Significance of Nuclear-Isotopic Technologies in food security, adaptation and mitigation of climate changes

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ABSTRACT

The most negative effect of global warming is climate change that leads to water scarcity. Rising global temperature intensifies hydrological cycle resulting heightened risks of more extreme erratic rainfalls and frequent drought and floods. On the other hand, unsustainable uses of natural resources increase worldwide degradation of extensive tracts of lands. Therefore, the impacts of global warming are the increasing risks of life and health, especially for people in developing countries. It is predicted that billion of people, particularly in the developing countries would faces shortages of water and foods in the next decades, as a result of the increasing pressure of lands and water resources to produce sustainable food security. Thus global action is needed to enable the developing countries to adapt and mitigate those climate changes. Agriculture has significance roles in food security and climate changes, since agriculture is one of an important source of greenhouse gas emissions. Whilst the developing countries contribute most of those emissions. On the other hand, most of the technical mitigation of agriculture could be realized in developing countries. Thus agricultural systems could contribute significantly to overall mitigation, that hopefully could reduce the extent of required adaptation and catastrophic in developing countries. Agricultural system would need to adapt unavordable climate changes and its impacts, in order to ensure the food security. Improving agricultural water management is one of the important ways for adapting agricultural production to combat the global warming and climate changes. Nuclear-Isotopic Technologies have been developed well and used intensively for ecological and agricultural purposes. This paper would review the potential role of Nuclear-Isotopic technologies in exploring potential synergism between food security, adaptation, and mitigation to produce an agricultural system that is more resilient to climate variability.

Keywords: Nuclear-isotopic technologies, climate change, adaptation, mitigation, food security.

INTRODUCTION

The world population is expected to be 8 billion by the year 2020, in which most of the population increases will occur in developing countries where the majority depend upon agriculture for their livelihoods. Therefore a pressure on the availability of land and water resources is facing by the developing countries to achieve a sustainable food security.

Besides this pressing issue, the increasing risks and impacts of the global warming and climatic variability need to be considered as well. Global warming is convinced to have negative impacts and induce climate changes. In turn it will put increasing pressures on sustainable land and water resources to produce sufficient food for the ever-increasing world population.

Climate change is an important global issue to be tackled. Climate change is alteration of the composition of the global atmosphere and natural climate variability observed over comparable time periods. It is caused by increasing greenhouse gasses (GHGs) of the earth's atmosphere (Table 1). These gasses allow solar radiation from the sun to travel through the atmosphere but prevent the reflected heat from escaping back into space. This causes the earth's temperature to rise, polar meltdown, sea level rise, desert climate change, flora and fauna extinction, emergence of new diseases, etc. The effects of climate change so far have appeared in the form of extreme weather, including heavy rainfall in shorter periods of time further leading to floods and landslides, and an increase in frequency and intensity of drought in parts of Asia and Africa in recent decades. Many of these changes have already led to multiple socio-economic impacts.

Table 1. Global Warming Potential (GWP) of Main Greenhouse Gases (GWP-GHGs)

Species	Antrophogenic Sources	Pre-industrial tropospheric concentration	Recent tropospheric concentration	Life Time (years)	GWP (Time Zone)#
					20 years
CO_2	Fosil Fuel Comb Land Use Conversion Industrial production	280 ppm	390.5 ppm	Variable	1
METHANE (CH_4)	Fosil Fuel Com Rice Fields Livestock Landfill Waste	700 ppb	1871 ppb	12	56
NITROUS OXIDES (N_2O)	Fertilizers Combution Industrial Processes	270 ppb	323 ppb	120	280

Developing countries are the most vulnerable to climate change impacts because they have fewer resources to adapt socially, technologically and financially. Climate change is anticipated to have far reaching effects on the sustainable development of developing countries including their ability to attain the United Nations Millennium Development Goals by 2015 (UN 2007). Many developing countries' governments have given adaptation action a high, even urgent, priority. However, developing countries have very different individual circumstances and the specific impacts of climate change on a country depend on the climate it experiences as well as its geographical, social, cultural, economic and political situations. As a result, countries require a diversity of adaptation measures very much depending on individual circumstances. However there are cross cutting issues which apply across countries and regions (Table 2).

Climate change solutions need to be identified and exploited synergy, as. well as seek to balance trade-offs, among the multiple objectives of sustainable development, disaster risk reduction and adaptation policies. Such initiatives also require new and sustained funding sources. The same sectors that are affected by climate change, albeit to differing degrees, are agriculture, water resources, human health, terrestrial ecosystems and biodiversity and coastal zones. Although knowledge of how best to do adaptation is still in its infancy, the Parties of the UNFCCC are increasing their support for action on adaptation. This includes the development of national adaptation programmes by some developing countries including least developed countries, and their integration into national strategies.

Over the next decades, it is predicted that billions of people, particularly those in developing countries, face shortages of water and food and greater risks to health and life as a result of climate change. Therefore, concerted global action is needed to enable developing countries to adapt to the negative effects of climate change that are happening now and will worsen in the future.

In Indonesia, the effects of climate change include the increase of temperature by an average of 0.3 °C since 1990, two to three percent increase in precipitation, harvest failures are threatening food security in some areas . Sea level rise causing the submergence of coastal fish and food cultivation areas as well as disappearance of small islands, and ocean temperature increase causing coral bleaching . West Sumatra, South Sumatra, Western Java, and Eastern Java of Indonesia are among the most vulnerable regions to climate change in Southeast Asia (Figure 1).

