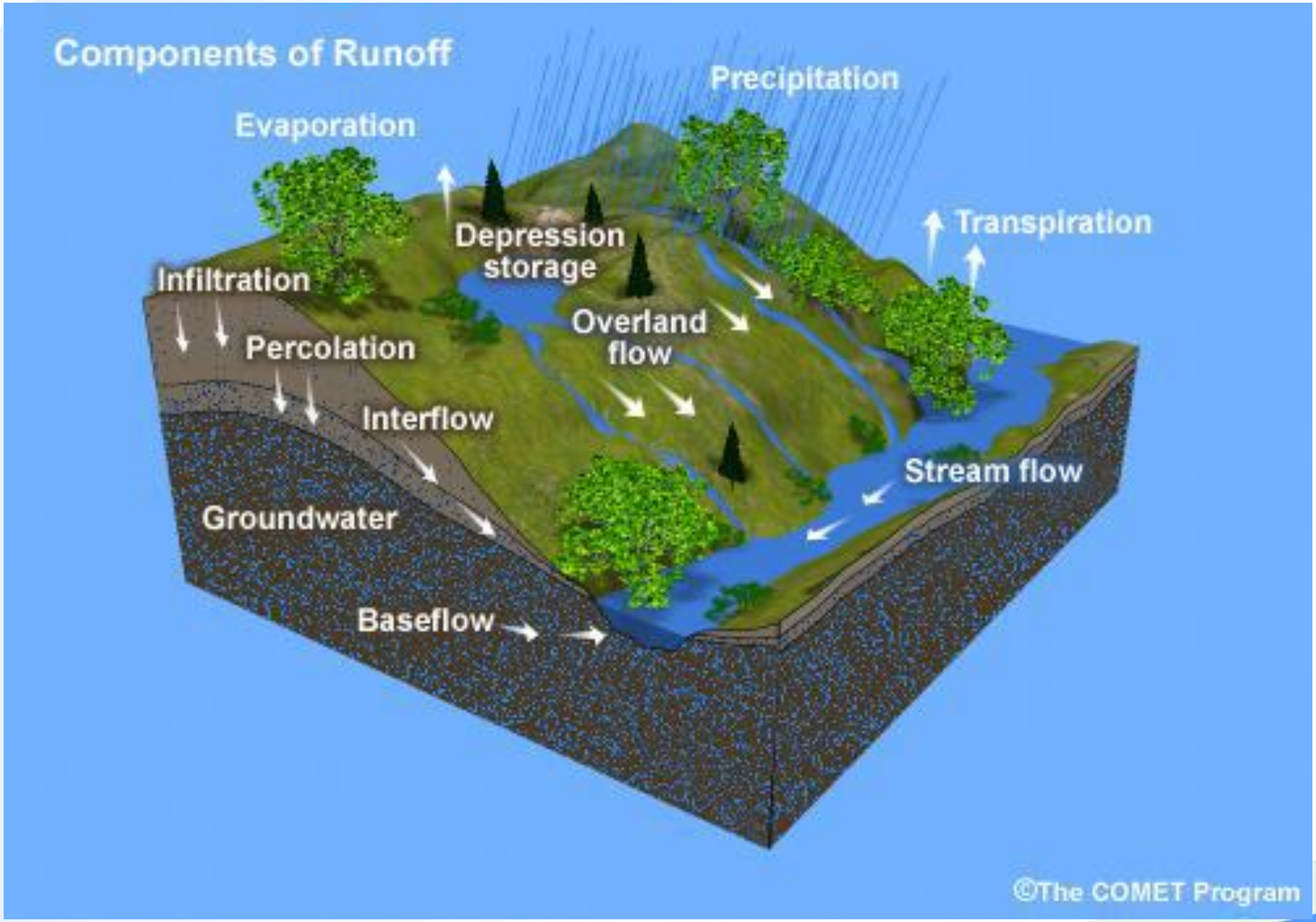




Decay of ^{14}C allows groundwater dating



Components of runoff

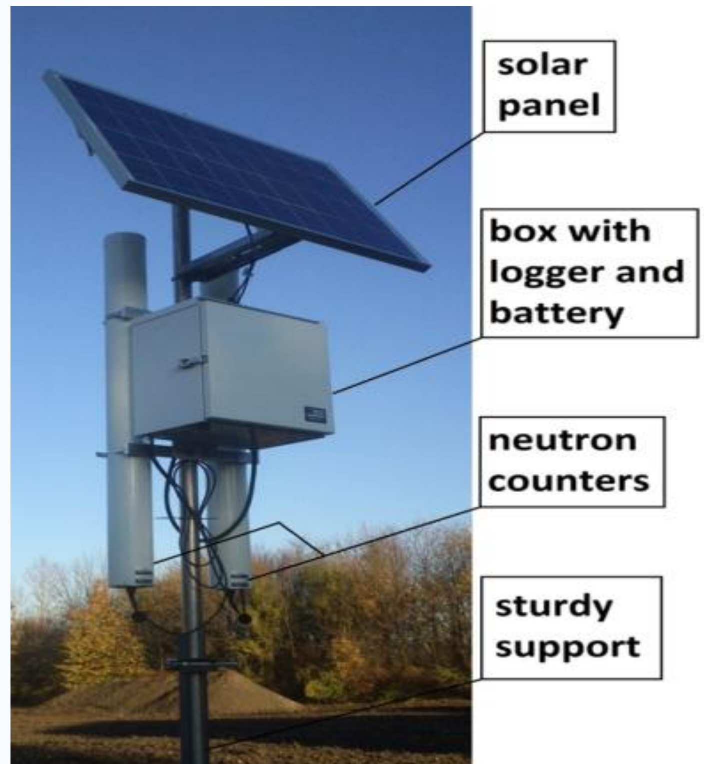


Soil Moisture Neutron Probe

Measure soil moisture to determine when and how much to irrigate, thereby helping farmers to save water. Also ideal for saline conditions.

