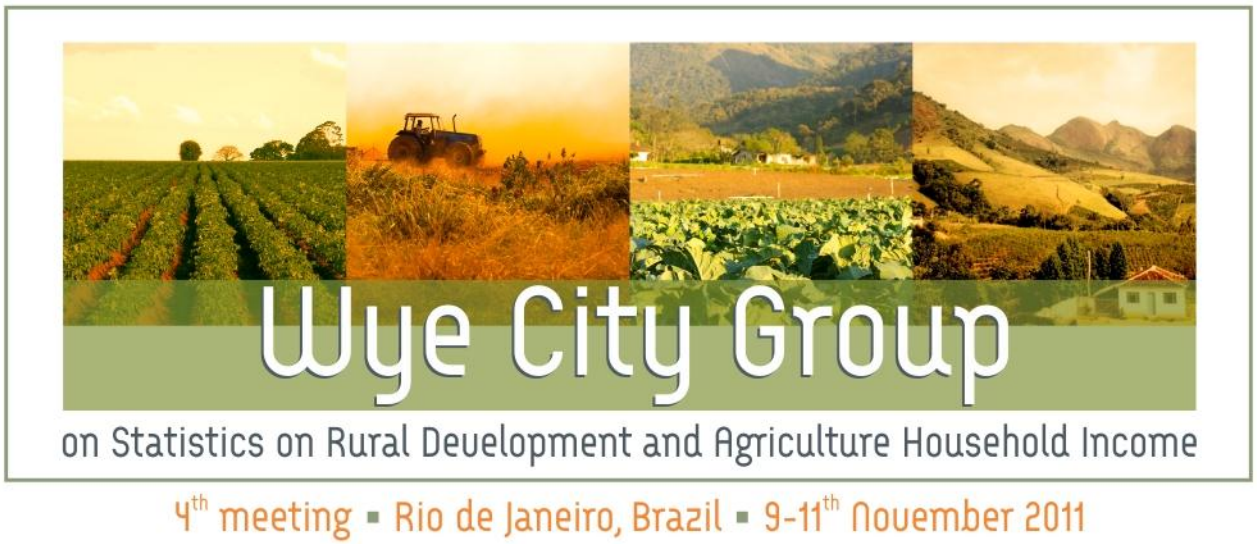

Agriculture and Greenhouse Gases: FAO's approach to addressing the unique challenges faced by agricultural statisticians

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ABSTRACT

The demand and need for data and information on greenhouse gas (GHG) emissions and mitigation potential and information from a diverse stakeholder community continues to grow. One such need is for the annual inventories of GHG emissions and removals related to agriculture, which most countries need to submit periodically to the United Nation Framework Convention on Climate Change (UNFCCC). The data needed for this reporting presents a unique challenge to inventory compilers, especially from developing countries, due to the scarcity of national data as well as technical capacity to monitor, collect and analyze relevant information. FAO, having a central role in the international arena within the agriculture, forestry and fisheries sectors and the experience and ability to undertake global assessments, clearly has a fundamental role in meeting these user needs. In addition, FAO has long maintained global datasets on agriculture and forestry that constitute an extremely valuable resource for compilation of GHG inventories. This paper reviews and highlights the most critical areas related to GHG agricultural emission data and outlines the work FAO is currently undertaking to strengthen countries ability to gather, compile and analyze GHG related data, with the aim of developing a first global assessment of GHG emissions from
the agricultural sector. Such efforts include gauging the mitigation potential of different farming practices and methodologies and analysis procedures (for example, for life cycle analysis – LCA). The results of this work being undertaken in FAO will directly contribute to the Global Strategy to Improve Agricultural and Rural Statistics, the Intergovernmental Panel on Climate Change (IPCC)

5th assessment report, as well as contribute to the UNFCCC negotiation process, as they will allow countries to produce the baseline emissions history needed to allow agriculture to access climate change financing mechanisms. This paper highlights these major challenges and provides some suggested solutions for filling the data gaps in the agricultural sector, as well as support for national inventory compilers and other stakeholders. It also outlines the additional benefits of improved estimates in GHG assessments for the agricultural sector.

Keywords: Agriculture, Greenhouse gas, Emissions, Monitoring, Database

1. Background

The agricultural sector faces increased environmental challenges linked to new production methods and intensified production systems needed to meet continued population growth and new energy demands around the world. The artificial inputs of energy, chemical products, and agricultural labour necessary to increase as well as sustain long-term agro-ecosystem production inevitably alters natural biogeochemical cycles, leading to serious environmental damages, including soil degradation; soil and water pollution; biodiversity loss; increased greenhouse gases emissions and disruption of carbon sinks. Such negative pressures increase in coming decades towards 2050, as the global population continues to grow towards 9 billion.

In particular, climate change presents unique challenges to agriculture. Global anthropogenic greenhouse gas (GHG) emissions, standing today at over 40 billion tCO_2eq annually and growing in tandem with energy use, are altering atmospheric concentrations well beyond natural levels. Current atmospheric CO_2 is about 390ppm, about 35% above the pre-industrial equilibrium. Perhaps even more importantly, the rates of GHG increase in the atmosphere are much faster than those underlying natural cycles. Agriculture is both a major culprit as well as a potential victim to the ensuing climate changes. On the one hand, it emits close to 30% of total anthropogenic emissions globally, through land management activities for crop cultivation and livestock production, including deforestation. On the other, agriculture stands to suffer more than other sectors the combination of warming temperatures and increased frequency and intensity of extreme weather events that are associated to the climate change regimes predicted for of coming decades.