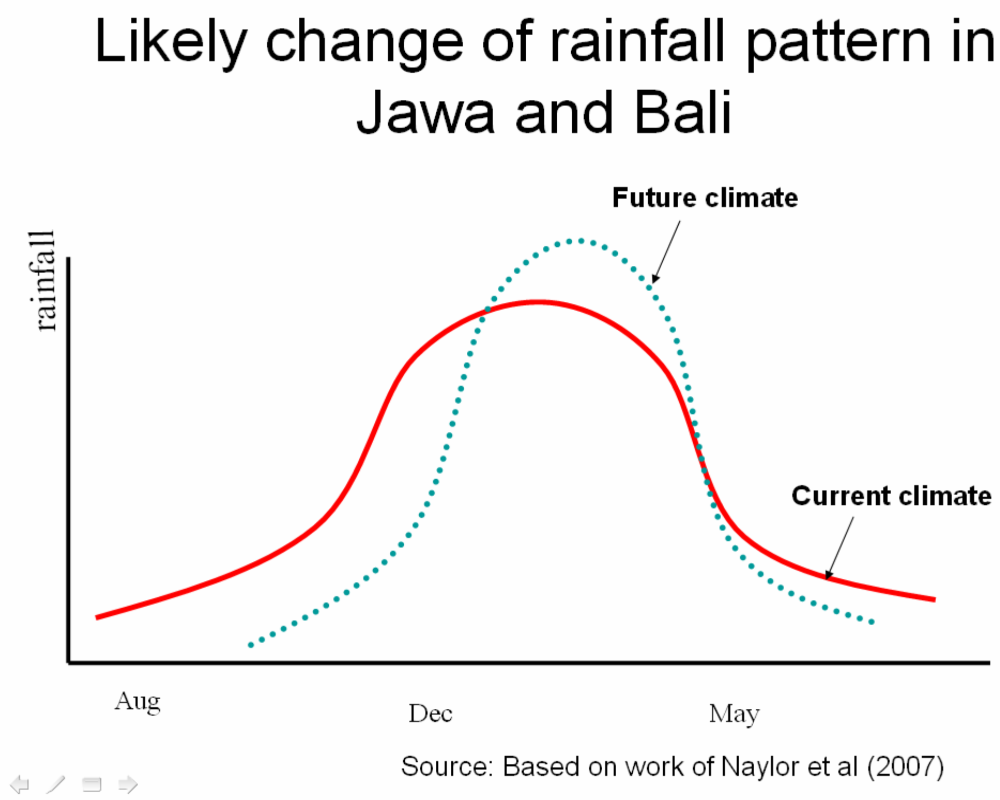

Figure 1. Rainfall-pattern change

As one of the most vulnerable regions in Southeast Asia, there are two reasons why Indonesia needs to be proactive in combating climate change. First, as the third largest of CO2 emmiter and characteristics of the geographical, geophysical and biological, Indonesia has the opportunity to play an important role in the global effort to stabilize climate. Second, the initial step of the important role has already begun, as Indonesia became the host of the 13th Conference of the parties of the UNFCCC, resulting in the Bali Road Map. Indonesia was also involved in the formulation of an initiative called the reduction of Emissions from Deforestation and Degradation (REDD). With the commitment to reduce GHG emission by 26 percent (or 41 percent with the assistance of developed countries), Indonesia also shows its important contribution to the global effort towards addressing the impacts of climate change. This will lead to various political and economic efforts to create opportunities for the Indonesian stakeholders to participate in the reduction of carbon emissions from various sectors and the improvement of environmental quality.

The impact and consequences of global warming for agriculture in developing countries

The food price crisis of 2008 has led to the re-emergence of debates about global food security and its impact on prospects for achieving the first Millennium Development Goal (MDG) to end poverty and hunger. Meanwhile, global climate change is considered as posing the greatest threat to agriculture and food security in the 21st century, particularly in many of the poor, agriculture-based countries such as South East Asia and Africa with their low capacity to effectively cope.

The impacts of climate change are already being experienced across the globe. The main impact of global warming on agricultural production can be summarized as follows: • Higher temperatures affect plant, animal and farmers' health, enhance pests and reduce water supply increasing the risk of growing aridity and land degradation. • Modified precipitation patterns will enhance water scarcity and associated drought stress for crops and alter irrigation water supplies. They also reduce the predictability for farmers' planning. • The enhanced frequency of weather extremes may significantly influence both crop and livestock production. It may also considerably impact or destroy physical infrastructure for agriculture. • Enhanced atmospheric concentrations of CO_2 may, for a limited period of time, lead to 'natural' carbon fertilization and thus a stimulus to crop productivity. • Sea level rise is likely to influence trade infra-structure for agriculture, may inundate producing areas and alter aquaculture production conditions.

Generally, the impact and consequences of global warming for agriculture tend to be more severe for countries with higher initial temperatures, greater climate change exposure, and lower levels of development. Particularly hard hit will be areas with marginal or already degraded lands and the poorest part of the rural population with little adaptation capacity.

This impact of global warming has significant consequences for agricultural production and trade of 2080 suggest a decline of some 15–30 per cent of agricultural productivity in the most climate-change-exposed developing country regions – Africa and South Asia. For some countries in these regions, total agricultural production could decline by up to 50 per cent. The poorest farmers with little safeguards against climate calamities often live in areas prone to natural disasters. More frequent extreme events will create both a humanitarian and a food crisis (Table 2).

Table 2 Climate change impacts in developing countries.

Environmental Impacts	Socio-economic resources and sectors affected
• Changes in rainfall patterns • Increased frequency andse verity of: Floods, Droughts, Storms, Heat waves • Changes in growing seasons and regions • Changes in water quality and quantity • Sea level rise • Glacial melt	• Water resources • Agriculture and forestry • Food security • Human health • Infrastructure (e.g. transport) • Settlements: displacement of inhabitants and loss of livelihood • Coastal management • Industry and energy • Disaster response and recovery plans

Water scarcity

The four major factors driving the increasing water demand are population growth, industrial development, the expansion of irrigated agriculture, and the impacts of climate change and climate variability. Water is a major input for agricultural production under both rainfed and irrigated conditions. Agriculture is the predominant user (75%–80%) of the available freshwater resources in many parts of the world. About one-third of the world's population lives in countries suffering from moderate to high water stress. By 2020, water use is expected to increase by 40% and 17% more water will be required to produce the food requirements of the growing population . Competition among different sectors for scarce water resources and increasing public concern about water quality for human, animal, and industrial consumption and recreational activities, have focused more attention on water management in agriculture. As water resources shrink and competition from other sectors grows, agriculture faces a dual challenge: to produce more food with less water and to prevent the deterioration of water quality through contamination with runoff, soil erosion, and sedimentation, and associated nutrients and agrochemicals .

The most negative impacts of climate change will be water scarcity. Changing climate will have significant impacts on the availability of water, as well as the quality and quantity of water that is available and accessible. Rising global temperatures will lead to an intensification of the hydrological cycle, resulting in dryer dry seasons and wetter rainy seasons, and subsequently heightened risks of more extreme and frequent floods and drought (Figure 2). Increased evaporation and evapotranspiration with associated soil-moisture deficits will impact rainfed agriculture. Recent estimates show that for each 1°C rise in average temperature dryland farm profits in Africa will drop by nearly 10% (FAO, 2008b). In addition, increased evaporation of open water storage can be expected to reduce water availability for irrigation and hydropower generation.

Figure 2 . Extreme results of climate change (drought and floods)

The outlook for the coming decades is that agricultural productivity needs to continue to increase and will require more water to meet the demands of growing populations. Ensuring equitable access to water and its benefits now and for future generations is a major challenge as scarcity and competition increase.

Land and soil-quality degradation

In a recent situation analysis of the food and agricultural sector in the developing world, it was noted that among several issues of global significance, the status of land degradation has continue to worsen in many parts of the world, and the impacts of climate change have exacerbating pressures on the natural resources. This increased worldwide degradation of extensive tracts of land causes a decline in productivity, disrupts vital ecosystem functions, negatively impacts biodiversity, and increases vulnerability to climate.