Cosmic Ray Neutron Sensor

Measure area-wide soil moisture (70 cm depth; 300 m radius (i.e. 30 ha in area)

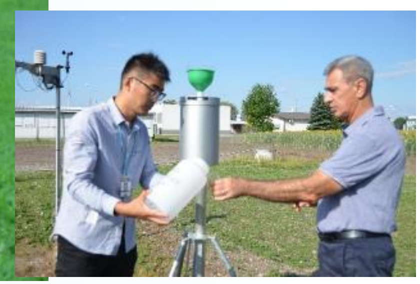


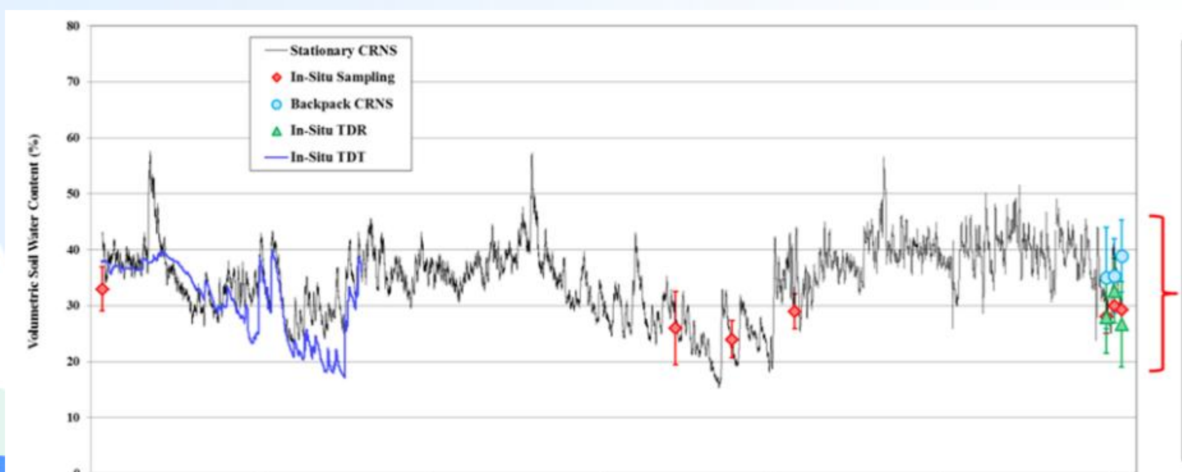
Role of Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture

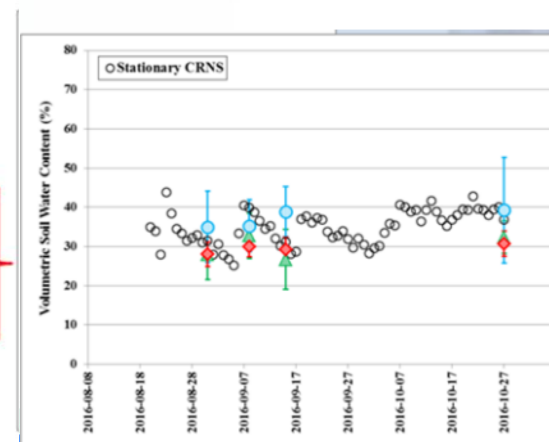
Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Joint FAO/IAEA Division through Soil and Water Management and Crop Nutrition Programme promotes the use of nuclear techniques for soil moisture assessment through:

- Coordinated Research Projects
- Technical Cooperation Projects
- Research and Development activities of Soil Lab