Countries have thus committed, within the United Nation Framework Convention on Climate Change (UNFCCC), to a reduction of their GHG emissions over coming decades, with OECD countries—so called Annex I parties to the convention, with developing countries listed as non-Annex I parties—having initially focuses via the Kyoto Protocol (KP) on reducing their GHG emissions to below 5% of 1990 levels in the commitment period of 2008-2012. Agriculture plays a major role in the global GHG budget, as discussed, and thus UNFCCC parties pay increasing attention to this sector in terms of helping them achieve their reduction commitments, especially in view of renewed attention to this sector in the climate policy agreements for the post-2012 commitment period. In fact, looking at the three major GHG gases, agriculture emits about 25% of global anthropogenic emissions of CO_2, over half of methane, and two-thirds of N_2O. Emissions of CO_2 are dominated by emissions from deforestation, with a small 5% component from energy and machinery use; emissions of methane are dominated by livestock production and rice cultivation; while emissions of are dominated by use of industrially produced inorganic fertilizer. Overall, livestock and feed production—including their role as a major driver for deforestation—dominate overall anthropogenic GHG emissions from agriculture, producing about three-quarters of the total.

In this context, adoption of better environmentally-sustainable production methods, as well as a focus on increased efficiency of resource use—especially soil, water and genetic resources for crops and livestock— is a major objective towards identifying the mitigation potential of GHG agricultural emissions, one that countries can use to plan their reduction commitments now and in coming decades. Such focus, importantly, lends to many synergies with and reinforces current rural development needs, considering that massive increases in agricultural production are often achieved at the expense of the surrounding environment[1]. In particular, many climate change mitigation strategies in agriculture tend to positively reinforce food security needs, by leading to better climate-adapted production systems with enhanced resilience, and by focusing on production solutions that create employment opportunities and respect local communities. The

[1] See, e.g., FAO 2011 "Linking sustainability, climate finance and the green economy in agriculture."

Intergovernmental Panel on Climate Change (IPCC) reports periodically on both the state of the science needed for identifying mitigation potentials around the world as well as provides guidelines for assessing, measuring and reporting GHG emissions, including from agriculture and related land use changes. In particular, IPCC Guidelines provide the methodological guidance to countries for reporting their annual inventories of greenhouse gas emissions and removals to the UNFCCC. The methods contained in the IPCC Guidelines differ in their complexity ranging from the simplest Tier 1 method, based on globally or regionally applicable default parameters, through Tier 2 methods based on country specific data, to Tier 3 methods involving more detailed modelling and/or inventory based approaches. The IPCC category Agriculture, Forestry and Other Land Use (AFOLU) presents a unique challenge to the inventory- compilers, especially from developing countries, due to the lack of national data.

In addition, the most recent IPCC assessment report (AR4, 2007) indicated many options for GHG mitigation in agriculture: from more efficient use and timing of chemical fertilizer to reduce N_2O emissions; to improvements to animal waste management systems and changes in animal diets to reduce methane emissions; to improvement in soil management techniques and land conservation—including reduced rates of deforestation, forest and grassland degradation. The challenges ahead lie in identifying specific subsets of such activities that are appropriate within the specific regional and socio-economic contexts of countries; quantify the associated GHG emission reductions; and finally, with particular attention to developing countries and especially least developed countries (LDCs), assess needs and gaps to design and implement effective project activities; assess and design monitoring and reporting needs and gaps; and investigate potential for regional scaling up.

Agri-environmental statistics and indicators, GHG emissions databases and environmental accounting frameworks are essential components of this strategy. They serve to assess, quantify and monitor the environmental performance of the different countries, and in particular UNFCCC non-Annex I parties, with a focus on measurements of absolute levels of agriculture-related GHG emissions including their trends, as well as identification of mitigation potential. In particular, robust and internationally recognized information tools and methodologies are needed to support climate change negotiation and associated funding processes. Such efforts are especially useful when linked directly to the IPCC process, which represents the technical and scientific reference of the UNFCCC Conference of Parties/Meeting of Parties to the Kyoto Protocol (COP-MOP) through its Scientific Body for Technology Advice (SBSTA). This is because climate financing to developing countries will be increasingly structured within regional climate response activity programs, such as Nationally Appropriate Mitigation Actions (NAMAs), based on sound science and monitored via a set of internationally accepted performance indicators. More in general, and in relation to the recognized linkages among sustainability, climate financing and the green economy, GHG-related information tools are complementary to—and in fact can often be derived within—rural statistics efforts, helping to further support policies towards effective incentive structures for sustainable management of natural resources, ensuring that national agricultural practices are developed and implemented within a holistic approach.

The FAO Statistics Division is currently working on the inclusion of relevant environmental data and indicators within the FAOSTAT[2] database. At present, FAOSTAT contains global coverage of integrated and compatible time series of statistics for about 200 countries covering agricultural production, prices, trade, forestry, fisheries, land use and agricultural inputs, etc. FAOSTAT has traditionally been focused on the production and trade aspects of food and agriculture for food security. In recent years with environmental issues being raised higher up the agenda, more emphasis has been placed on the datasets and indicators related to the environment

[2] http://faostat.fao.org

has led to the development of an Agri-environmental domain in FAOSTAT due to be disseminated in early 2012.

Such efforts provide an effective leverage towards building a GHG central repository for agriculture, coherent with IPCC and UNFCCC goals. Indeed, FAO has long maintained global datasets on agriculture and forestry that constitute an extremely valuable resource for compilation of inventories of greenhouse gas (GHG) for the AFOLU sector as noted in the IPCC Guidelines. However, these datasets cater to a wide range of information needs and may differ from the data required for GHG compilation in certain key respects. In addition, GHG related data are needed by an ever increasing stakeholder community, for a number of purposes[3]. Assessing the environmental impact of agricultural products through life-cycle assessments, for example, is becoming a key requirement in both the public and private sectors. To meet the new needs of stakeholders requires a broader set of data at a finer resolution. This paper investigates the unique set of challenges and opportunities towards the development and compilation of GHG-relevant agriculture environmental indicators (AEIs) at FAO, addressing assessment needs and gaps of developing countries and especially LDCs—but also focusing on key scientific needs that create equal challenges to developed countries as well. We first identify data that is already available for use in the preparation of UNFCCC compliant GHG national inventories, and links to access the data with relevant metadata are provided in the report. This paper further identifies major data gaps in estimating GHG emissions and calculating the mitigation potential of the agriculture, forestry and other land-use (AFOLU) sectors.