Both land-use change and intensification of agricultural production on existing croplands can have significant adverse impacts on soils, but these impacts – just as for any crop – depend critically on farming techniques. Inappropriate cultivation practices can reduce soil organic matter and increase soil erosion by removing permanent soil cover. The removal of plant residues can reduce soil nutrient contents and increase greenhouse gas emissions through losses of soil carbon. The most significant indirect emissions are changes in natural vegetation and traditional land use, including deforestation and soil degradation. Soil carbon losses caused by agriculture account for one tenth of total CO2 emissions attributable to human activity since 1850. Deforestation is a common land-preparation practice in many agricultural regions that leads to massive loss of carbon stocks and massive CO2 emissions. The IFOAM Basic Standards for Organic Production and Processing prohibit the clearing of primary eco-systems. The world's soil is however a major store of carbon – approximately three times the amount in the air and five times as much in forests (Figure 3).

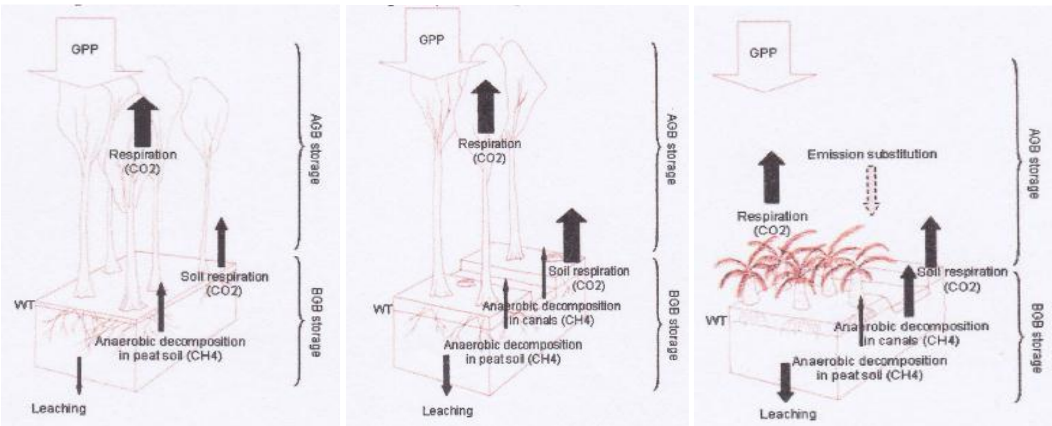

Figure 3. Carbon fluxes caused by natural land and ecosystem conversion (left to right : primary/undrained; drained and partly logged; oil palm plantation)

Improper management agricultural practice pronounce the impact on environment. Clearing of all vegetation and construction of roads will reduces the permeability of the land, causes a loss of soil faunal activity, and compacts the land, all of which increases top soil runoff and causes soil erosion. Therefore cultivation of monoculture at large scale on such condition has a negative effect on soil fertility. Top soil prone to erosion and as impacts degradation of soil fertility takes place. Continued land degradation has major impacts on future agricultural supply response. Salinization of soils, nutrient depletion and soil erosion all reduce the productivity of lands for agricultural production. In cases of advanced degradation, lands become unsuitable for agricultural production. Overall, UNEP estimates a loss of 0.2 percent in cropland productivity per year globally due to unsustainable agricultural practices.

Food security

Food security is defined as a ‘situation when all people, at all times, have physical, social and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life’. All dimensions of food security are likely to be affected by climate change . Importantly, food security will depend not only on climate and socio-economic impacts on food production, but also (and critically so) on economic growth, changes to trade flows, stocks, and food aid policy.

Threats from climate change, population growth and unsustainable resource use are affecting different regions of the world. Trends in population, diet, resource degradation and climate change impacts on productivity indicate that there is a real risk of global food shortfalls as the century progresses. It is obvious that food insecurity and climate change are already inhibiting human well-being and economic growth throughout the world. These problems are poised to accelerate. However, countries vary in their vulnerability to climate change, the amount and type of GHGs they emit and their opportunities to reduce GHG emissions and improve agricultural productivity.

Under present trends, by 2030, maize production in Southern Africa could decrease by up to 30% while rice, millet and maize in South Asia could decrease by up to 10%. By 2080, yields in developing countries could decrease by 10% to 25% on average while India could see a drop of 30% to 40%. By 2100, while the population of three billion is expected to double, rice and maize yields in the tropics are expected to decrease by 20–40% because of higher temperatures without accounting for the decrease in yields as a result of soil moisture and water supplies stressed by rising temperatures. Future warming of around 3 °C (by 2100, relative to 1990–2000) could result in increased crop yields in mid- and high-latitude areas, but in low-latitude areas, yields could decline, increasing the risk of malnutrition. A similar regional pattern of net benefits and costs could occur for economic (market-sector) effects. Warming above 3 °C could result in crop yields falling in temperate regions, leading to a reduction in global food production.

To feed 9 billion world population by 2050, the world will need to produce approximately 70% more food than at present to cope with growing population and dietary changes. This is going to put agricultural production systems and the environment under ever increasing pressure. It is important to gain a better understanding of the functioning of terrestrial and aquatic ecosystems and their interrelation with the availability and quality of water. This calls for a shift in the management of ecosystems and the water within them for food security. Agricultural production systems have to be recognized and managed as a landscape of interlinked agro ecosystems with the potential for multiple functions (Figure 4). Building resilience to climate change and other shocks needs to be mainstreamed into agricultural planning to ensure food security targets.

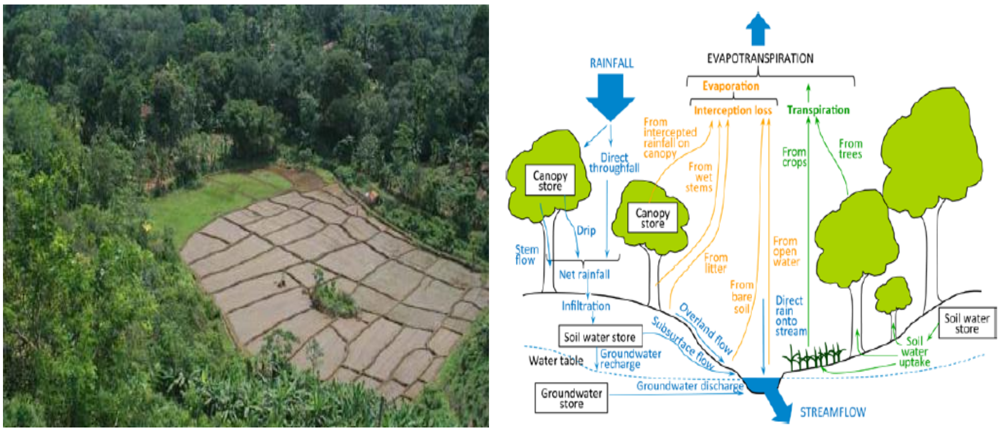

Figure 4. Landscape and hydrological cycle of agro-forestry system

Sustainable agriculture

Agriculture is at the nexus of three of the greatest challenges of the 21st century – achieving food security, adapting to climate change, and mitigating climate change while critical resources such as water, energy and land become increasingly scarce.