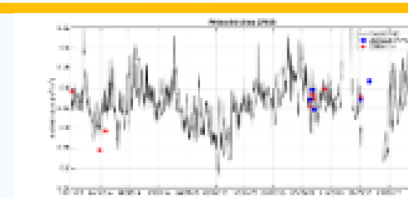




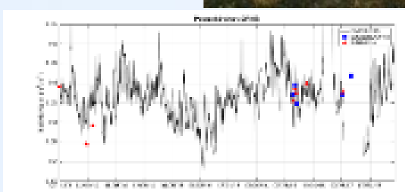
Soil moisture monitoring using CRNS

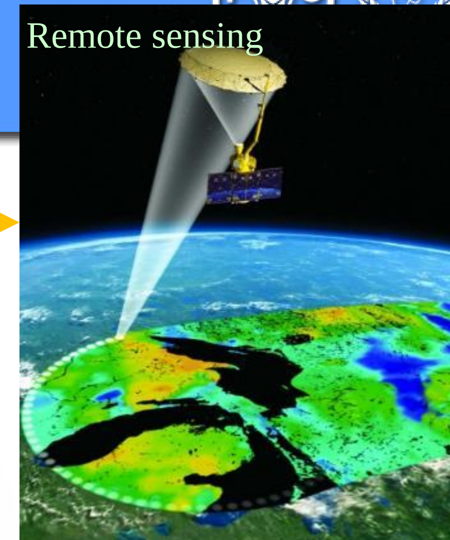
Stationary CRNS

CRNS data

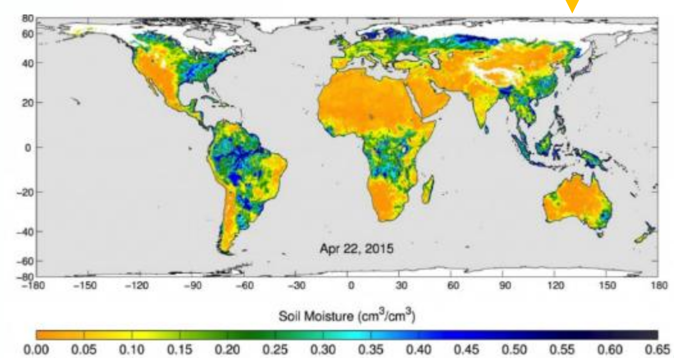


CRNS data



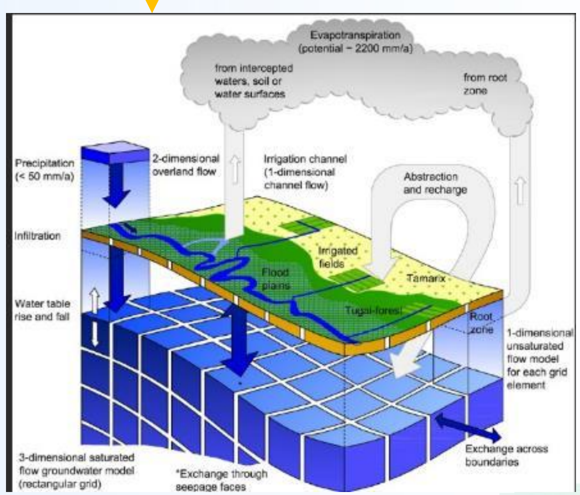


Validation of soil moisture assessment by remote sensing



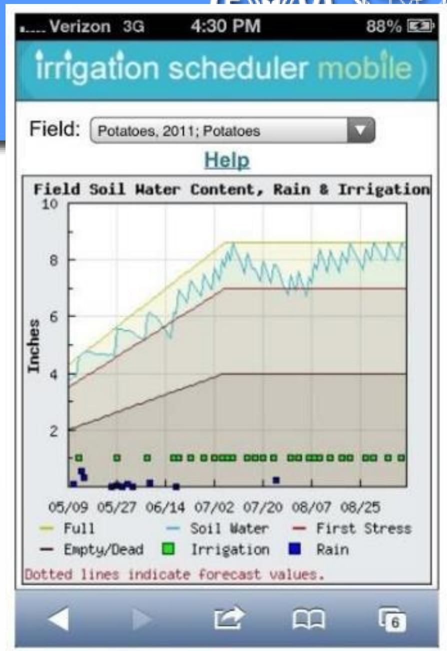
Soil moisture maps

Input data for hydrological modelling



Hydrological model MIKE-SHE

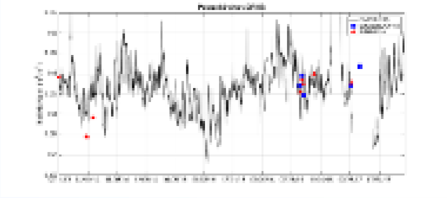
Further improving WUE by irrigation scheduling and heterogeneity mapping



Improving irrigation management

Traditional irrigation (poor WUE)

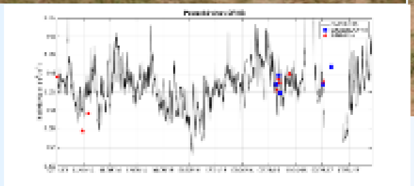
Modern irrigation (improved WUE)