2. Environmental Statistics and Indicators

Within the context of the environmental challenges and opportunities for agriculture within the climate change problem, agri-environmental statistics and indicators are required to play key roles: they help analysts and policy makers better understand the nature and magnitude of future risks and benefits related to mitigation activities, in particular in conjunction with food security and other key rural development goals; they facilitate the analysis of causes and interactions of environmental issues as a function of climate policy; and finally, they provide the quantitative background needed to monitoring and reporting GHG emissions within an internationally accepted framework for use towards rewarding through climate finance effective mitigation responses in agriculture, including through NAMAs.

In this context, the FAO Statistics Division is preparing a multidisciplinary agri-environmental dataset composed by environmental data from the thematic databases already available at FAO or from other institutions (both statistics and geospatial datasets) and derived agri-environmental indicators to further expand the domains covered by FAOSTAT. Agri-environmental indicators (AEIs) are indicators able to describe and assess state and trends in the environmental performance of agriculture in order to furnish useful indications to scientists and policymakers about the state of the environment, about the effects of different policies, as well as about the efficiency in the use of budgets in terms of environmental outcomes. AEIs have ideally to be robust, timely, simple, and relevant to the different stakeholders involved in agriculture. An outline of the AEIs database is portrayed in Annex 1.

[3]Two major expert meetings were held at FAO to help identify emerging needs in GHG data gathering, analysis and reporting. See for instance: http://foris.fao.org/static/data/nrc/IPCC-FAO_IFAD_Meetingreport20100423FINAL.pdf; www.fao.org/climatechange/59239/en/

In general, the main constraint in the operational use of AEIs, including for GHG assessment, is the lack of reliable data, limiting the number of indicators that can be actually regularly produced. The statistical methodological development of the AEI framework has been led by the OECD[4] and EUROSTAT[5]. The FAOSTAT Agri-environmental domain has been developed in coordination with the OECD and EUROSTAT frameworks, in order to gain from the theoretical background already developed by these institutions with the aim of extending the geographical coverage of OECD and EUROSTAT AEIs to the rest of FAO member countries as available.

The definition of the FAO AEIs framework and the coordination with the existing frameworks presented above had to face challenges arising from limited data availability. While OECD and EUROSTAT designed their frameworks primarily over a limited number of Developed Countries (OECD countries and European Union member states), with established and solid structures in charge of data collection, in the case of FAO the area of interest covers virtually all the globe, and there are great differences in the amount of data available in the different countries and regions.
The FAOSTAT Agri-environmental domain under development includes 19 indicators, described by 68 data series. For agri-environmental statistics, the FAO Statistics Division collects and disseminates data based on the:

- Land use questionnaire, which includes the following categories: Country area (including area under inland water bodies), Land area (excluding area under inland water bodies), Agricultural area, Arable land and Permanent crops, Arable land, Temporary crops, Temporary meadows and pastures, Fallow land (temporary: less than 5 years), Permanent crops, Permanent meadows and pastures, Forest area, Other wooded land, Other land covering the country as a whole. Data are also available on Area equipped for irrigation, etc.

- Fertilizer questionnaire requests official data on production, trade and use for crop production. The information presented represents a broad picture of the situation regarding official data gathered on fertilizers statistics.

- Pesticides questionnaire requests data on consumption for major groups of pesticides (insecticides, herbicides, fungicides, plant growth regulators and rodenticides) and seed treatments.

These indicators are shown in Table.1, including relevant direct and indirect linkage to the assessment of GHG emissions and mitigation potential.

[4] OECD. 2001. Environmental Indicators for Agriculture. Vol. 3: Methods and Results. Paris: OECD. http://www.oecd.org/dataoecd/24/35/40680869.pdf
[5] European Commission. 2006. Development of agri-environmental indicators for monitoring the integration of environmental concerns into the common agricultural policy. Communication from the Commission to the Council and the Parliament. COM(2006) 508 final.
Eurostat, DG Agriculture, DG Environment, JRC, EEA. 2001. Towards agri-environmental indicators - Integrating statistical and administrative data with land cover information.Topic Report No. 6. Copenhagen: EEA. http://www.eea.europa.eu/publications/topic_report_2001_06

Table 1. Agri-environmental indicators under development within FAOSTAT, including linkages to GHG assessment. AOLU, REDD+ refers to mitigation via biological C-sequestration above and below ground.

Domain	Subdomain	Indicator	GHG Link
Responses	Land	Agri-environmental commitments	AFOLU, REDD+
		Organic agriculture	N_2O
Driving forces	Fertilizers	Mineral fertilizers consumption	N_2O
	Pesticides	Pesticides consumption	Energy CO_2
	Water	Area equipped for irrigation	Energy CO_2
	Energy	Energy use	Energy CO_2
	Land	Agricultural land use change	AFOLU, REDD+
		Share agricultural land	AFOLU, REDD+
		Cropping patterns	C-Sequestration
		Livestock patterns	CH_4, N_2O
		Conservation agriculture	Soil C
	Air & Climate Change	Ammonia emissions	CH_4, N_2O
Pressure	Nutrients	Gross Nitrogen Balance	N_2O
		Gross Phosphate Balance	CH_4, N_2O
	Air & Climate Change	GHG emissions from agriculture	Direct CO_2, CH_4, N_2O
	Water	Water use in agriculture	Soil C, CH_4, N_2O
	Soil	Soil erosion	Soil C
	Energy	Biofuel	AFOLU, REDD+
State	Soil	Soil quality	Soil C