Sustainable agriculture simultaneously increases production and income, adapts to climate change and reduces GHG emissions, while balancing crop, livestock, fisheries and agroforestry systems, increasing resource use efficiency (including land and water), protecting the environment and maintaining ecosystem services. The goal for sustainable food production systems is to maximize productivity of both land and seascapes within humanity's 'safe operating space' for the planet – 'safe' from the perspective of achieving food security within the planet's safe environmental boundaries. Contexts will vary in different geographic regions and locations. Improvements to agricultural production systems should allow more productive and resilient livelihoods and ecosystems, contributing to a more secure, sustainable and safe food system and providing access to adequate food and nutrition, and allowing poor rural people to escape from and remain out of poverty. Sustainable agriculture lies at the heart of delivering poverty reduction.

Mitigation and adaptation

Agriculture plays four important roles in climate change: • Farming emits greenhouse gases (GHGs). • Changes in agricultural practices have a big potential to be carbon sinks. • Changes in land use, caused by farming have great impact on GHG emissions. • Agriculture can produce energy and bio-derived chemicals and plastics, which can replace fossil fuel. Therefore, agricultural sector can be an important part of the solution to climate change. This can be done by capturing synergies that exist among activities to develop more productive food systems and improve natural resource management. Increased agricultural productivity and resilience, under changing the climatic conditions, can benefit to poverty reduction, especially among vulnerable smallholder farmers. Consequently, agriculture practice can be put for an early action since it is readily available and cost-effective mitigation option. Technically mitigation potent of agriculture is high, of which 70 percent can be obtained from developing countries. This sector contributes 14 percent of global GHGs, of which 74 percent comes from developing countries (Figure 5). Therefore global climate change concerns has put the agriculture sector, particularly in developing countries in more broad responsible, i.e. to be resilient (adaptation) to climate changes, to reduces/removes greenhouse gases (GHGs, mitigation), and to enhance achievement of food security and millenium development goals (MDGs).

GREENHOUSE-GAS-EMISSION PROFILE OF AGRICULTURE

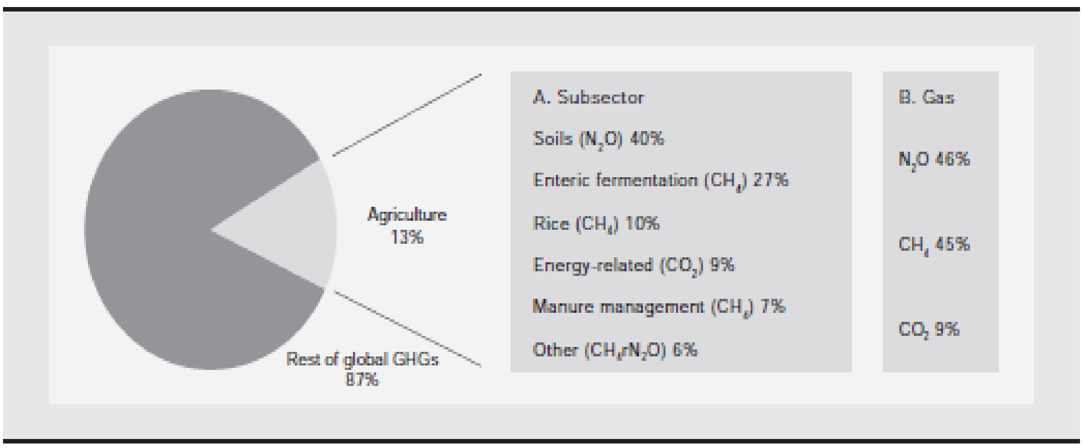

Figure 5. Green House Gas production of agricultural practice.

The scale of action needed to tackle climate change is unprecedented and involves two concurrent approaches: • Mitigation: actions that tackle the causes of climate change, such as reducing greenhouse gas emissions.• Adaptation: actions that minimise the consequences of actual and expected changes in the climate. These processes are inherently linked. Adaptation should enable agricultural systems to be more resilient to the consequences of climate change. Mitigation addresses its root causes, thereby limiting over time the extent and cost of adaptation, as well as the onset of catastrophic changes. Both are needed and a number of agricultural management practices can do both, while helping to meet development and food security requirements. They are likely to receive increasing priority within holistic approaches to food security and climate changes. Increased agricultural resilience and productivity, under changing climatic conditions, can benefit poverty reduction, especially among vulnerable smallholder farmers. A wide range of options in agriculture offer such potential synergies. Others may involve trade-offs, some of which can be managed. The degree to which society needs to adapt depends on the extent of climate change, which depends on greenhouse gas emissions. The Kyoto Protocol (1997) to the United Nations Framework Commission on Climate Change (UNFCCC) requires ratifying industrialised countries to limit their greenhouse gas emissions by agreed amounts below their 1990 levels over the period 2008-2012. Under REDD scheme developing countries having huge tropical forest could play important role on climate change by reduction of GHGs emissions.

Adaptation

Agriculture, in a number of areas, already needs to adapt to more rapid and intense changes in climate (temperature, rainfall) and related changes in distribution patterns of pests, weeds and diseases. Because of the climate change speed pressure, it is urgent that the vulnerability of developing countries to climate change is reduced and their capacity to adapt is increased and national adaptation plans are implemented. Future vulnerability depends not only on climate change but also on the type of development path that is pursued.Thus adaptation should be implemented in the context of national and global sustainable development efforts. The international community is identifying resources, tools and approaches to support this effort. Climate change adaptation is especially important in developing countries since those countries are predicted to bear the brunt of the effects of climate change.

Adaptation to climate change in developing countries is vital and has been highlighted by them as having a high or urgent priority. Although uncertainty remains about the extent of climate change impacts, in many developing countries there is sufficient information and knowledge available on strategies and plans to implement adaptation activities now. The mosteffective adaptation approaches for developing countries are those addressing a range of environmental stresses and factors. Strategies and programmes that are more likely to succeed need to link with coordinated efforts aimed at poverty alleviation, enhancing food security and water availability, combating land degradation and reducing loss of biological diversity and ecosystem services, as well as improving adaptive capacity. Sustainable development and the Millennium Development Goals are a necessary background to integrating adaptation into development policy. Reduction policies are also important elements of adaptation.