CRNS data

Improving dryland management

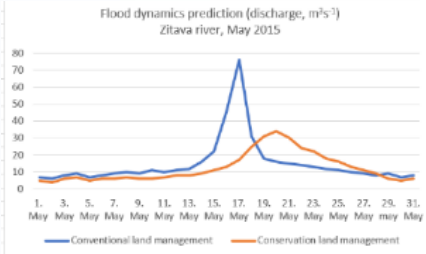
Overgrazing control

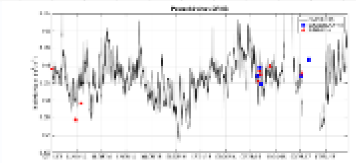


CRNS data

Flood forecast

Early warning system

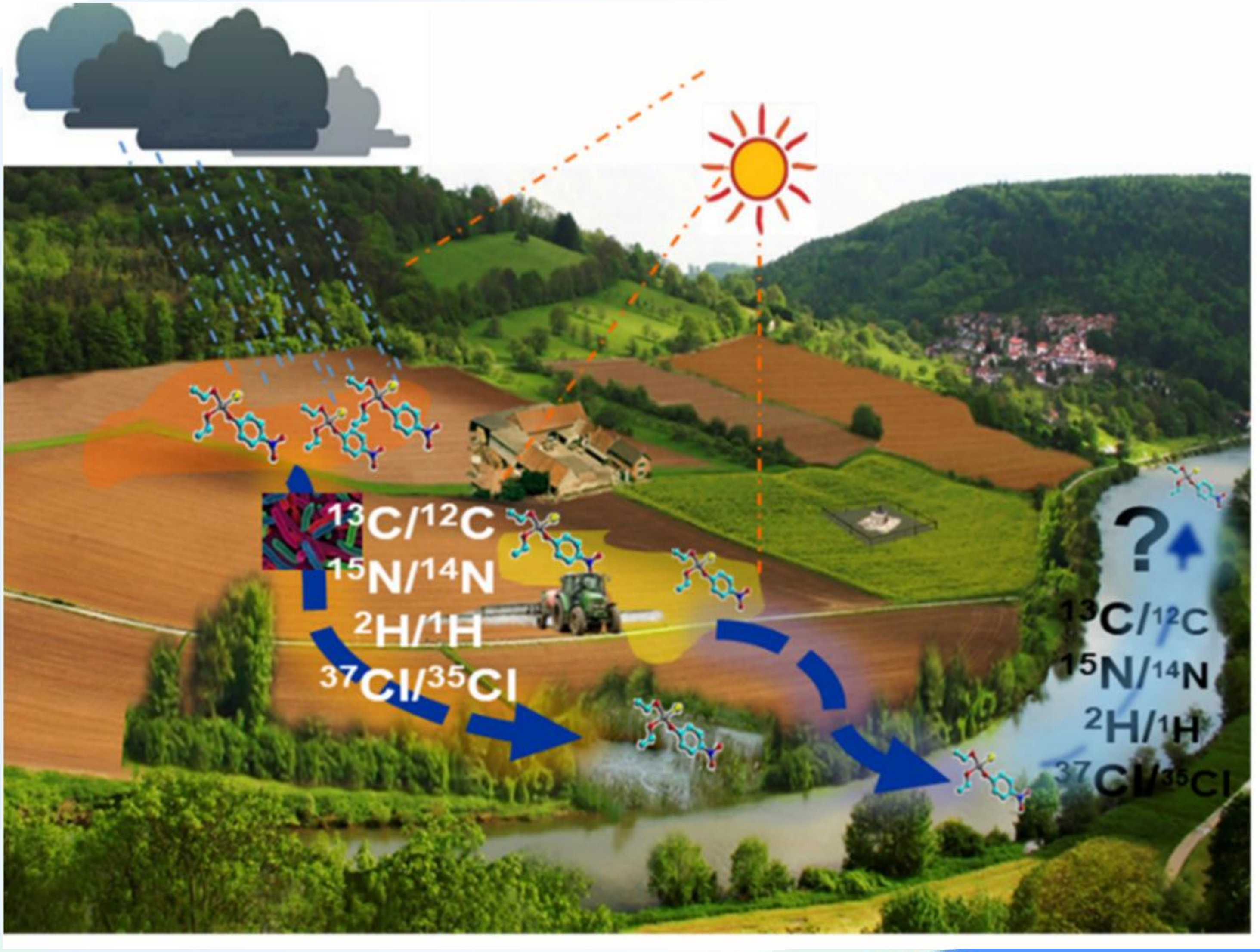




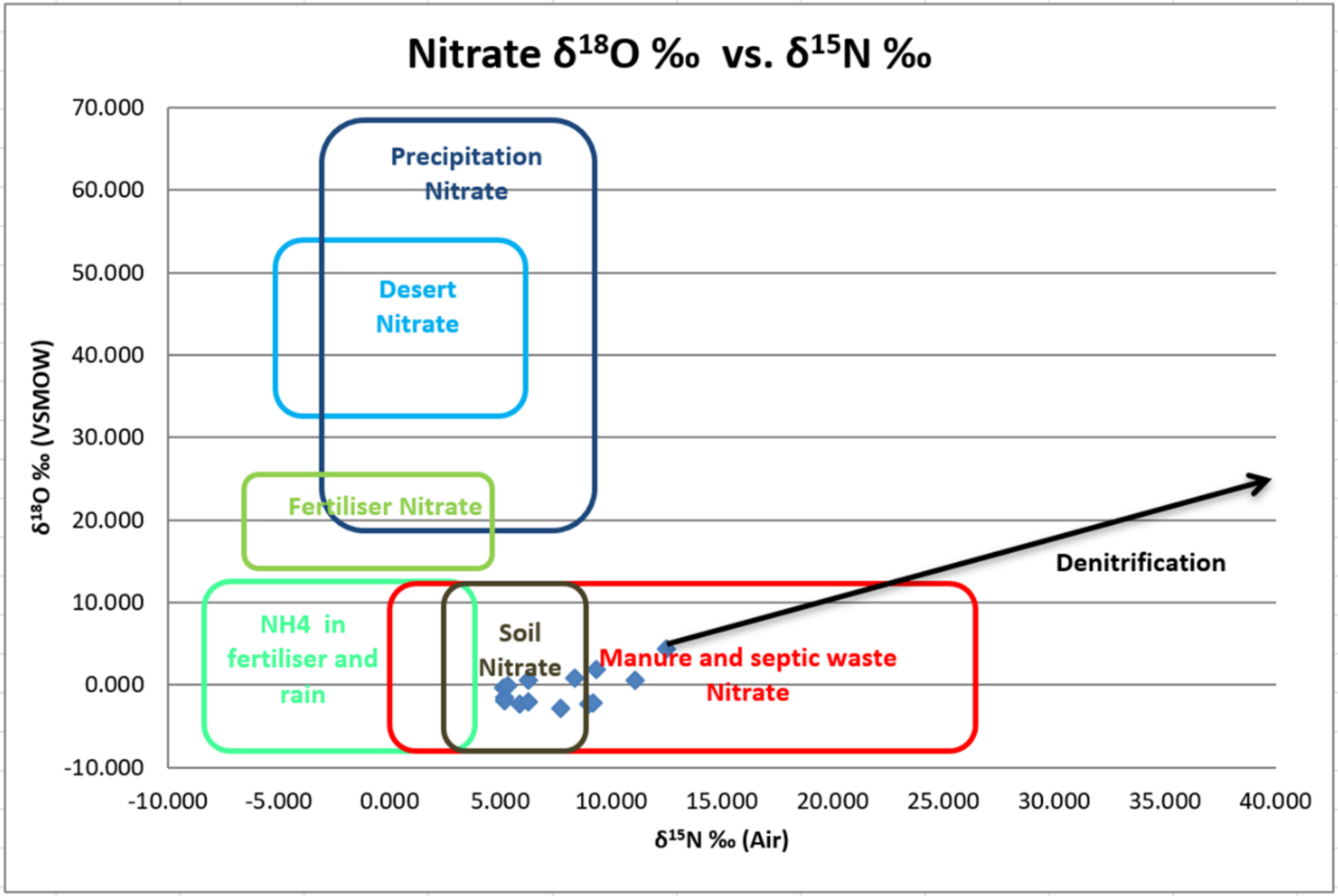
CRNS data

