CDM: Recommendation Form for Small Scale Methodologies (version 01)

(To be used for presenting questions/proposals/amendments to the simplified methodologies for small-scale CDM project activity categories)

Date of SSC WG meeting:	16–19 June 2009, SSC WG 21
Title/Subject (give a small title or specify the subject of your submission, maximum 200 characters):	Broadening the applicability of AMS-III.A to legume – grass rotation and additional options for fertilizer use
Indicative methodology to which your submission relates (refer the items of Appendix B of the Simplified Modalities and Procedures), if applicable.	AMS-III.A
Name of the authors of the query:	Mr. Matthias Krey / Ms. Peg Armstrong-Gustafson Institution: Perspectives Climate Change GmbH / Amson Technology krey@perspectives.cc, peg@tmgmanagement.com

Summary of the query:

Please use the space below to summarize the query related to SSC methodologies/categories SSC Modalities and Procedures provide recommendation/analysis of the SSC WG.

Original text from PP:

As project developers, we would like to propose the following revisions to the methodology in order to broaden its application potential:

(1) Extension of applicability to specific legumes – grass rotations

(2) Extension of the applicability to synthetic fertilizers containing nitrogen other than urea

(3) New default emission factor for urea

Ad (1) Extension of applicability to any legume – grass rotation:

The following is a revised version of the same section of our previously submitted request for revision SSC_279.

The present methodology applies to a soybean – corn crop rotation pattern. Broader definition of the methodology to a legume – grass crop rotation would provide for a greater reduction in urea being used in common crop rotation patterns and not limit the methodology only to areas where corn and soybeans are grown. The result would be a greater CDM potential of the underlying project type.

Crop rotation is a planned order of specific crops planted on the same field. Crop rotation also means that succeeding crops are of a different genus, species, subspecies, or variety than the previous crop. Examples would be barley after wheat, row crops after small grains, grain crops after legumes, etc. The planned rotation sequence may be for a two- or three-year or longer period. Some of the general purposes of rotations are to improve or maintain soil fertility, reduce erosion, reduce the build-up of pests, spread the workload, reduce risk of weather damage, reduce reliance on agricultural chemicals, and increase net profits (see *NDSU Environmental Bulletin. Crop Rotations for Increased productivity. Dr. Michael D. Peel, EB-48. Jan. 1998).*

Because climate, soil type, extent of erosion, and suitable cash crops vary around the globe, rotation schemes vary as well. Examples are listed below for Ukraine, India and China.

Ukraine (not a CDM country, for illustration only)

Farms in Ukraine employ a variety of crop-rotation schemes, some including four or more crops, some only two. A six-year crop rotation in the winter grain region will often include two consecutive years of wheat and one season of "clean fallow," during which no crop is sown. The chief reason for including fallow in the rotation is to replenish soil-moisture reserves, and it is more widely used in southern eastern Ukraine where drought is not uncommon. A typical crop sequence might be: fallow, winter wheat, winter wheat, sunflowers, spring barley, and corn. Wheat almost always follows fallow. According to farm directors, this enables the wheat -- which is typically the priority crop -- to benefit from the reduced weed infestation. (Fields are cultivated several times during the fallow season.). Some crop rotations include several consecutive years of a forage crop. An example of such a rotation would be: fallow, two years of winter wheat, and four years of perennial forage. The perennial forage is usually alfalfa; farmers will get three to four cuttings per year, five if the crop is irrigated. In southern Ukraine, clean fallow is frequently omitted and a crop rotation will likely include sugar beets and/or sunflower, the region's chief industrial crops. A typical seven-year rotation might be: winter wheat, winter barley, sugar beets, winter wheat, winter barley, sunflowers, and corn. The summary is that a corn-soybean rotation is not as prevalent as some other legume-grass rotations (see *Country Summaries, FAO, 2007*).

India

Below are typical crop rotation strategies for a rice production area where pulse (legumes, including soybeans) would be used in rotation (see *Country Summaries, FAO, 2007*). This project was conducted using satellite mapping. The table highlights the different crop rotation options and quantifies the percentage of land area devoted to each option.

Table 1: Statistics of different Crop rotation classes derived using SPOT VGT data (2001-02)

Sl No.	Crop Rotation Classes (Kharif-Rabi-Summer)	% of Net-Sown Area
1	Rice-Fallow	55.59
2	Upland crops-Fallow	25.15
3	Rice-Pulse-Fallow	10.88
4	Rice-Fallow-Pulse	3.66
5	Rice-Fallow-Rice	2.84
6	Fallow-pulse-Fallow	0.95
7	Fallow-Rice	0.45

China

Table 2: The Use of Soybean in Crop Rotation Practices in Different Regions of China.