The challenges of adaptation to climate change for agriculture in many parts of the world are enormous. The process of adaptation begins with an assessment of the different dimensions of vulnerability and of the appropriateness of a range of potential options for action, including their costs and benefits. In practice, adaptation is a collection of coping strategies, with each strategy focused on a particular threat. Some of these actions may be taken by individuals or communities reacting to climate change hazards as they occur; others may be more planned, depending for their initiation on government policies and institutions.

Table 3. Adaptation measures in key vulnerable sectors highlighted in national communications of developing countries

Vulnerable sectors	Reactive adaptation	Anticipatory adaptation
Water Resources	▪ Protection of groundwater resources ▪ Improved management and maintenance of existing water supply systems Protection of water catchment areas ▪ Improved water supply ▪ Groundwater and rainwater harvesting and desalination	▪ Better use of recycled water ▪ Conservation of water catchment areas ▪ Improved system of water management ▪ Water policy reform including pricing and irrigation policies ▪ Development of flood controls and drought monitoring
Agriculture and food security	▪ Erosion control ▪ Dam construction for irrigation ▪ Changes in fertilizer use and application ▪ Introduction of new crops ▪ Soil fertility maintenance ▪ Changes in planting and harvesting times ▪ Switch to different cultivars ▪ Educational and outreach programmes on conservation and management of soil and water	▪ Development of tolerant/resistant crops (to drought, salt, insect/pests) ▪ Research and development ▪ Soil-water management ▪ Diversification and intensification of food and plantation crops ▪ Policy measures, tax incentives/subsidies, free market ▪ Development of early warning systems

Mitigation

Another policy response to climate change, known as climate change mitigation is to reduce greenhouse gas (GHG) emissions and/or enhance the removal of these gases from the atmosphere (through carbon sinks) by reducing their sources or by increasing their sinks. Even the most effective reductions in emissions, however, would not prevent further climate change impacts, making the need for adaptation unavoidable. In the absence of mitigation efforts, the effects of climate change would reach such a magnitude as to make adaptation impossible for some natural ecosystems. For human systems, the economic and social costs of unmitigated climate change would be very high.

Many countries, both developing and developed, are aiming to use cleaner, less polluting, technologies. Use of these technologies aids mitigation and could result in substantial reductions in CO_2 emissions. Policies include targets for emissions reductions, increased use of renewable energy, and increased energy efficiency. Studies indicate substantial potential for future reductions in emissions. Despite the many examples of successful attempts to reduce GHG emissions in agriculture within different environments, overall the potential for implementing large-scale mitigation measures has seen relatively little progress. Barriers include limited access to finance, technology and resources and lack of appropriate political, institutional and economic policies, as well as the possibility of short-term yield losses followed by long-term gains with some types of mitigation practices.

Scientific consensus on global warming, together with the precautionary principle and the fear of abrupt climate change is leading to increased effort to develop new technologies and sciences and carefully manage others in an attempt to mitigate global warming. Most means of mitigation appear effective only for preventing further warming, not at reversing existing warming. The Stern Review identifies several ways of mitigating climate change. These include reducing demand for emissions-intensive goods and services, increasing efficiency gains, increasing use and development of low-carbon technologies, and reducing fossil fuel emissions.

Food Security Potential		
	Food Security Potential: High **Carbon Sequestration Potential: Low** • Expand cropping on marginal lands • Expand energy-intensive irrigation • Expand energy-intensive mechanized systems	**Food Security Potential: High** **Carbon Sequestration Potential: High** • Restore degraded land • Expand low energy-intensive irrigation • Change from bare to improved fallow • Agro-forestry options that increase food or incomes • Conservation tillage and residue mgmt, limited trade-offs with livestock • Improved soil nutrient management
	Food Security Potential: Low **Carbon Sequestration Potential: Low** • Bare fallow • Continuous cropping without use of organic or inorganic fertilization • Slope ploughing • Over-grazing	**Food Security Potential: Low** **Carbon Sequestration Potential: High** • Reforestation/afforestation • Restore/maintain organic soils • Expand bio-fuel production • Agro-forestry options that yield limited food or income benefits • Conservation tillage and residue mgmt, large trade-offs with livestock
		Carbon Sequestration Potential

Table 4. Relation between mitigation and food security

Agriculture is currently the most cost-effective, market-ready way to remove carbon dioxide from the atmosphere. Scientific research is needed to determine which agricultural techniques, practices, and systems will achieve actual climate mitigation. With the right type of agriculture, emissions leading to climate change can be minimized and the capacity of nature to mitigate climate change can be harnessed to sequestrate significant quantities of atmospheric carbon dioxide – especially in the soil (Figure 6). The Farming Systems Trial offers an opportunity to examine the climate mitigation potentials of different existing agricultural systems. The results suggest the huge possibilities for agriculture. Global adoption of Organic Agriculture has the potential to sequester up to the equivalent of 32% of all current man-made GHG emissions. Organic Agriculture is a production system that sustains the health of soils, ecosystems, high crop yields, and people. It utilises ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. It combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved. The Food and Agriculture Organisation of the United Nations (FAO) regards Organic Agricultural as an effective strategy for mitigating climate change and building robust soils that are better adapted to extreme weather conditions associated with climate change5. The IPCC's Fourth Assessment Report also recommends the use of practices which are standard in Organic Agriculture for mitigating climate change. Organic Agriculture optimally combines these different practices in a systematic manner and sustains agricultural production in resource-limited regions. Organic farming system can sequester significant levels of carbon dioxide from the atmosphere ranged from 0.25 up to 11 ton per ha per year (Table 5).

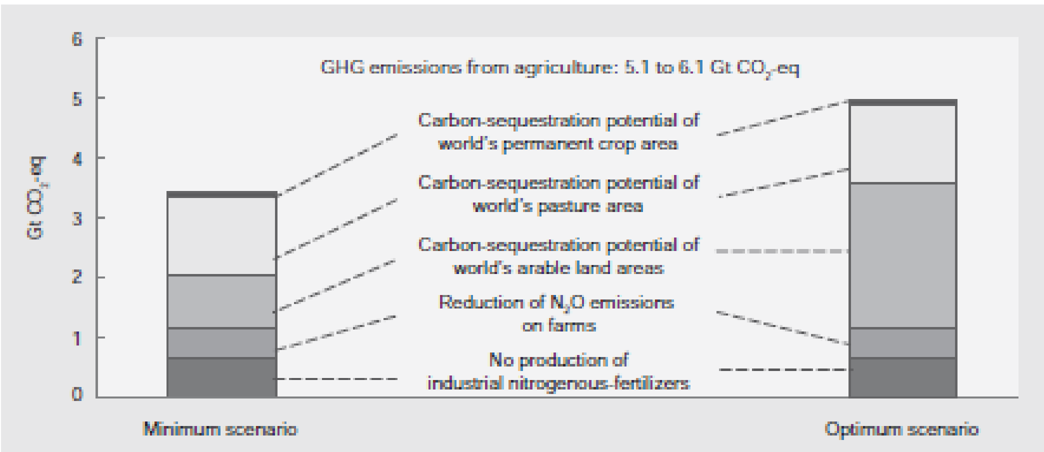

Figure 6. Carbon sequestration from 2 different agricultural practice.