Minimizing Water Pollution from Agriculture

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture



IAEA TC Project SLO5004

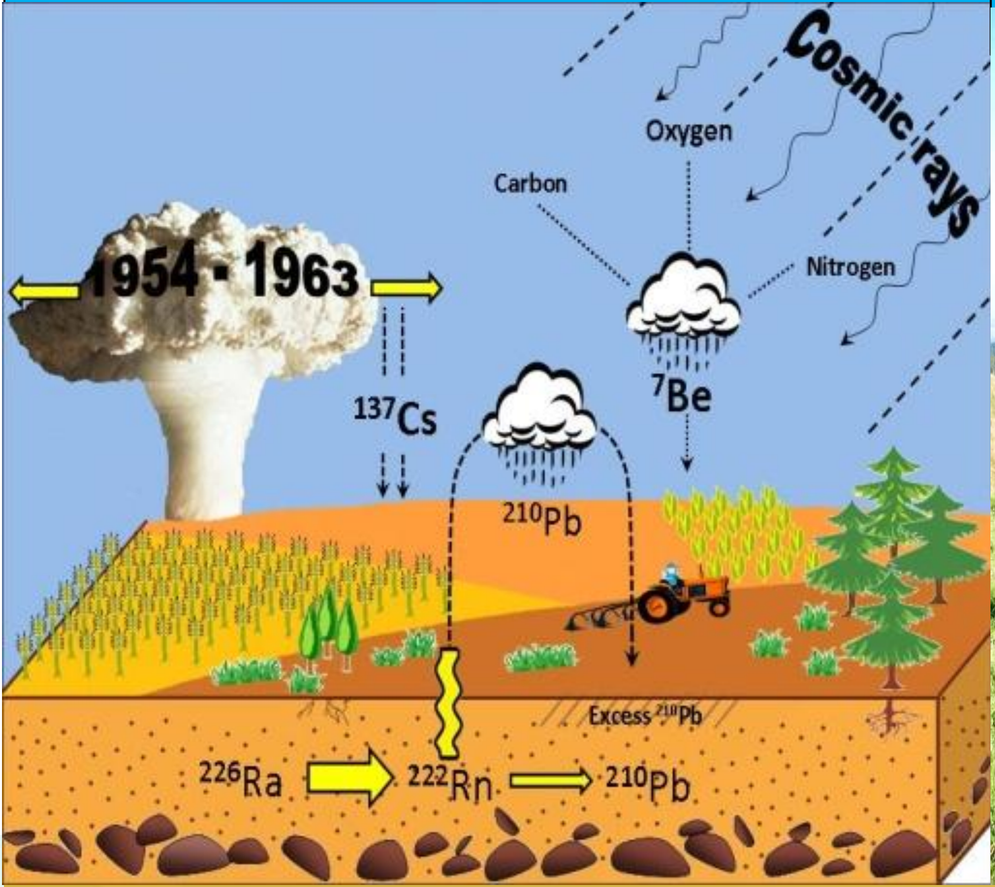


Nuclear Techniques Used (continued)

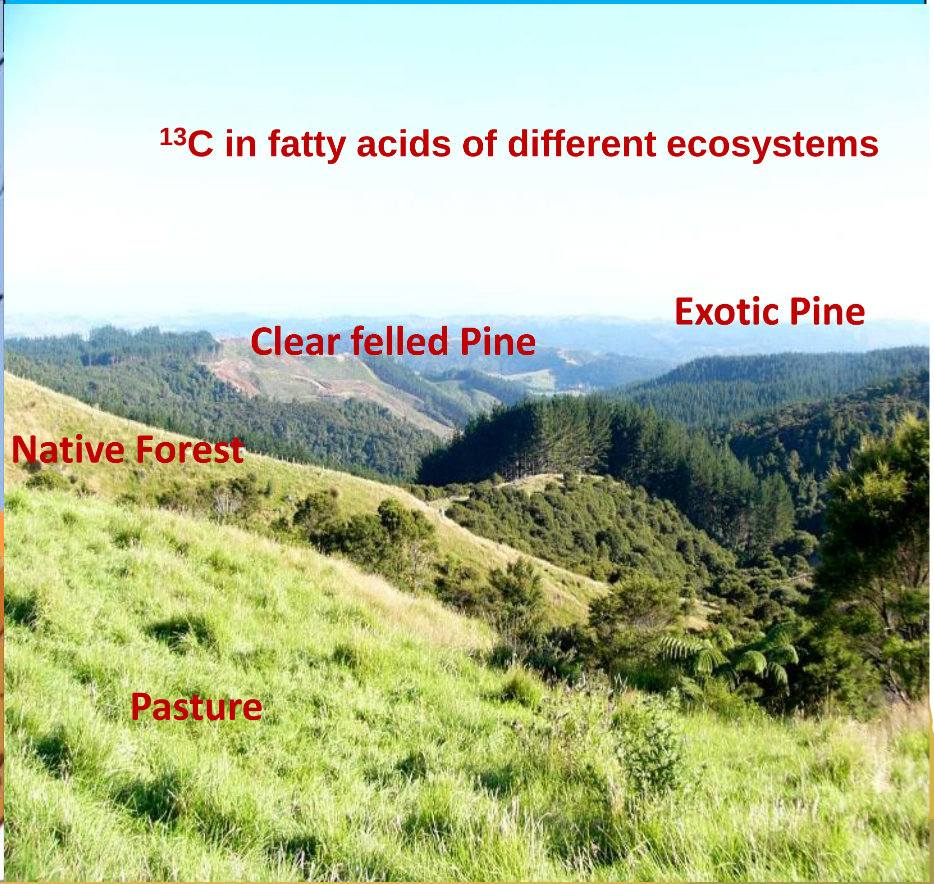
Fallout radionuclides:
^{137}Cs, ^{210}Pb and ^{7}Be

