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Submission by the Food and Agriculture Organization of the United Nations (FAO)
To the United Nations Framework Convention on Climate Change (UNFCCC)
In relation to the Koronivia joint work on agriculture (4/CP.23)
On topic 2(d)

The decision (4/CP.23) on Koronivia Joint Work on Agriculture (KJWA), and its road map (FCCC/SB/2018/L.1) recognize the fundamental importance of agriculture in responding to climate change, as well as, facilitate the process for agreeing on concrete actions for safeguarding food security, ending hunger, and the particular vulnerabilities of food production systems to the adverse impacts of climate change. For this reason, FAO welcomes the opportunity to submit its views on the topic 2(d) – *Improved nutrient use and manure management towards sustainable and resilient agricultural systems*. Under the KJWA road map.

The management of nutrients in agricultural systems, particularly nitrogen and carbon, from sources including inorganic and mineral fertilizers, manure, composts and recycled materials has a clear relationship to climate change, greenhouse gas (GHG) emissions, soil degradation, agricultural productivity and food security, as well as the resilience of farms and farmers to climate change impacts.

The inefficient use of nutrients and manure management can be a large source of GHG emissions but, if managed properly, can be turned into an advantage by reducing costs, increasing productivity, and recycling nutrients and energy. Given FAO's role as a knowledge provider, and considering that climate change cuts across all its areas of work, FAO is underlining the importance of topic 2(d), and highlights its cross-linkages to other KJWA topics, including 2(c) - *Improved soil carbon, soil health and soil fertility under grassland and cropland as well as integrated systems, including water management;* and 2(e) - *Improved livestock management systems,* as well as the ones to be discussed during the intersessional workshop in New Zealand in 2020. Therefore, FAO proposes some key issues to be addressed during the in-session workshop dedicated to topic 2(d) and beyond, as outlined in this submission.

1. Need for a holistic approach for nutrient use and manure management

Nutrient management in crop-livestock-aquaculture activities at the farm level largely contribute to GHG emissions associated with agriculture sectors, often with trade-offs between production gains and emissions. These and other agronomic and land management practices and decisions have effects on nutrient flows at the landscape or larger (country or global) scale, with potential downstream emissions of GHG emissions, soil erosion and perturbations to the nutrient and hydrological cycles.

The key challenge to reduce GHG emissions through nutrient use and manure management is the lack of more systematic and holistic approach. Nutrient management needs to take into account the different scales at which recycling can occur, including on-farm, at landscape or watershed level through the interaction of specialized farming enterprises, and at global scales. Furthermore, nutrient recycling (circular bio-economy) is critical to reduce emissions and to enhance the productivity of different components on agri-food systems. For example:

- More than 80% of nutrients such as Nitrogen and Phosphorus consumed by animals through feed is excreted in manure. Without proper manure management, Nitrogen and Phosphorus are lost into the environment causing global warming and a cascade of impacts such as acidification, eutrophication and biodiversity loss.
- Feed production is another source of nutrient emissions into the environment, mainly related to manure and synthetic fertilizer applied to crops and grassland. Further nutrient losses occur during the post-farm processing through wastewater or organic wastes.

In order to guarantee productivity in agriculture and prevent emissions into the environment, the right choice should be made on nutrient source, and on the rate, time and place of application. As far as the right source is concerned, the usage of manure prevents the production of fertilizer which is associated to GHG emissions. In addition, manure deposition preserves the ecological integrity of soils and positive trade-offs also exist with soil water retention, carbon sequestration and plant health. Manure deposition in soil provides organic matter increasing soil fertility and quality and hence contributing to resilient agricultural systems. While manure is typically rich in nitrogen and includes many other nutrients, the usage of fertilizer can be made to meet nutrients requirement for e.g. phosphorus.

Besides macronutrients, also micronutrients in soils and feed play a major role. Micronutrients directly contribute to high quality animal diets which ultimately result in increased animal health and production. As increased production is directly correlated to GHG emission, the provision of micronutrients - also through additives - is essential.

Moreover, to reduce nitrous oxide emissions and hence mitigate GHG emissions from livestock production, a multi-criteria approach needs to be adopted. Specific measures enabling to reducing nitrous oxide emissions result in increased emissions of other components (e.g. NO_3 and NH_3), hence shifting the problem from global warming to other environmental impacts. The life cycle assessment is helpful to identify trade-offs and prevent shift of burdens.

While usage of specific feed additive families can result in decreased nutrient content in manure and hence in reduced emissions. Such reduced nutrient content however reduces the value of manure as nutrient source. Therefore, a more holistic view is necessary, when approaching sustainable nutrient use and manure management to reduce GHG emissions.