Table 5: Overview of key the case studies

Case study	**Country**	**System**	**Organic practices used**	**Mitigation benefits**
Farming Systems Trial	USA	Arable crops	organic fertilization crop rotation cover crops	2.3 ton Carbon/hectare/year
Pure Graze	The Netherlands	Pasture-based diary system	use of natural reproductive cycles locally produced fodder and feed reduced use of concentrate feed	0.4 ton Carbon/hectare/year 10% (per kg produce) and 40% (per hectare) less GHG emissions than conventional farming
Composting in Egypt's desert	Egypt	Vegetable crops	composting	0.85 ton Carbon/hectare/year
DOK trial	Switzerland	Arable crops	organic fertilization crop rotation including grass clover cover crops	0.25 ton Carbon/hectare/year
Agroforestry	Indonesia	Cocoa/forest	intercropping with trees and shrubs	11 ton Carbon/hectare/year

The Role of Nuclear-Isotopic Technology in food security and global warming

Nuclear-isotopic techniques (NITs) offer unique contributions to promote more sustainable and resilient agricultural production, at the same time being safe and cost effective. For example, they can be used to compare and measure the efficiency and efficacy of different agricultural land and water resource management practices. Identifying and refining the best of these practices is crucial to the long term preservation of natural resources such as arable soils and water, which are under increasing pressure due to climate change.

Water is perhaps the most precious of natural resources, and the resource most threatened by climate change. Already under significant stress worldwide due to expanding populations and economic activity, freshwater resources in many regions are suffering a double blow due to climate change. This is placing many communities at risk and demands greater efforts to promote sustainable resource management and increase water availability. Isotope techniques provide highly effective, cost efficient and safe means to collect precise information about freshwater resources such as location, size, flow origins and replenishment rate. This knowledge is necessary to help water authorities manage their resources in a more sustainable manner. It is of even greater importance with regard to aquifers, as communities are increasingly forced to turn to these underground resources due to the diminishing availability of surface water.

There is a wide range of isotopic (stable and radioactive) and nuclear techniques that can be potentially used to study specific issues related to soil quality and health, plant nutrition, crop physiology, and crop water productivity and water use efficiency. The soil moisture neutron probe (SMNP) has been widely utilized in agricultural research studies on water use efficiency. Soil water content at different depths in the soil profile can be measured periodically. This SMNP provides a rapid, reliable, cost-effective, and nondestructive technique and is still considered as the reference equipment for field monitoring of soil water content. Data generated from this monitoring are used for calculating the soil water balance and estimating the soil water used by plants in function of soil depth and time. Thus, the SMNP provides an evaluation of evapotranspiration (ET), i.e., the bulk amount of soil water loss associated with soil evaporation and transpiration out of plant leaves. The SMNP is also used in studies to evaluate WUE under different irrigation technologies like drip irrigation, subsurface drip irrigation, deficit irrigation, regulated deficit irrigation, alternate root-zone drying, and alternate furrow irrigation, that aim to minimize soil evaporation and increasing water availability for plant use. It can be employed to assess the quantity of water supplied by surface irrigation and the uniformity of its distribution.

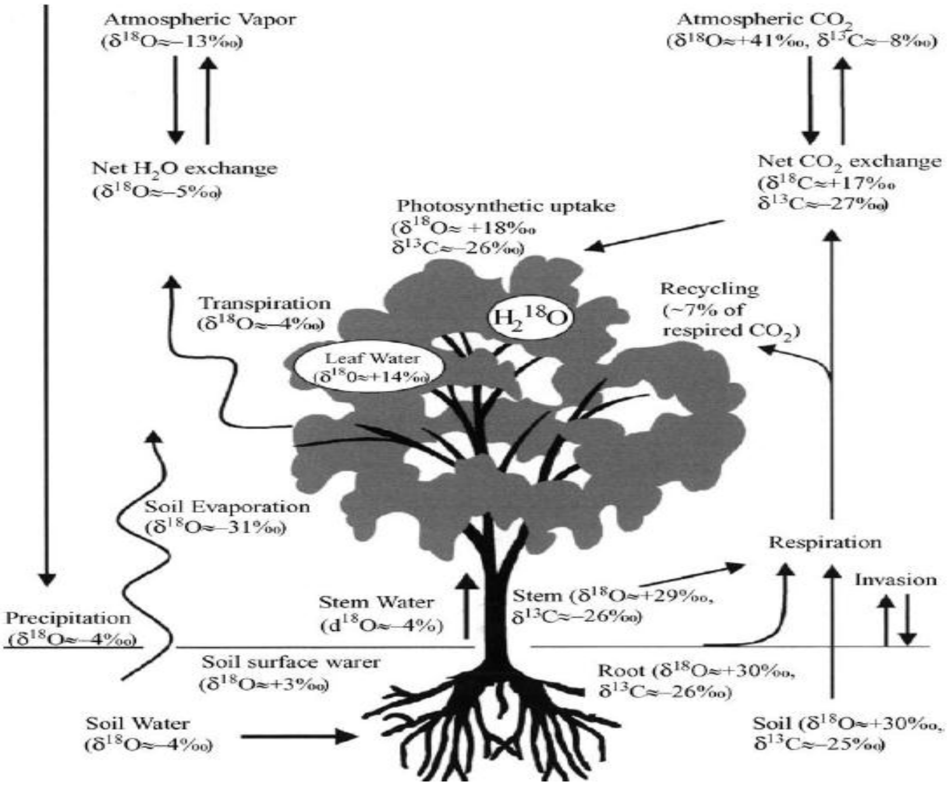

Figure 7. Isotopic composition of C, O and H pools in Terrestrial ecosystems. The values are approximations and will vary considerably with geographical location and environmental Conditions.

Stable isotopes of water, 2H, and 18O at the natural abundance level have been extensively used in plant-water relations research to investigate physiological and hydrological processes from plant to ecosystem scale (Figure 4, Figure 7). Thus, stable isotopes of water are routinely measured for tracking sources of water in vegetation. In agriculture, the crop water requirements are evaluated as bulk evapotranspiration, which includes both soil evaporation and plant transpiration. Due to the natural fractionation among isotopes of hydrogen and oxygen, soil water at increasing depths in the soil profile and plant materials have their own fingerprint. Therefore, it is possible to partition evapotranspiration into its two components in order to obtain information to minimize soil evaporation, the nonproductive loss of water. Both hydrogen (H) and oxygen (O), which are element constituents of water can exist as light and heavy isotopes. The light isotopes (1H and 16O) evaporate more readily than the heavy isotopes (2H and 18O). Thus the stable isotopic ratios of H (2H/1H) and O (18O/16O), which are often expressed as the enrichment of 2H (δ 2H) and 18O (δ 18O) in soil water. Water vapor within the plant canopy and plant leaves can provide an estimate of soil evaporation (E) and plant transpiration (T).