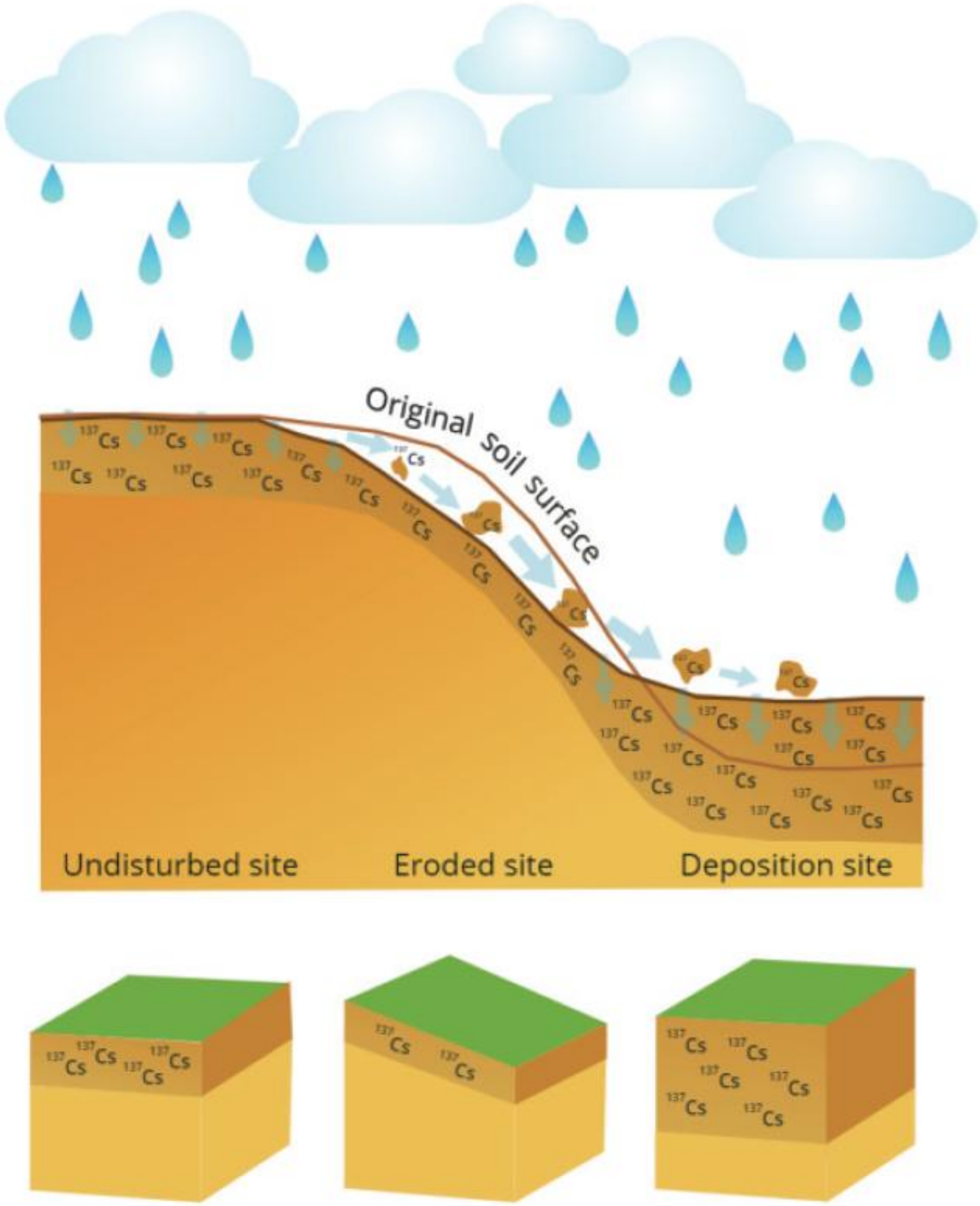
Compound Specific Stable Isotope Analyses (CSSI)