Holistic approaches are also useful to understand how the manure generated by livestock production interacts with soil nutrient budgets, defined as the difference between nutrient inputs from fertilizer and animal manure and the withdrawal through harvesting crops and grazing or mowing of grass. Indeed, different manure management strategies should be applied in case of a positive budget (nutrient overload or surplus), which represents a potential loss to the environment through excessive accumulation in the soil, or in case of a negative budget (indicating a potential nutrient deficit).

Nutrient budget approach (per ha of agricultural land) is key to evaluate how manure can be beneficial or harmful for soils and the environment. In this regard, an excessive concentration of manure per ha, generally challenging for super-intensive livestock development trajectories, may result in major nutrient overloads in soil and water, that constitute a serious concern for the environment and public health.

Animal manure, in addition to nutrients, contains large numbers of microorganisms that - if excessively concentrated in soil and water - can lead to microbiological pollution and contamination. Therefore, proper sustainable manure strategies should include microbiological assessments of water quality in various sampling points along livestock production areas.

2. Addressing sustainable nutrient use and manure management

Parties and observer organizations identified in their submissions to UNFCCC on KJWA (March, 2018) a number of key common challenges to improve nutrient use and manure management towards sustainable and resilient agricultural systems. These, among others, include regulatory framework for addressing nutrient use, guidance for more optimized and rational use of inorganic fertilizers, need to define agricultural techniques and timings to maximize nutrient uptake, knowledge and technology transfer, sophisticated site-specific monitoring and modelling technology for precision agriculture to optimize the use of nutrients.[a]

FAO, together with other partner organizations, have developed a number of tools and methodologies, and have been leading global initiatives on the subject of nutrient use and manure management(listed in the Annex 1), that are already addressing some of the challenges that have been identified by Parties and observers. The most outstanding ones are the following:

[a] FAO, 2018. *Koronivia Joint Work on Agriculture: Analysis of Submissions.* Rome. 42 pp. (also available at http://www.fao.org/3/CA2586EN/ca2586en.pdf)

- **International Code of Conduct for the Use and Management of Fertilizers**[b] is a framework that has been endorsed by FAO Member Countries at the 41st session of the FAO Conference. It provides a locally adaptable framework and voluntary set of practices with which governments, the fertilizer industry, agricultural extension and advisory services, supporting academic and research institutions, actors in the nutrient recycling industry, civil society and end-users can contribute to sustainable agriculture and food security from a nutrient management perspective by following or adhering to the guidelines and recommendations provided. The Code supports stakeholders to advance nutrient recycling technologies and the efficient and effective use of fertilizers (including synthetic, mineral and organic fertilizers, manure and recycled nutrients) to reduce environmental impacts caused by excess nutrients such as water pollution and greenhouse gas emissions. It also aims to improve food safety, nutrition as well as farmer livelihoods.
- Livestock Environmental Assessment and Performance (LEAP) Partnership[c] is a multisector platform hosted by FAO to provide more information about the environmental performance and the sustainability of livestock supply chains through standardized indicators for improved measures. The technical paper **Nutrient flows and associated environmental impacts in livestock supply chains**[d] was developed to provide comprehensive guidance to assess nutrient use efficiency and to identify solutions for nutrients and manure management under the LEAP. This technical document helps to identify practices so that the right choice is made for rate, time and place of nutrient application. The guideline assists to identify trade-offs between climate change and other environmental impacts hence helping to prevent shift of burdens when identifying mitigation options.
- In order to identify nutrient efficiency gaps and the mitigation potential of specific interventions in livestock production, the scope of the **Global Livestock Environmental Assessment Model** (GLEAM)[e] is currently being expanded to include a component on nutrients use efficiency.

Conclusions

Considering that there is significant amount of guidance materials, tools and practices available at the global and national level, there is a potential to capitalize on the existing knowledge and experiences and upscale and downscale them between global and national levels. This knowledge can address the need to move nutrient cycles towards a "circular economy" or "bio-based economy" through improved nutrient use and efficiency, nutrient recycling, sequestration of soil organic carbon and enhanced soil fertility.

FAO is taking a leading role in advocating for food security and sustainable agriculture and it offers support to countries seeking to undertake transformative changes in agricultural sectors in the face of climate change. In line with its *Climate Change Strategy*, FAO is providing the following support to countries:

- *Coherent and enabling policy, legal and institutional frameworks for climate action;*
- *Research, analysis and tools that respond to the needs of countries;*
- *Knowledge sharing and capacity development for implementation and action;*
- *Access to finance to scale up climate investment; and*
- *Support in monitoring and reporting progress in climate action.*

FAO will continue to provide this support and looks forward to working in partnership with other actors in the climate and development fields to advance the implementation of the KJWA, in a coherent way, towards COP26 and beyond.