Carbon isotope discrimination (CID) may be used as a tool for assessing crop Water use efficiency (WUE). WUE is often considered as the mass of carbon dioxide fixed by the plant in exchange for the mass of water transpired. During photosynthesis, carbon dioxide is subjected to an isotopic fractionation, with lighter 12C more readily taken up by plants than 13C. The kinetics of diffusion of carbon dioxide and water through the leaf stomata openings depends on the size of their aperture. Under drought stress, the plant closes its stomata, a process which impedes both exchanges. A side effect is the discrimination of the heavy isotopes of C, O and H; therefore, water scarcity results in a plantdepleted content in 13C, for example, which is measured by the ratio of 13C/12C (i.e., δ13C) in its dry matter. A cultivar that is resistant to water scarcity should display less depletion in 13C compared to a susceptible cultivar). Soil scientists as well as plant breeders have used this method strategically for screening and evaluating WUE of crops such as barley, bread wheat , peanut, and upland rice. For rice (Oryza sativa L.), the CID values from flag leaves can potentially be used to select rice for salinity tolerance, since flag leaf CID correlated well with grain CID, and both positively correlated with grain yield. In addition, CID measured in different plant parts at harvest can be used as an indicator of how water availability varied during the cropping season.

In addition, the isotope technology plays an important function in the management and assessment of hydrology and water resources, especially on ascertaining the recharge sources, amounts and ages of groundwater, the interaction between surface water and groundwater, the effects on the pollution of surface water to groundwater, etc. We can obtain many key data with little investment, which can’t be obtained by other regular methods. Meanwhile, environmental radionuclides of 7Be, 137Cs, and 210Pb have been used to obtain information on short-term (< 30 days), medium-term (~40 years) and long-term (~100 years) average soil redistribution rates and patterns in the landscape, respectively, and hence area-wide (watershed) erosion and sedimentation.

The development of an integrated nutrient management package (involving not only manufactured fertilizers but also natural sources of nutrients such as rock phosphates, biological N fixation, animal and green manures, etc.) along with the recycling of crop residues has resulted in a greater demand for the use of 15N, 32P, and sulfur-35 (35S) isotopes as tracers to develop efficient agronomic practices tailored to the specific cropping systems and local conditions. Significant advances have also been made during the past decade in the development and application of natural variations in the abundance of stable isotopes (deuterium, 13C, 15N, 18O, and 34S) to assess the dynamics of nutrients and water in the soil-plant system. These developments have been possible due to advances in automated systems for stable isotope ratio measurements in soil, plant, water, and gas samples.

Nuclear and isotopic techniques (NITs) can play a major role in addressing soil C sequestration, climate, and human interactions, and the biogeochemical cycling of C and its coupling with those of N, P, S, and water . The NITs can be used to capture atmospheric CO2 and N2O in soils and reduce N2O emissions In the atmosphere, to mitigate climate change while fuelling crop growth.

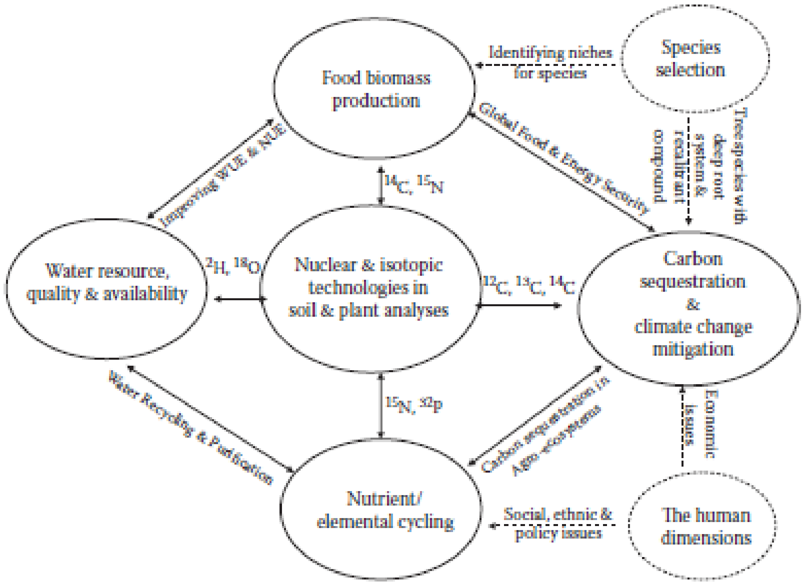

FIGURE 8. The role of isotopic techniques in addressing global issues of carbon sequestration to advance food security and mitigate climate change. (From Nguyen, M. L., *Integrated soil-water-plant solutions for biomass production and environmental performance as influenced by climate change*, Report of the FAO/IAEA Consultants Meeting, Vienna, Austria, November 12–14, 2007. With permission.)

The diagram in Figure 8 shows the role of isotopic techniques in addressing important issues of food and biomass production such as C sequestration in agroecosystems, bioenergy production on degraded or marginal soils, and declining availability and quality of water resources. In this carbon-climate-human system, there are also strong interactions between changing climate and species selection and adaptation and human dimensions such as related economic, social, cultural, ethnical, and political factors (dotted circles).

Nuclear-based techniques can also play an essential role in the research and development of suitable soil C sequestration technologies in agricultural lands to provide data backed by scientific evidence. Because of the need to stabilize the stored C in the soil, key mechanistic studies would be conducted to get a better understanding of processes and driving factors that control the dynamics (transformations/turnover) of specific compounds of SOC, as well as the functions of soil biota (biological component of soil quality), thus demanding the refined quantification of C, nutrient, and water pools as well as fluxes in a given agroecosystem. The measurement of natural variations in the abundance of stable isotopes (deuterium, 13C, 15N, 18O, 34S) in components of the agroecosystem (SOM, standing biomass, ground and surface water, atmospheric gases) can provide unique information on such pools and fluxes.

Significant advances have been made in the development and application of isotopic techniques in the fields of biology, ecology, biogeochemistry, and environmental sciences. These developments have been possible due to novel isotope techniques such as compound-specific isotope analysis, advances in instrumentation, analytical techniques, electronic data acquisition, and automated systems for isotope ratio measurements in soil, plant, water, and gas samples. However, these advanced techniques need to be further refined and protocols harmonized for worldwide application in agricultural research. The advent of synchrotron facilities that allow the exploitation of particular qualities of synchrotron radiation as a research tool and the continuing development of synchrotron-based techniques (such as X-ray absorption, florescence and tomography) to improve spatial resolution and sensitivity offer exciting opportunities to unravel processes and factors influencing soil-water-nutrient-plant-rhizosphere interactions.