Region	Crop Rotation Strategy	Remarks
Northeast China	Soybean-corn-broom corn-corn Soybean-broomcorn (rice)-corn Spring soybean-spring	One crop per year

	wheat	
Valley of the Yellow and Huaihe Rivers	Winter wheat-summer soybean Winter wheat-summer soybean-corn Winter wheat-summer soybean-no crop winter-cotton	One crop per year or three crops in two years
Valley of the Yangtze River	Winter wheat – summer soybeans-winter wheat-corn Winter wheat-summer soybeans-winter corn-cotton Winter wheat-summer soybeans-winter wheat-rice Winter wheat-summer soybeans and corn-winter wheat-sweet potato	Two to three crops per year
Southeast China	Early rice-autumn soybeans-winter wheat or corn Early rice-autumn soybeans-green manure or fallow in winter-late rice-winter wheat or corn	Water supply is low in autumn. Soybeans are frequently sown after the rice harvest

Source: *Zhang Mengheng, 1999. Problems and Solutions on Cultivation of Soybeans. China Braille Press, Beijing, China.*

As a result, it can also be noted that legumes are not always planted in an alternating rotation with grass crops. There are some farming systems where a farmer may plant two subsequent grass crops before planting a legume. The urea offset effect will equally occur in this case, i.e. urea application will be reduced to zero for the legume planting and urea application to the subsequent grass crop will be reduced. If a second grass crop follows the first, no further urea offset might take place. But as the methodology accounts for any urea used in the project activity, the baseline and project emission calculation procedures as defined in the methodology could equally be applied to such situation and would still result in a correct calculation of the greenhouse gas emissions.

Table 1 identifies the large groups of microorganisms that engage in symbiotic nitrogen fixation and the identified host plants. It also outlines the location of the plant tissue where the symbiotic nitrogen fixation occurs.

Table 1 Symbiotic Nitrogen Fixation

Microorganisms		**Host plants**	
Large group	Genera	Plant group	Tissue
Bacteria (□-Proteobacteria)	*Rhizobium, Bradyrhizobium, Azorhizobium* *Mesorhizobi*	Legumes and Parasponia	Nodule (induced)

	um *Ensifer*		
Actinomycetes	*Frankia*	Betulaceae and 8 family(trees)	Nodule (induced)
Cyanobacteria	*Nostoc*	Bryophytes (*Antheros* etc.)	Leaf cavity
	Nostoc (*Anabaena*?)	Pteridophyte (*Azolla*)	Leaf cavity
	Nostoc	Cycadophyta (*Cycas,Macrozamia* etc.)	Collaroid root
	Nostoc	Angiosperm (*Gunnera*)	Gland tissue

Source: *FAO Document-* Biological Fixation and its Use in Agriculture; *Wantanabe, Dr. Iwao, Mar 30, 2000*

Our methodology is primarily focused on those microorganisms that fix nitrogen in the nodules of legumes (bacteria and alpha bacteria microoganisms). Legumes are plants of the pea or bean family, Leguminosae. Legumes are able to fix atmospheric nitrogen, a process called biological nitrogen fixation, that provides nitrogen to the growing plant. Legumes are able to do this because of a symbiotic relationship with certain bacteria called rhizobia. The ability to form this symbiosis reduces the need for synthetic fertilizer, reducing the production of CO_2 that results from the production of synthetic fertilizers. Leguminosae is one of the largest families of flowering plants with 18,000 species classified into around 650 genera (see *Polhil and Raven, 1981*) or approximately one twelfth of all known flowering plants around the worlds. They range from dwarf herbs of arctic and alpine vegetation to massive trees of tropical forests. These legumes are used as crops, forages and green manures all over the world depending on the climate, soil structure, soil pH and farming systems (see *Farming Systems and Poverty, 2008, FAO*).

For the purposes of this proposal only specific rhizobia and legumes are eligible: Table 2 identifies the Rhizobium species proposed to be eligible and their major hosts (legumes). Many Rhizobium species have a broad host plant range. This may mean that within a plant genus, the rhizobium is a symbiotic fit with many species. This is noted in the table with the plant genus identified and the nomenclature ssp *following it in order to indicate wide application to many pertinent legume crops in the species. Listing every species would consume a great deal of space. The complete listing of plants may be found at the International Legume Database and Informational Service,* **www.ildis.org** .