To estimate erosion and sedimentation

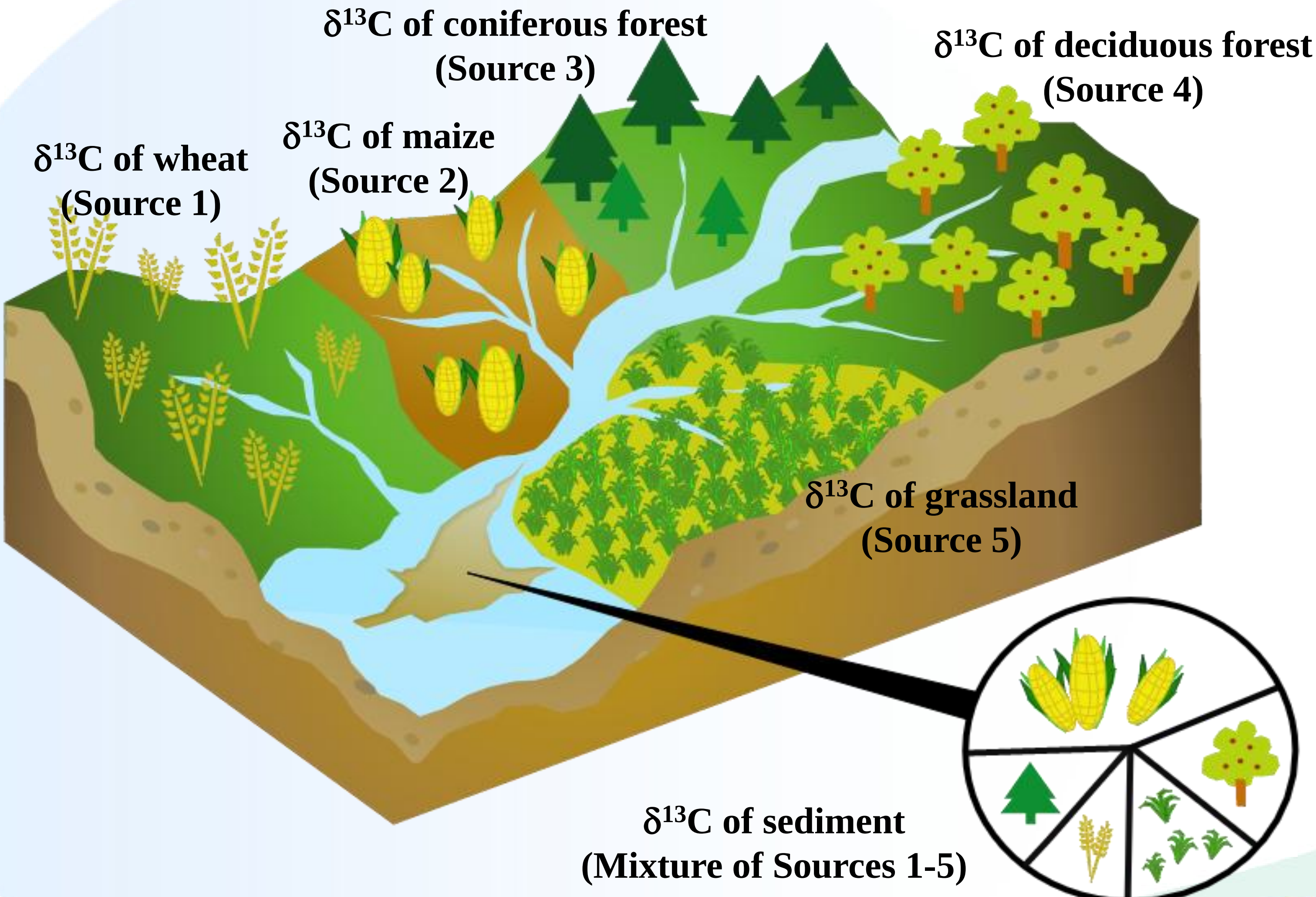


To identify the sediment sources





Scheme of the ^{137}Cs and soil redistribution by erosion: undisturbed, eroded and deposition site.


δ13C of coniferous forest (Source 3)
δ13C of deciduous forest (Source 4)
δ13C of maize (Source 2)
δ13C of wheat (Source 1)
δ13C of grassland (Source 5)
δ13C of sediment (Mixture of Sources 1-5)

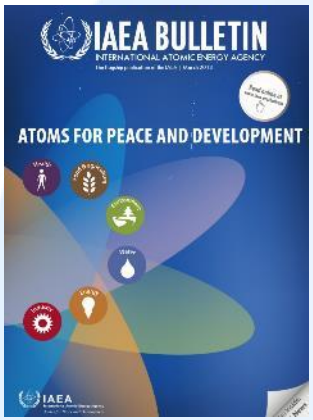

IAEA
How to Win a Fight Against Soil Erosion: Nuclear Science Helps Farmers in Morocco


IAEA
Water in Philippine City Safe to Drink, Study Using Isotopic Techniques Finds


Return to Traditional Terracing Improves Farm Production in Madagascar


IAEA
Five Years On: Nuclear Science Enables Young Philippine Chemist to Study Long-term Impact of Typhoon Haiyan


IAEA
Egypt and Senegal Receive Gamma Detectors to Help Combat Soil Erosion


IAEA BULLETIN
INTERNATIONAL ATOMIC ENERGY AGENCY
ATOMS FOR PEACE AND DEVELOPMENT
IAEA


How to win the fight against soil erosion: saving fertile land and preserving water quality with the help of nuclear techniques
By Nicole Jawerth and Miklos Gaspar
Saving farmland in Morocco

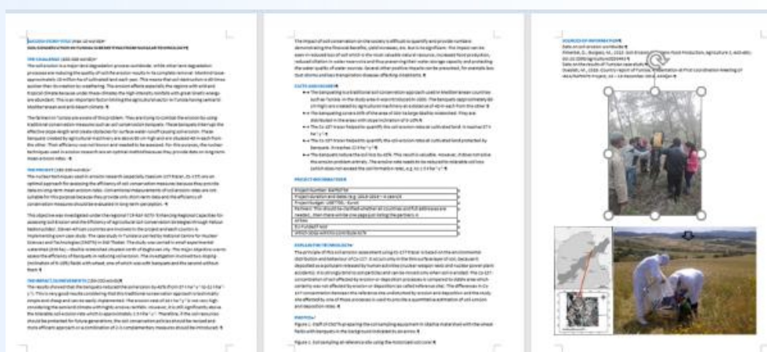

IAEA BULLETIN
INTERNATIONAL ATOMIC ENERGY AGENCY
Nuclear Science & Technology
Addressing current and emerging development challenges
Killing more cancer cells than ever before: a new era in radiotherapy, p. 4
Fertilizer and an atomic balancing act to increase productivity and protect the environment, p. 11
Jeopardy at sea: what atoms in clams tell us about ocean acidification, p. 14