2.1 Current activities and Future Directions for Improving Environmental and GHG Data and indicators

A number of international activities on environment statistics are currently underway. The United Nations Statistical Commission[6] Forty-first session held 23-26 February 2010 and the Forty-second session in 2011 included a number of items on the environment. The agenda of the Commission included the following items on environment statistics: Report of the Secretary-General on the Framework for Environmental Statistics (E/CN.3/2010/9); Report of the Inter-secretariat Working Group on Environment Statistics (E/CN.3/2010/10) and Report of the Committee of Experts on Environmental-Economic Accounting (E/CN.3/2010/11). The Commission acknowledged that the United Nations Framework for the Development of Environment Statistics (FDES) had been a useful framework in many countries and endorsed the programme of work on the revision of the FDES. The Commission noted that the FDES provided a number of principles that should be followed in the revision process. In particular, the need to engage all stakeholders, including the scientific community and the need to ensure complementarity with the Handbook of National Accounting: Integrated Environmental and Economic Accounting

[6] http://unstats.un.org/unsd/statcom/sc2010.htm and http://unstats.un.org/unsd/statcom/sc2011.htm

(SEEA) 2003 was stressed. The third Expert Meeting on FDES[7] will be held in November 2011 with the expectation that a revised Framework for Environmental Statistics be presented to the United Nations Statistical Commission at the 2012 session.

The System of Environmental-Economic Accounts (SEEA)[8], currently under revision, will provide the internationally agreed conceptual framework to measure the interactions between the economy and the environment and the state of the environment. The revised SEEA will build upon its predecessors: the SEEA-2003 and the SEEA-1993. The revised SEEA is also expected to be present to the United Nations Statistical Commission at the 2012 session. At the sixth Meeting of the United Nations Committee of Experts on Environmental-Economic Accounting (UNCEEA) held in June 2011, a proposal for the development of a System of Environmental and Economic Accounting for Agriculture (SEEA-AGRI), was presented by FAO Statistics Division. Within this framework, agriculture is interpreted in the broad sense as all activities related to crops, livestock, forestry and fisheries. The development of the SEEA-AGRI will be led by FAO. FAO will seek technical assistance, where relevant, from the London Group[9]. The Committee agreed that the concept of SEEA-AGRI is of high importance. The Committee welcomed the willingness of FAO to lead the work on this subsystem of the SEEA, noting that agriculture together with forestry and fisheries make up a large portion of ecosystem services. It was suggested that SEEA-AGRI be used to help establish a hub between SEEA and the wealth of statistics available at FAO. The SEEA-AGRI will provide a statistical framework for countries to monitor key agri-environmental statistics such as GHG emissions.

The FAO Statistics Division Land use questionnaire (2010) for the first time included items on land used for organic production and land in conversion to organic production. The new items in the questionnaire will be: agricultural area certified organic; agricultural area in conversion to organic; arable area organic; arable area in conversion to organic; permanent crops area certified organic; permanent crops in conversion to organic; permanent meadows and pastures area organic; permanent meadows and pastures in conversion to organic (see Annex 2). By adding the organic area and the area in conversion to organic production, additional valuable information will be made available to policy analysts and makers on this farm management practice.

In December 2009, FAO initiated a consultation process inviting experts and representatives from key institutions, including IPCC to review the state of knowledge on GHG emissions and mitigation potentials in the agriculture, forestry and fisheries sectors and to assess the need for monitoring and assessment of GHG cycle, emissions and mitigation potential in the agriculture, forestry and fisheries sectors. The consultation highlighted the need for a global assessment which would supplement and support existing monitoring/assessment frameworks (such as UNFCCC/IPCC and the FAO Global Forest Resources Assessment - FRA) and would contribute to ensuring robust data collection which meet a variety of needs, including policy design and implementation. The IPCC category Agriculture, Forestry and Other Land Use[10] (AFOLU) presents a unique challenge to the inventory compilers especially from developing countries due to the paucity of national data. FAO has long maintained global datasets on agriculture and forestry that constitute an extremely valuable resource for GHG inventories compilation for the AFOLU sector as noted in the IPCC Guidelines. However, these datasets cater to a wide range of information needs besides GHG inventory compilation and may differ from the data required for GHG compilation in

[7] http://unstats.un.org/unsd/environment/fdes/fdes_egm.htm
[8] http://unstats.un.org/unsd/envaccounting/ceea/meetings/UNCEEA-6-4.pdf
[9] http://unstats.un.org/unsd/envaccounting/workshops.asp?fType=2&mType=L
[10] AFOLU Agriculture Forestry and Other Land Use *(AFOLU) sector of 2006 IPCC Guidelines and* Agriculture *and* Land Use, Land Use Change and Forestry (LULUCF)/Land Use Change and Forestry (LUCF) *of the* GPG *and* GPG-LULUCF/1996 IPCC Guidelines.

certain key respects. Therefore, some additional guidance on the access to, and use of, these datasets beyond what is available in the IPCC Guidelines is useful for inventory compilation especially for developing countries and those with limited resources.

Within the general AIEs effort undergone at FAO, particular attention is being devoted to quantifying GHG emissions and mitigation potentials, with a goal to obtain synthetic and comprehensive assessments for the different countries, consistently with IPCC methodologies and UNFCCC requirements, and providing specific attention to the assessment, monitoring and reporting needs and gaps of LDCs. This activity is carried out within the project: "Monitoring and Assessment of GHG Emissions and Mitigation Potentials in Agriculture", within the Mitigation to Climate Change in Agriculture (MICCA) Programme[11]. Its first three years of activity are funded by the Norwegian and German Governments. Key project goals are as follows:

- Generate knowledge that can help developing countries identify mitigation options in agriculture, forestry and fisheries -consistently with their rural development goals, in particular reinforce food security and increase resilience of agro-ecosystems, resulting in better adapted production systems.

- Development of a FAO GHG database on emissions and mitigation potentials, to support countries UNFCCC reporting goals, as well as providing a guideline to identify national mitigation goals and strategies, including NAMAs.