Table 2 ***Rhizobia Species and Their Major Hosts***

Genus (rhizobia)	**Species (rhizobia)**	**Hosts (legumes)**
Rhizobium		
	R. meliloti	*Medicago* (Alfalfa) *Melilotus* *Trigonella* spp.
	R.fredii	*Glycine max,* (Soybean)

		Glycine soja
	R. leguminosarum bv. viciae	*Vicia fava* (Faba bean) *Pisium sativa* (pea) *Lathyrus* spp.
	R. leguminosarum bv. trifolii	*Trifolium* spp. (clovers)
	R. leguminosarum bv. phaseoli	*Phaseolus vulgaris* (common bean)
	R.tropici	*Phaseolus vulgaris,* (common bean) *Leucoena* spp (Ipil Ipil(in Philippines)) *Macroptilium* spp.
	R. etli	*Phaseolus vulgaris* (common bean)
	R.galegae	*Galega officinali* *G.orientalis*
	R.loti	*Lotus* spp. (Birdfoot trefoil)
	R.huakuii	*Astragalus sinicus* (Chinese milk vetch or Renge)
	R.ciceri	*Cicer arietinum*
	Rhizobium sp. strain NGR234	tropical legumes *Parasponia* etc.
Bradyrhizobium		
	B. japonicum	*Glycine max* *Glycine soja*
	B.elkani	Glycine max Glycine soya *Macroptilium* spp.
	Bradyrhizobium sp.	*Vigna* (cowpea) *Arachis* (peanut) Many tropical legumes
	Bradyrhizobium sp. strain *Parasponia*	*Parasponia* spp.
Azorhizobium		

	A.caulinodans	*Sesbania rostrata (*stem nodules)

Source: *FAO Document-* Biological Fixation and its Use in Agriculture; *Wantanabe, Dr. Iwao, Mar 30, 2000*

Source: www.migrobiologyprocedure.com/rhizobium-and-legume-root-nodulation/rhizobium-classification.html

In any of the above rhizobium – host legume plant combinations listed in Table 2, the biological nitrogen fixation concept works. These bacteria have been specifically identified and tested in combination with the host plant. Numerous websites are available that document the research findings. They are: www.migrobiologyprocedure.com/rhizobium-and-legume-root-nodulation/rhizobium-classification.html; www.dsmz.de/microorganisms; www.nbrc.nite.go.jp/; www.ildis.org.

The production of the rhizobium, as listed in the original methodology, would not change regardless of the specific bacteria inoculant produced. In the production of inoculants, rhizobia are mass cultured in fermentor vessels and the culture is then used to impregnate a sterile or non-sterile inoculant carrier. Standard formulations use humus (peat) as a carrier. The liquid formulation is becoming increasingly popular with farmers throughout the developing and developed world. In terms of convenience, farmers would ultimately prefer inoculant marketed as a pre-coating on seed. A complete manual for the production of inoculants can be found at **www.ctahr.hawaii.edu/bnf/inoc_production_resources.asp** .

The nodulation test proposed in the methodology can be used with any nodulating legume. The nodules on any legume may be cut open and a pink to dark pink color will denote biological nitrogen fixation. A green, white or grey color in the nodules indicates that no biological nitrogen fixation is occurring in the nodules and that an exogenous source of nitrogen is being used by the plant. The legumes listed in Table 2 are all nodulating and the nodule test is appropriate as proposed in the original methodology. Below are photos of various nodulating legumes to show as examples:

Photo 1: nodulated clover

Photo 2: nodulated soybean

Photo 3 nodulated peanut root

Photo 4 nodulated cow pea root

Photo 5 nodulated Medicago truncatula

The conclusion is that the claims of the methodology to use rhizobium bacteria as an inoculant to stimulate biological nitrogen fixation and to displace synthetic urea, the calculations for inoculant production emissions and the test for biological nitrogen fixation using the nodules, would not change,as long as the specific rhizobium and specific host plant combinations, listed in Table 2, are used in the cropping pattern. .