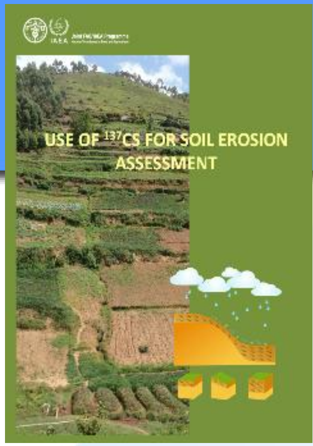

Young Philippine chemist finds missing environmental data by turning to nuclear science
By Miklos Gaspar

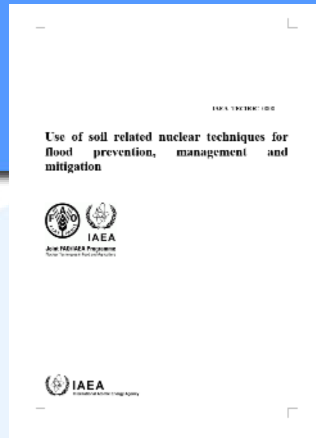

IAEA BULLETIN
INTERNATIONAL ATOMIC ENERGY AGENCY
Nuclear Science & Technology
Addressing current and emerging development challenges
Killing more cancer cells than ever before: a new era in radiotherapy, p. 4
Fertilizer and an atomic balancing act to increase productivity and protect the environment, p. 11
Jeopardy at sea: what atoms in clams tell us about ocean acidification, p. 14

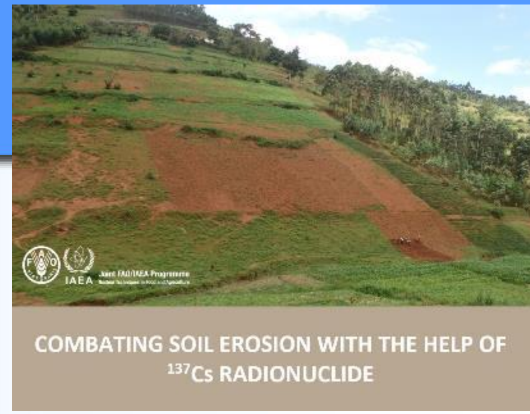

Egypt and Senegal receive gamma detectors to help combat soil erosion

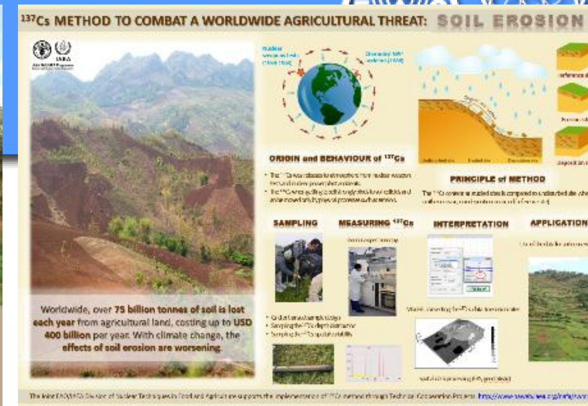

IAEA
MADAGASCAR
Return to traditional terracing improves farm production in Madagascar



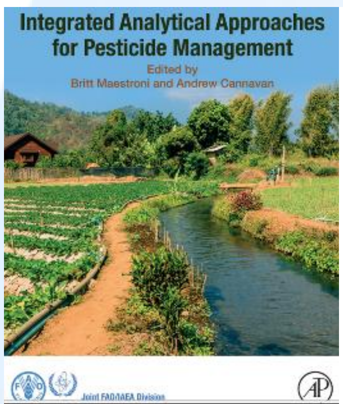


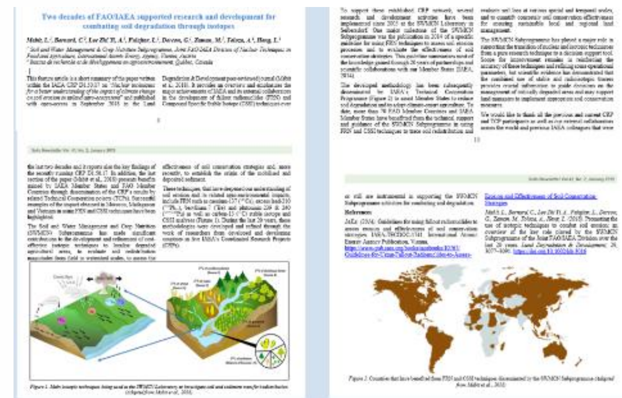


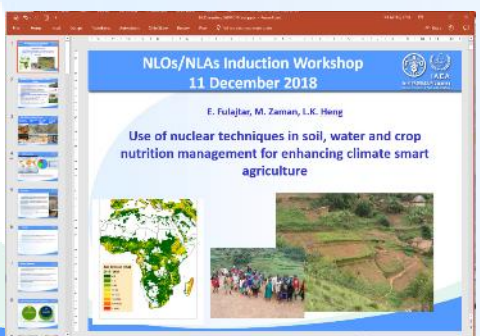




During 1 year over 600 downloads







Thank you for your attention