- Close collaboration with IPCC and UNFCCC in support of negotiations

[11] http://www.fao.org/climatechange/micca/en/

3. Monitoring and Assessment of GHG Emissions and Mitigation Potential in Agriculture

The monitoring and assessment of GHG emissions and mitigation potential (M&A GHG) project is an integral component of the AIEs effort within FAOSAT. Similarly, it aims at strengthening FAO and member countries' ability to gather, compile and analyse GHG related data; developing a first global assessment of GHG emissions from the agricultural sector; gauging the mitigation potential of different farming practices and methodologies; identifying economically viable and sustainable practices; building international consensus and developing guidelines on data, metadata and analysis procedures (for example for life cycle analysis – LCA). The results will directly contribute to the IPCC fifth assessment report, thus supporting the UNFCCC negotiation process by helping to produce the baseline emission data needed to allow agriculture to access climate change financing mechanisms.

A preliminary activity of the M&A GHG project was to link directly with IPCC at the outset of its activities, to jointly analyze needs and gaps towards improving GHG data collection and reporting activities, highlighting information gaps in the data and providing key recommendations. IPCC needs include the following.

With regards to enhancing measurements and reporting related to the terrestrial carbon cycle:

- More consistent and transparent global definition of forest;
- Improvements in National inventory and country statistics;
- Standardisation of methodology used to collect forestry information;
- Extensive surveys in tropical biomes of the different C pools;
- Submission of the geographic location of where LUC is occurring;
- Information on the fate of harvested wood products;
- Analysis of forest management practices;

With regards to improving global estimates from agriculture:

- Increase in the frequency of submission or increase in the number of years National Communications submitted by non–Annex I countries;
- Commitment to develop country specific emission factors, i.e., higher tiers for calculating emissions;

With regards to mitigation strategies:

- Increase in the number of studies investigating the mitigation potential of agro–forestry in tropical regions;
- Increase in the number of studies investigating the mitigation potential of grasslands;
- Increase in the number of studies of the mitigation of methane and nitrous oxide for croplands and grasslands and also the management of organic soils;
- Improvement in reporting of annual national statistics of animal numbers and area under each land use type;

Statistics on land use are required in order for deriving environmental indicators related to GHG data. Such agri-environmental statistics are compiled by FAO—and can be extended to include relevant GHG information that helps to address the identified gaps— through a variety of methods, such as censuses, surveys, remote sensing, administrative records, questionnaires, monitoring and network facilities for the development of environmental indicators and assessments.

The data published in FAOSTAT on land, labour, water, fertilizers, pesticides etc., that are for the large part also relevant to compute GHG emissions and assess mitigation potentials (Tab. 1), are compiled through the FAO agriculture resources questionnaires for building resources accounts and vital for environmental analysis. The data collected, however, are not adequate for directly assessing GHG emissions of social and economic activities. In addition, the data reflect national averages and aggregates while environmental problems are, in most cases, site and time specific. In brief, data published in FAOSTAT are not totally geared towards environmental problems since the primary datasets were not originally collected for that purpose.

In addition, significant temporal and regional gaps exist in how countries are able to collect required information to FAO. Regional review and assessment on the latest FAO questionnaires with respect to official data reported by countries on selected agriculture resources data domains (land use, fertilizers and pesticides) in terms of latest year reported and percentage of data items reported as compared to totals items provides an indication of capacity, revealing low levels in LDCs—especially in Africa (see for example, Tab. 2)—where country response to FAO questionnaires on Land use, Pesticides and Fertilizer questionnaires have been very poor in recent years.

Table 2. Number of countries responding to FAO fertilizers questionnaire in Africa by region (2007-2010)

Africa	Number of countries	2007		2008		2009		2010	
		Replies	Response rate	Replies	Response rate	Replies	Response rate	Replies	Response rate
Central Africa	9	0	0%	3	33%	1	11%	0	0%
Eastern Africa	17	3	18%	6	35%	5	29%	2	12%
Northern Africa	6	1	17%	3	50%	3	50%	2	33%
Southern Africa	5	0	0%	0	0%	1	20%	0	0%
Western Africa	16	4	25%	6	38%	3	19%	4	25%
TOTAL AFRICA	53	8	15%	18	34%	13	25%	8	15%

3.1 Data available at FAO

During the preliminary consultations with IPCC, a number of key international data sources for GHG that are already computed, gathered and managed at FAO were identified. Detailed references are provided in Annex 1. These key data sources relevant to AFOLU GHG data include:

- FAO, *Forest Resource Assessment* (FRA www.fao.org/forestry/fra);
- FAO, *National Forest and Monitoring Assessment* (NFMA www.fao.org/forestry/nfma/en/);
- FAO, *Harmonized World Soil Database* (http://www.fao.org/nr/water/news/soil-db.html);
- FAO, *Global Climate Maps* (www.fao.org/nr/climpag/climate/index_en.asp);
- FAO, *Global Planted Forests Thematic Study* (http://www.fao.org/forestry/plantedforests/10368/en/);
- FAO, *FAOSTAT* (http://faostat.fao.org/default.aspx)

- FAO/IIASA, *Agro-ecological Soil database* (http://www.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/index.html).

3.2 Data and Knowledge Gaps

Whilst major key data sources have been identified, there are still major data gaps and inconsistencies regarding requirements for countries for reporting their annual inventories of greenhouse gas emissions (GHG) and removals to the UNFCCC. International agricultural statistics have traditionally focused on issues relating to agricultural production, agricultural trade and food security. FAO has statistical datasets from the 1960's, which focus on agricultural production and trade (crops, livestock) in quantity and monetary terms. The statistical domain used to generate the key agricultural and food security indicators (such as production yields or the number of undernourished in a country) is well-established and have long time series of data for most countries. The FAO FAOSTAT database (http://faostat.fao.org/) was developed with this focus on agricultural production and food security and subsequently is structured to primarily suit these needs. Where there are key data gaps for producing indicators, such as production yields or the number of undernourished, considerable efforts are made to estimate data and to ensure these key indicators can be calculated.