Corn is a member of the Poaceae or Gramineae family of plants. Plants of this family are commonly called grasses of which there are about 600 genera and between 9,000 – 10,000 species (*see Kew Index of World Grass Species*). The Paoceae (or Gramineae) plants are one of the most important of all plant families for human economies and include food grains (commonly known as cereals), lawn grasess, forages and bamboo, widely used for construction throughout east Asia and sub-Saharan Africa. A key characteristic of grasses, unlike legumes, it that they are not capable of fixing their own nitrogen for growth. Therefore, they must have an exogenous source of nitrogen, either from carryover nitrogen from a previous legume crop, from organic nitrogen such as animal or human waste, or synthetic fertilizer. (It

should be noted that the carryover nitrogen from a legume crop is usable by the following grass crop regardless of the legume that produced it or the grass crop utilizing it.) These grasses, used in rotation, should not be limited to corn, as is stated in the current methodology, as corn is not always adapted to the environment or another grass is needed in the farming system. Other grass crops used in rotation with legumes are barley, maize (corn), oats, rice, rye, sorghum, wheat, millet, bamboo, rye grass, sugarcane, and fescue, to name a few. Therefore, depending on the many diverse faming systems found in the world (see *Farming Systems and Poverty, 2008, FAO*), the revision of the methodology to include other grass crops would broaden its applicability on a global basis.

Thus, the authors request to broaden the applicability of the methodology to any legume-grass crop rotation, where the rhizobium-legume combination is one listed in Table 2, making it more appropriate for regional faming practices and expanding its capacity for CDM potential.

Ad (2) Extension of the applicability to synthetic fertilizers containing nitrogen other than urea

Urea is a type of N-fertilizer (synthetic nitrogen fertilizer) that is commonly applied on agricultural lands in developing countries. At the same time also other types of N-fertilizers are applied in developing countries. Hence, we think that it makes sense to broaden the applicability of the present methodology to also include application of N-fertilizers other than urea as well as fertilizers that include nitrogen besides other plant nutrients (K and P).

In the present methodology the CO_2 emission factor in the methodology rightly depends on the type N-fertilizer as the sources of GHG emissions from N-fertilizer production vary significantly across types and technologies of N-fertilizer production. Nitrogen is supplied in N-fertilizers as ammonium (NH_3 or NH_4+), amine (NH_2 - in urea), or as nitrate (NO_3-). All three forms of nitrogen require ammonia as a feedstock (see *Kongshaug, G. 1998. Energy Consumption and Greenhouse Gas Emissions in Fertilizer Production. IFA Technical Conference, Marrakech, Morocco, 28 September-1 October, 1998)*. As the CO_2 emissions associated with ammonia production are significant and widely researched, we in the following provide a suggestion for inclusion of all synthetic fertilizer types in the methodology irrespective of whether they are N-fertilizers or other synthetic fertilizers that include N.

The following table provides an exemplary list of the N-fertilizer types requested to be included in the methodology. The table also provides an exemplary conservative calculation of the emission factor (t CO_2/ t N-fertilizer) based only on the ammonia (NH_3) content of the N-fertilizer.

N-fertilizer types	N content (% of mass) **1)**	NH3 content (% of mass) **2)**	Emission factor t CO2/t NH3 **3)**	Emission factor t CO2/t N-fertilizer **4)**
Single nutrient products N-fertilizer				
Anhydrous Ammonia (NH3) "Ammonia"	82	67.2	2.104	1.415
Ammonium Sulfate [(NH4)2SO4]	21	17.2	2.104	0.362
Monoammonium Phosphate (MAP)	11	9.0	2.104	0.190
Diammonium Phosphate (DAP)	18	14.8	2.104	0.311
Ammonium Nitrate (NH4NO3)	33.5	27.5	2.104	0.578
Calcium Ammonium Nitrate (CAN)	26	21.3	2.104	0.449
Any other synthetic fertilizer containing N (e.g. multi nutrient fertilizers (N-P-K))	**X)**	**X)**	**X)**	**X)**

X) depending on fertilizer type

Sources:

1) see *IDFC 1999: A Guide to Fertilizer Products for Traders*; see *Kongshaug, G. 1998. Energy Consumption and Greenhouse Gas Emissions in Fertilizer Production. IFA Technical Conference, Marrakech, Morocco, 28 September-1 October, 1998*
2) calculated based on molecular weight ratio of 0.82 N/NH_3; see *Kongshaug, G. 1998. Energy Consumption and Greenhouse Gas Emissions in Fertilizer Production. IFA Technical Conference, Marrakech, Morocco, 28 September-1 October, 1998*
3) conservative European average value of natural gas based ammonia production; see *2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3: Industrial Processes and Product Use; Chapter 3.2 Ammonia Production*
4) calculated based on 2) and 3)

The CO2 emission factor of N-fertilizer production in the above table has been calculated based on the standard NH_3 content in the specific type of single nutrient N-fertilizer used as well as a conservative CO2 emission factor for ammonia production in developing countries.