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[b] FAO, 2019. *International Code of Conduct for the Use and Management of Fertilizers*. Rome. 43 pp. (also available at http://www.fao.org/3/ca5253en/CA5253EN.pdf)

[c] FAO, 2019. *Livestock Environmental Assessment and Performance Partnership.* In: *FAO* [online]. Rome. [Cited 12 September 2019]. http://www.fao.org/partnerships/leap/en/

[d] FAO, 2018. *Nutrient flows and associated environmental impacts in livestock supply chains: Guidelines for assessment.* Rome. 156 pp. (also available at http://www.fao.org/3/CA1328EN/ca1328en.pdf)

[e] FAO, 2019. *Global Livestock Environmental Assessment Model.* In: *FAO* [online]. Rome. [Cited 12 September 2019]. http://www.fao.org/gleam/en/

Annex 1: A stock take of FAO's work

Activity/ Initiative/ Publication	Brief description and how it is relative to Koronivia
International Code of Conduct for the Use and Management of Fertilizers[b]	The Code provides a locally adaptable framework and voluntary set of practices with which governments, the fertilizer industry, agricultural extension and advisory services, supporting academic and research institutions, actors in the nutrient recycling industry, civil society and end-users can contribute to sustainable agriculture and food security from a nutrient management perspective by following or adhering to the guidelines and recommendations provided.
Nutrient flows and associated environmental impacts in livestock supply chains: Guidelines for assessment[d] developed by the Livestock Environmental Assessment and Performance (LEAP) Partnership[c]	These guidelines aim to introduce a harmonized international methodology to assess nutrient flows and impact assessment for eutrophication and acidification for livestock supply chains taking the specificity of the various production systems involved into consideration. The methodology strives to increase understanding of nutrient use efficiency and associated environmental impacts and to facilitate improvement of livestock systems' environmental performance. The guidelines are a product of the Livestock Environmental Assessment and Performance (LEAP) Partnership, a multi-stakeholder initiative whose goal is to improve the environmental sustainability of livestock sector through better metrics and data. The objectives of these guidelines are: • To develop a harmonized, science-based approach resting on a consensus among the sector's stakeholders; • To recommend a scientific, but at the same time practical, approach that builds on existing or developing methodologies; • To promote an harmonised approach to assess nutrient flows and impact assessment, relevant for global livestock supply chains; • To identify the principal areas where ambiguity or differing views exist concerning the methodological framework. While LEAP guidelines focus on livestock sector, the publication provide also a complete guidance on the quantification of nutrient flows in agriculture systems. These guidelines are of direct use by FAO member countries and agricultural stakeholders to build national inventories and perform nutrient use assessment for voluntary reporting to UNFCCC. These guidelines are also being considered as basis in the revision of IPCC guidelines. FAO would support the dissemination of these guidelines and organization of regional workshop to support member countries to get insights into the status of their nutrient management and identify mitigation options. Moreover, based on these guidelines, FAO can support countries to set realistic mitigation targets that are measurable and achievable. FAO can help countries to improve their reporting, measurement and verification approaches by shifting from Tier 1 to Tier 2 approaches, which are provided in these guidelines. Moreover, FAO can also support the integrated approach for climate change mitigations, which consider nitrogen and carbon cycles together. This aspect is important because N and C are both necessary to achieve soil carbon targets for instance.
Save and Grow[f]	Policy guidance tool for sustainable agriculture with the basic premise to reduce inputs while increasing outputs by using better farming practices.
Agroecology[g]	FAO promotes agroecology as a way to transition towards more sustainable agriculture and food systems. In addition, FAO has many projects related to building resilience to climate change through Farmer Filed Schools (FFS) and agropastoral Field Schools (APFS), which in most cases involve better management of nutrients at the farm level.
The role and use of green manure / cover crops on small farms[h] (GMCC)	GMCC field programmes to Foster the use of crop rotation that include GMCC and legumes to enhance soil nutrient balances. FAO highlights the importance GMCC practices to improve soil nutrient balance in order to increase nutrient uptake by crops and enhance productivity.