At the national level, many country statistical systems are not yet designed for collecting data on parameters relevant for GHGs (which should be undertaken in a continuous and systematic way). Assessments such as life-cycle analysis, which requires information at each stage and for each input of production systems, is even more difficult to gather. Many countries need additional capacity and guidance on gathering this type of data, and incentives to release it. Emission factors and carbon stock factors are often available but need further development and validation. A number of general issues on the subject of data gaps were identified in the sessions and include:

- Data gaps are particularly large in developing countries. Around 110 countries regularly report agricultural production-data to FAO. The non-reporting countries are unlikely to be in a position to start reporting in the short-term. Considerable investment in staff and resources is needed to improve this situation;
- Data quality generally has not been systematically assessed. It is therefore difficult to evaluate the quality of data within some national datasets;
- A lot of the data required is in private hands (particularly for the processing phase). The issue of confidential (commercial) data is one which is becoming more pressing for FAO, particularly in regard to production of various agri-environmental inputs such as fertilizers and pesticides;
- Some data is too aggregated, some too site-specific (particular for the processing phase, where figures might be plant-specific) – the right balance between practicality and accuracy is required in order to identify good and bad practices and reward improvements;
- Guidance is needed to deal with data gaps (estimation procedures etc.). Clear and consistent data imputation procedures need to be established and implemented in the various agri-environmental data domains;
- Baseline emissions factors from different farming systems need to be established and better descriptions of agricultural land management practices and their emission impacts are needed.

Specific Data Gaps include: (i) Emissions factors for nitrous oxide have large potential consequences but appropriate factors are currently scientifically uncertain. Data on the level of nitrous oxide from dispersed manure in rangeland systems is particularly lacking; (ii) Ruminant digestibility is a key area in need of more data for life-cycle assessments (LCA); (iii) A more

systematic assessment of technologies and practices needs to be made; (iv) Improved estimation of carbon stocks and fluxes in the agricultural sector are required, especially regarding soil carbon (for example soil depth measurements); (v) Improved data is required for certain agro-ecological zones, production and cropping systems and soil dynamics, e.g. data is poor or missing for many tropical cropping systems and most grasslands, and many soil management responses are often poorly understood; (vi) A tree biomass database containing original tree biomass measurements and models would be very valuable; and (vii) Improved data on agricultural inputs (such as fertilizers), management practices and processing are required.

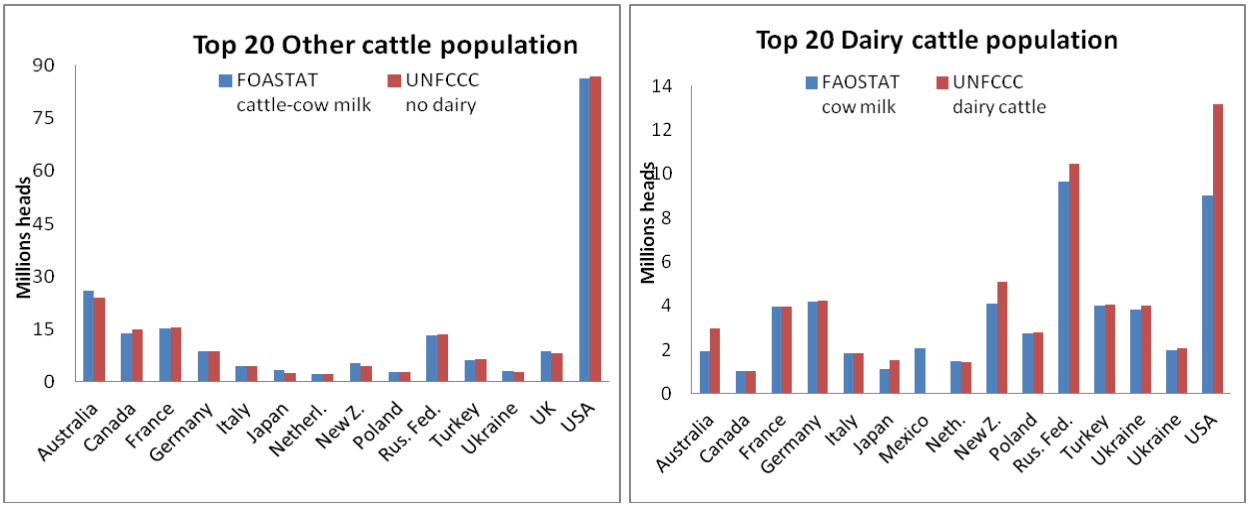
3.3 Example: Estimating and Reporting Manure N Content

Nitrogen and phosphorus are the main crop growth limiting nutrients in agriculture. Their main sources for plants are mineral fertilizers and livestock manure. Deficiency of nutrients can impair soil fertility and reduce crop yields while a surplus of them can represent a threat for the environment due to N and P losses from agricultural land to surface and ground water systems (eventually leading to eutrophication and acidification). In this context the gross nitrogen and phosphorus balance (GNB) is a useful indicator of the pressure exerted by agriculture on the environment. Data about the consumption of nutrients supplied by mineral fertilizers are published in FAOSTAT. These data are collected through FAOSTAT country questionnaires and are available for several countries. On the other hand, the calculation of N and P content in livestock manure of different animal species is a difficult task, due to the lack of an established methodology. Importantly, manure N content is a key parameter for the computation of CH_4 and N_2O GHG emissions from treated fields.

The total amount of Nitrogen and Phosphorous contained into the manure is estimated by multiplying the total numbers of livestock species by specific manure coefficients. While several institutions are involved in the definition of appropriate coefficients, a consistent approach has not been defined. A consultation with stakeholders (OECD, EUROSTAT, EEA, IIASA, E.C.-DG-ENV) revealed that no common and widely accepted methodology is available for the estimation of manure nutrient content, and that the sets of coefficients available from statistics are not well documented. Studies concerning N/P excretion and their influencing factors are still limited and it is necessary to reach a unique and harmonized approach across all countries in order to set up a valid set of excretion coefficients. In this context, methodologies used for the calculation of the coefficients and to compare the coefficients used by different organizations were compared to those calculated by the FAO using FAOSTAT reported data and a Life-cycle model analysis

Specifically, cattle, pigs, goats and sheep numbers are available from FAOSTAT. Data on total cattle and pig population were compared with UNFCCC and EUROSTAT, showing no big differences between countries. As pointed out before, livestock categories in other organizations are subdivided depending on the age, feeding management, age of animals or weight of animals. FAOSTAT database only contains aggregate figures on cattle and milking cows (animal which have been milked during the year). The category "*other cattle*" was created by subtracting the number of milking cows to the total number of cattle. It includes therefore calves, heifers and bulls. Data on pigs is aggregated into one unique category, with no differentiation on weight.