Nuclear techniques can also make valuable contributions to the development of new crop varieties able to provide higher yields and to tolerate drought, reduced soil quality and the harsher weather patterns wrought by climate change. This can include crops produced for humanand livestock consumption.

Nuclear techniques can help control these insect populations both while crops are in the field and after harvesting, and for livestock. Protecting crops and livestock from insect pests, as warmer temperatures will result in the geographic spread of such pests. This will put more reduce on potentially damaging effects on food security and economic development.

Table 8 displays selected investigations and reviews to illustrate how stable isotopic (13C, 2H, 18O, 15N) techniques are employed to generate knowledge at the process level, i.e., mechanisms, emission rates, and controlling factors at several spatial and temporal scales. This isotopic information in agricultural and natural landscapes can be further used to derive effective management strategies to mitigate GHG emissions and enhance nutrient and water use efficiencies.

Table 6. Selected Applications of Isotopic Techniques in Greenhouse Gas (GHG) Studies.

No	GHG	Isotopic Techniques	Experimental Work	References
1	N2O	Natural abundance (15N and 18O isotopic signatures)	Soil microbial processes affecting nitrous oxide (N2O) emissions and factors influencing nitrification and denitrification in tropical Amazon rain forest soils	Perez et al. 2003
2			Factors affecting nitrous oxide (N2O) emissions from extensively managed grassland in Bavaria, Germany	Tilsner et al. 2003
3			Factors affecting soil nitrogen dynamics and N2O emissions in European grasslands	Wrage et al. 2004
4			Extent of N2O and N2 emissions from soil and those produced by nitrifying and denitrifying bacteria	Webster and Hopkins 2004
5			Study of N2O topsoil fluxes and the dynamics of N2O formation, consumption, and emission	Van Groningen et al. 2005
6			Soil N2O emissions and global N2O budgets	Kim and Craig 1993
7		15N natural abundance and enrichment methods	Five 15N approaches used for estimating denitrification in soils: 1) variations in 15N natural abundance; 2) mass balances using 15N-labeled fertilizers; 3) use of 15NO3 in isotope dilution and modeling of N cycling; 4) addition of 15NO3 and measuring 15N2 gas emissions; and 5) 15N2 gas isotope dilution studies	Myrold 1990
8		15N enrichment	15N-based methods used for estimating denitrification include isotope fractionation,	Groffman et al. 2006

No	GHG	Isotopic Techniques	Experimental Work	References
		methods	isotope dilution, 15N mass balances, and direct measurement of 15N-labeled gases upon addition of 15N-nitrate- and 15N-ammoniumlabeled salts. The addition of 15N-labeled salts to achieve high levels of enrichment increase the availability of N and may result in overestimation of denitrification.	
9		15N and 18O enrichment	Use of 18O-labeled water and 15N-labeled ammonium nitrate to distinguish respective N2O contributions from i) nitrification, ii) nitrifyer denitrification, and iii) denitrification	Wrage et al. 2005
10			15N-labeled nitrate to estimate denitrification in sediments	Nielsen 1992
11	CO2	Natural abundance (13C and 18O)	13C signatures of respired CO2 to investigate SOC dynamics in grassland under elevated CO2	Pendall and King 2007
12			13C signatures in air, plant, and soil samples to assess SOC storage in relation to rising air CO2 concentrations	Leavitt et al. 1994
13			13C signatures of respired CO2 to investigate the SOC dynamics in grassland under elevated CO2	Pendall and King 2007
14			13C signatures in air, plant, and soil samples to assess the relative contributions of root and soil heterotrophic respiration to total soil respiration in situ.	Andrews et al. 1999
15			Interannual variations 18O signatures in atmospheric CO2 from assimilation and respiration	Cuntz et al. 2003
16			18O signatures in soil water and soil CO2 to	Ferretti et al. 2003

No	GHG	Isotopic Techniques	Experimental Work	References
			partition Evapotranspiration (ET) into its components under normal and elevated CO2 conditions in a semiarid short grass steppe	
17			18O signatures in soil water and soil CO2 to study isotopic equilibration of 18O between carbon dioxide and water in soils, which is a major component of the 18O isotopic balance of atmospheric CO2	Tans 2002
18		13C natural abundance and 13C enrichment	13C natural abundance and 13C enrichment to study impacts of climate change on ecosystem C cycling with a focus on below-ground soil-plant responses (SOM, roots, and rhizosphere) to elevated CO2 and temperatures	Pendall et al. 2004a
19		13C enrichment	13C labeling of the elevated CO2 to evaluate changes in root biomass and C/N ratios over 5 years, and to quantify the input rate of new C or rhizodeposition in ambient and elevated CO2 treatments	Pendall et al. 2004b
20	CH4	13C natural abundance	13C signatures from DOC isolates found in water, peat, and agricultural drains to examine relationships with formation of trihalomethane (THM)	Bergamaschi et al. 1999
21		Enriched products (13C–CH4 and 14NH4 15NO3, 15NH4 15NO3)	To study the effects of elevated CO2 concentrations on the emissions of N2O and CH4 (oxidation/emission), 14NH4 15NO3 and 15NH4 15NO3 enable the determination of respective contributions of nitrification and denitrification to N2O emissions.	Baggs and Blum 2004

Conclusion

Nuclear- isotopic techniques can be used in either basic research to investigate the processes of GHG production in soils and gain a better understanding of the main factors influencing the GHG production and consumption processes, or in applied research to assess the value or effectiveness of selected management practices on the mitigation of GHG emissions in agroecosystems. All this knowledge is essential not only to policymakers for formulating adequate local regulations and policies to meet international commitments to reduce atmospheric concentrations of GHGs, but also to farmers for adoption of appropriate management practices to increase agricultural productivity (food security) and to enhance adaptation to climate change and variability in agricultural systems (mitigation). This can be summarized that Nuclear-Isotopic Technology can play important roles on : 1. Better understanding of biogeochemical sources and processes; 2. To develop integrated soil-water-plant technologies : enhancement of soil quality, productivity,sustainability for food security ; 3.Provide information for adaptation and mitigation to climate change; 4.Valuable tools to to achieve the MDG of food security and environmental sustainability ; 5. Networking, coordination, information and communication technology exchanges will be important tools for further development and wide application of these techniques; 6. essential information for policymakers.

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DISCUSSION

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Isotope techniques in the near future which will Mr use in studies that will be done Father?

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in addition to P32 and N15 isotope techniques to study the efficiency of fertilization, Soil Moisture Neutron Probe (SNMP) and natural Carbon Isotope Discrimination (CID) will be used for the management of irrigation and Water Use Efficiency. Natural isotope N15 Discrimination (Natural Abundance method) will be used to measure fixation N.