[f] FAO, 2011. *Save and Grow. A policymaker's guide to the sustainable intensification of smallholder crop production.* Rome. 102 pp. (also available at http://www.fao.org/3/a-i2215e.pdf)

[g] FAO, 2019. *Agroecology Knowledge Hub.* In: *FAO* [online]. Rome. [Cited 12 September 2019]. http://www.fao.org/agroecology/home/en/

[h] FAO, 2011. *Green Manure/ Cover Crops and Crop Rotation in Conservation Agriculture on Small Farms.* Rome. 97 pp. (also available at http://www.fao.org/fileadmin/user_upload/agp/icm12.pdf)

Assessment of global biological nitrogen fixed by agricultural crops	This assessment provides a standard methodology and tools to estimate the amount biological nitrogen fixed by important pulse crops. Increasing the amount of nitrogen biologically fixed will positively contribute to mitigate effects of climate change and improve food security by optimizing the amount of fertilizers required for agricultural production. The key aspects of this assessment is to monitor the nutrient dynamics, i.e. the change of available nitrogen in the soil due to the introduction of legumes. In addition the change in nutrient balance in the soil, especially N:P ratio, must be monitored over time.
Global nitrogen use assessment in livestock sector.	This activity explores the contribution of the livestock sector to the global nitrogen losses and provides an overview of nitrogen flows and losses along the livestock supply chain by country, region and production system. It also assess the nitrogen-use efficiency indicators and quantify the emissions of N_2O, NH_3, NO_x and nitrates and organic nitrogen loads to watercourses. The analysis follows a modular modelling and covers N flows at crop/feed production, animal production and processing of animal products. It also explores the improvement pathways towards sustainable nitrogen use in livestock sector and quantify the cost-benefits of mitigation interventions. This activity provides insights and evidence to livestock stakeholders around the world and stimulate policy dialogue to improve the sustainability of nitrogen use in agriculture, not only from climate aspect but also from air and water pollution aspects. The approach used can also be applied to the entire agriculture systems in different contexts to understand the magnitude of N use and losses.
Technology and knowledge transfer project on the sustainable use of organic fertilizers to increase soil health and fertility by reducing inputs of soil contaminants	The objective of this project is to implement a capacity development and technology transference programme on sustainable soil management, via South-South cooperation for developing countries in Asia, Africa, Latin America and Near East, with a focus on the production and use of safe organic fertilizers for increasing soil fertility and ensure enough safe food production.
The Global Soil Doctors programme[i]	The Global Soil Doctors programme is a farmer-to-farmer training system which aims to build the capacity of family farmers on the sustainable use and management of soils and therefore of their agricultural lands. By doing so, the Soil Doctors programme fills a gap in regions where extension services are not available and, if present, it supports them in disseminating good agricultural practices, including on-farm nutrient management. This is done with the help of a Soil Testing Kit, which provides the Soil Doctors and other local farmers with tools to assess the health of their soils, including the nutrient status of their soil. The programme also offers educational material to help the farmers in choosing the best management practices based on their soils' properties.
Publication on the results of a project related to the **conservation and improvement of soil quality in Sao Tome**[j]	This publication/ case study describes a project on rehabilitation of degraded soils in Sao Tome. The main objective of the project was to increase and sustainably diversity agricultural production across conservation while improving soil quality. This publication tackles the issues of erosion and soil fertility, and provides effective and sustainable management practices to remediate them.
More People, More Food, Worse Water? A Global Review of Water Pollution from Agriculture[k]	Worldwide, the most common chemical contaminant found in groundwater aquifers is nitrate from farming. The intensification of livestock production means that water pollution (of surface and groundwater) by organic matter from livestock farming is now significantly more widespread than organic pollution from urban areas. "Traditional" regulatory instruments continue to be a key tool in reducing farm outputs of pollutants: water quality standards; pollution discharge permits; mandatory best practices; buffer zones around farms; minimizing the use of fertilizers and pesticides. On livestock operations, traditional techniques such as restoring degraded pasturelands and better managing animal diets, feed additives and medicines are needed — while more also needs to be done with new nutrient recycling techniques and technologies, and better manure management such as farm waste biodigesters.

[i] FAO, 2019. *The Global Soils Doctors Programme.* In: *FAO* [online]. Rome. [Cited 12 September 2019]. http://www.fao.org/global-soil-partnership/pillars-action/2-awareness-raising/soil-doctor/en/

[j] FAO. 2000. *Manual on Integrated Soil Management and Conservation Practices.* Rome. 214 pp. (also available at http://www.fao.org/3/x4799e/x4799e.pdf)

[k] IWMI, CGIAR, FAO, 2018. *More People, More Food, Worse Water? A Global Review of Water Pollution from Agriculture*. Rome. 207 pp. (also available at http://www.fao.org/3/ca0146en/CA0146EN.pdf)