Figure 1. Comparison of animal categories between FAOSTAT and UNFCCC databases.



The total amount of nitrogen content in manure for cattle of FAO model was calculated for European countries by multiplying the herd data of the 2005 Gridded Livestock of the World (GLW) (FAO, 2007) by the corresponding nitrogen excretion coefficients for each herd category. These data were compared with the available corresponding data contained within the EUROSTAT database (http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database).
The comparison showed a quite good agreement between FAO model nitrogen excretions and the EUROSTAT data: overall our estimate was 92% of the EUROSTAT data for Europe.. The regression between the two datasets was described by R^2= 0.9904 (Fig. 2).

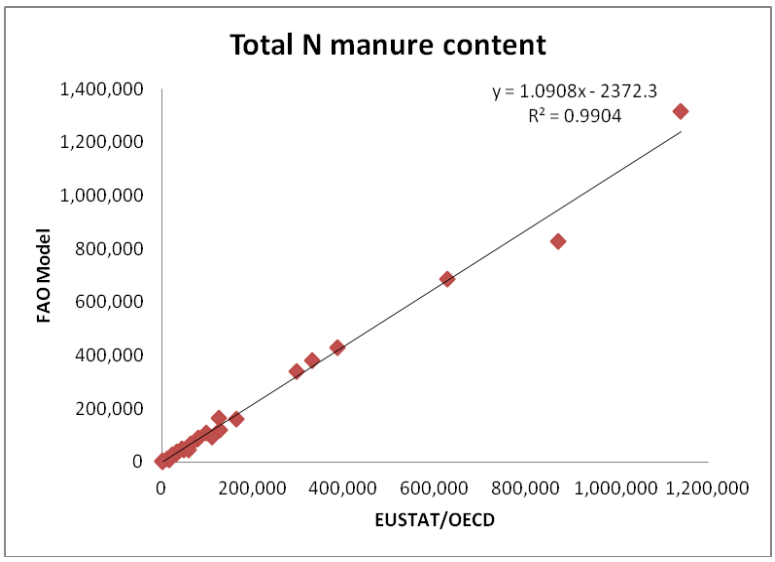


Figure 2. FAO model vs. EUROSTAT/OECD data on N manure content

3.4 Methodological issues

A number of key methodological issues need to be addressed in developing a GHG central database and assessment at FAO. Because such new methodological and data tools aim at supporting IPCC and UNFCCC/SBSTA processes, IPCC methodologies (Tier 1-3) will be used were possible, to be supplemented with additional FAO-developed methodologies and protocols. Furthermore, frequency and spatial scale of measurements needs to be determined in order to

provide wide application by end user countries (e.g., resolving spatial variability issues through, pilot sampling, remote sensing and stratification). Determination of the choice of unit will be important. For example, emissions per unit of a single commodity will be different from emissions per unit of nutritive value (e.g. protein or calories) which might also be context-specific.

Geo-referenced data on cropping systems and the application of remote sensing will be needed for the detection and classification of land-use changes. For emissions from land-use change, an agreement will be needed upon how to handle emissions timing. Timing of emissions must be considered. Indeed, different times of actual physical emissions are typically applied in order to count relatively immediate land-use change emissions over time. To date, this aspect of timing is handled in one of three ways: counting all emissions instantaneously, using an amortization period, and using some form of discount rate.

On needed guidance, issues relate to guidance on the scale of application, which would vary with the type of emissions and activities or products considered; guidance on the accounting of co-products from agricultural production; guidance on the level of uncertainty acceptable for different mitigation uses (e.g. offsets, Nationally Appropriate Mitigation Actions - NAMAs) and for assessing this uncertainty; and guidance on emission segregation (from unregulated emissions) that is otherwise subject to limitations. Finally, analysis calculating mitigation benefits should take account of the robustness of the practice in achieving the projected reduction, i.e. how dependent the reductions are on the details of the implementation. More robust practices should receive higher awards/incentives;

4. Conclusions

FAO has began a process towards the improvement of global monitoring and assessment of GHG emissions and mitigation potential, embedded within its own efforts to expand environmental indicators in FAOSTAT, in close collaboration with IPCC and UNFCCC.

A comprehensive appraisal is now being undertaken to assess the critical priority gaps that need to be filled, what inputs and costs are required and the country capacity building that needs to be undertaken at the national level. From this, a work programme was developed with a focus on improvement of the data collection process, country capacity building, development of country case study, the processing and analysis required in developing a global assessment. Part of the work undertaken includes guidance document on how to apply LCA-type analyses for better linking GHG mitigation, adaptation and food security issues, including the development of a database containing resources required for LCA type work (containing standardized data on production systems for raw materials, agro-ecological zones, land management practices, processing technologies, and other major elements of product lifecycles). Such activities support the creation of detailed technical guidance for potential appropriate national mitigation actions (NAMA) in developing countries and especially LDCs. The development of a data warehouse for FAOSTAT and other FAO databases is underway and will lead to easier integration and use of the agri-environmental data held in FAO.