Based on this approach it is also possible to calculate the emission factor t CO2/t fertilizer for any type of synthetic fertilizers as long as the mass ratio of N in the fertilizer is known using the following formula:

$$EF_{CO2,f} = Ncont_f * 0.82 * 2.014\, tCO_2 / tNH_3$$

Where:

EF(CO2,f) is the emission factor for the production of fertilizer f (tCO2/tonnes fertilizer f)

Ncont(f) is the N content of fertilizer f on a mass ratio basis

0.82 is the mass ratio between N and NH_3

2.014 is a conservative emission factor for ammonia production in t CO_2/t NH_3

Following the response from the SSC WG to our previous request for revision (SSC 279) we have incorporated in the revised methodology applicability condition that the fertilizers applied in the project scenario shall not add more non-nitrogen nutrients to the plantation than the baseline. This also required the monitoring of P an K levels, which have also been incorporated in the revision.

Hence, the authors request to broaden the applicability of the methodology to (a) the above list of single nutrient N-fertilizers for which in the absence of reliable project specific data the above listed conservative CO_2 emission factors may be used (b) any synthetic fertilizer (for which the mass ration of N in the fertilizer is known) for which in the absence of reliable project specific data the CO_2 emission factors may be calculated based on the conservative approach described above.

(3) New default emission factor for urea

In its current version the methodology suggests different sources for determination of the emission factor of urea. Besides a default factor, the methodology allows to use local values, IPCC values or scientific literature (para. 10 of the methodology).

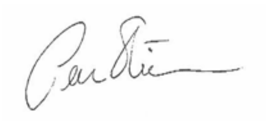
The IPCC guidelines provide the following guidance on the selection of emission factors for fertilizer. The applicable emission factor for ammonia production depends on the technology. For urea production,

greenhouse gases (GHG), as the CO_2 contained in urea will be released during/after application. These emissions have to be accounted for as GHG emissions in agriculture *(see 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3: Industrial Processes and Product Use; Chapter 3.2 Ammonia Production).* Thus, according to IPCC, total GHG emissions from urea would be GHG emissions during ammonia production – intermediate CO_2 storage in urea + CO_2 release due to urea application. As per IPCC guidelines, 0.733 t CO_2 are required for the production of one tonne of urea. Assuming a CO_2 emission factor 2.104 t CO_2/t NH_3 (average European emission factor for ammonia production with natural gas as hydrocarbon source) the resulting overall emission factor for urea would be 1.54 t CO2/t urea. This value is also in line with research findings, as e.g. Davis and Haglund, 1999 (see *Davis, J. and Haglund, C. 1999. Life Cycle Inventory (LCI) of Fertiliser Production. Fertiliser Products Used in Sweden and Western Europe. SIK-Report No. 654.Masters Thesis, Chalmers University of Technology*) who calculated a European average for urea emission factor of 1.85 t CO2/t urea, not accounting for CO_2 credits during production. Other authors determined similar values (see *Kongshaug, G. 1998. Energy Consumption and Greenhouse Gas Emissions in Fertilizer Production. IFA Technical Conference, Marrakech, Morocco, 28 September-1 October, 1998, 18p.; Schlesinger, W.H. 2000. Carbon sequestration in soils: some cautions amidst optimism. Agric. Ecosyst. Environ. 82:121-127.; West, T.O., and M. Marland, 2002. A synthesis of carbon sequestration, carbon emissions, and net carbon flux in agriculture: comparing tillage practices in the United States. Agric. Ecosyst, Environ. 91:217-232.*). The authors therefore request the revision of the default factor to 1.54 t CO2/t urea.
Recommendation by the SSC WG: Please use the space below to provide amendments/change (in your expert view, if necessary).
Please refer to paragraph 8 of the meeting report of the SSC WG 21 (http://cdm.unfccc.int/Panels/ssc_wg).
Answer to authors of query by the SSC WG: Please use the space below to provide answer to the authors of the above query
The small-scale working group of the CDM Executive Board would like to thank the author for the submission. The SSC WG agreed to recommend a revision of AMS-III.A to include options to choose from a range of grass-legume combinations for the project. Please refer to annex 4 of the SSC WG 21 meeting report.

Signature of SSC WG Chair ……………………………………………..

(Hugh Sealy)

Date: 19/06/2009



Signature of SSC WG Vice-Chair ……………………………………………..

(Peer Stiansen)

Date: 19/06/2009

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