As next steps, an international framework will be developed through the integration and expansion of existing assessments (such as the FAO Global Forest Resources Assessment) and will be based on IPCC principles and methods for AFOLU. The initiative is open to partnership with a interested stakeholders including experts, universities, government institutions and the private sector. With these partners the following next steps will be taken:

- Detail a work programme on data collection process, country capacity building, development of country case studies and finally develop a global assessment;

- Survey a sample of countries for barriers and limitations to adopting or developing GHG emission databases and use this information to help devise a strategy to overcome the issues;
- Set up a mechanism for sharing information;
- Define immediate deliverables in short-term with long-term goals in perspective;
- Fast implementation of steps towards improving the data collection process;
- Capacity-building at country level;
- A set of country case studies to be carried out as first example, to eventually generate a global assessment using the IPCC Tier 1 methodology;
- Focus on expansion of framework assessment to all countries and encourage capacity-building to allow independent access to reliable information and data;
- Review, restructure and re-focus FAOs FAOSTAT database to address the needs of agri-environmental data users.

Taking the above steps will lead to the building of capacity to meet national data needs as well as generating the data and information required to improve GHG emissions estimates for the agricultural sector, with a view to support inclusion in poist-2012 UNFCCC climate agreements and related mechanisms.

8. References:

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Annex 1. Agri-Environmental Indicators domain in FAOSTAT

Domain	Subdomain	Indicator	Series
Responses	Land	Agri-Environmental Commitments	Protected area
			Protected area as % on total area
		Organic Agriculture	Organic Agriculture area
			Organic Agriculture (share on total area)
Driving forces	Fertilizers	Min.Fertilizers Consumption	K Fertilizers consumption/agric.area
			N Fertilizers consumption/agric.area
			P Fertilizers consumption/agric.area
			Nitrogen Fertilizers (N total nutrients)
			Nitrogen Fertilizers (P205 total nutrients)
			Nitrogen Fertilizers (K20 total nutrients)
			N+P Fertilizers (total nutrients)
			N+P+K Fertilizers (total nutrients)
			N+P+K (total nutrients) Cons. per hectare
			N+P (total nutrients) Cons. per hectare
	Pesticides	Pesticide Consumption	Pesticide use by Ha of agricultural land
			Pesticide Consumption (total)
	Water	Area equipped for irrigation	Total area equipped for irrigation
			Share of Irrigated Agricultural Area
	Energy	Energy use	Energy used in agriculture/forestry
			Share of agricultural energy consumption on the total energy consumption
			Energy from Coal & Peat as
			Energy from Oil Products
			Energy from Natural Gas
			Energy from Geothermal/Solar
			Energy from Biofuels/Waste
			Energy from Electricity
			Energy from Heat
	Land	Agricultural land use change	Agricultural land use change compared to the previous year
		Share agricultural land	Agricultural Area/Land Area
		Cropping patterns	Arable land
			Permanent crops
			Permanent meadows and pastures
			Share Perm.Crops on AgrLand
			Share Perm.Pasture on AgrLand
			Share arable land on AgrLand
		Livestock patterns	Cattle, Pigs, Sheep total density
			Cattle density
			Pigs density
			Sheep and Goats density
			Poultry density
			Cattle and Buffaloes (Total)
			Sheep and Goats (Total)
			Poultry Birds (Total)
			Pigs (Total)
			Pigs share on total livestock
			Cattle share on total livestock
			Poultry share on total livestock
			Sheep share on total livestock
			Pigs share on total livestock (excl.Poultry)
			Cattle share on total livestock (excl.Poultry)
			Sheep share on total livestock (excl.Poultry)
			Total Livestock number
			Total Livestock number (excl. Poultry)
		Conservation agriculture	Conservation agriculture area: >30% ground cover
			Conservation agriculture area as % of cultivated area
	Air & Climate Change	Ammonia emissions	Ammonia emissions from Agriculture
			Share of agricultural ammonia emissions on total ammonia emissions
Pressures	Nutirents	Gross Nitrogen Balance	Gross Nitrogen Balance
		Gross Phosphate balance	Gross Phosphate balance
	Air & Climate Change	GHG emissions from Agriculture	Share GHG from agriculture/total GHG emissions
			Total GHG emissons from agriculture
	Water	Water use in Agriculture	Agricultural water withdrawal
			Agricultural water withdrawal as % of total water withdrawal
	Soil	Soil Erosion	Average Soil Erosion
			Average Soil Degradation
	Energy	Biofuels	Total biofuels production
			Share of biofuels on total renewable energy production
State	Soil	Soil Quality	Average carbon content in the Topsoil

Annex 2. FAO Questionnaire on Agricultural Resources: the inclusion of the Organic dimension (extract)

Country area (1)	(1)=(2)+(33)
Land area (2)	(2)=(3)+(29)+(30)+(31)
Agricultural area (3)	(3)=(8)+(23)
Agricultural area organic, total (4)	(4)=(5)+(6)
Area certified organic (5)	
Area in conversion to org anic (6)	
Agricultural area irrigated (7)	(7)=(14)+(16)+(22)+(28)
Arable land and Permanent crops (8)	(8)=(9)+(18)
Arable land (9)	(9)=(13)+(15)+(17)
Arable land organic, total (10)	(10)=(11)+(12)
Area certified organic (11)	
Area in conversion to organic (12)	
Temporary crops (13)	
Temporary crops irrigated (14)	
Temporary meadows and pastures (15)	
Temporary meadows and pastures irrigated (16)	
Fallow land (temporary: less than 5 years) (17)	
Permanent crops (18)	
Permanent crops organic, total (19)	(19)=(20)+(21)
Area certified organic (20)	
Area in conversion to organic (21)	
Permanent crops irrigated (22)	
Permanent meadows and pastures (23)	(23)=(27)+(29)
Permanent meadows and pastures organic, total (24)	(24)=(25)+(26)
Area certified organic (25)	
Area in conversion to organic (26)	
Permanent meadows and pastures - Cultivated (more than 5 years) (27)	
Permanent meadows and pastures - Cultivated and irrigated (28)	
Permanent meadows and pastures - Naturally grown (29)	
Forest area (30)	
Other wooded land (31)	
Other land (32)	
Inland water (33)	