ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE ENGINEERING AND TECHNOLOGY

NATIONAL INVENTORY OF N_2O EMISSIONS FROM AGRICULTURE AND WASTE SECTORS: EMISSION ESTIMATION AND UNCERTAINTY ANALYSIS

M.Sc. THESIS

Meltem TAŞKIN ÇETİNKAYA

Department of Environmental Engineering

Environmental Sciences and Engineering Graduate Programme

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İSTANBUL TEKNİK ÜNİVERSİTESİ ★ FEN BİLİMLERİ ENSTİTÜSÜ

TARIM VE ATIK SEKTÖRLERI İÇİN ULUSAL N_2O EMISYON ENVANTERİ: EMİSYON HESAPLAMASI VE BELİRSIZLİK ANALİZİ

YÜKSEK LİSANS TEZİ

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Meltem Taşkın Çetinkaya, a M.Sc. student of ITU Graduate School of Science Engineering and Technology student ID 501151723, successfully defended the thesis entitled "National inventory of N_2O Emissions from Agriculture and Waste Sectors: Emission Estimation and Uncertainty Analysis", which she prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

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Date of Submission : 4 May 2018
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To my family,

FOREWORD

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ABBREVIATIONS

AOB	: Ammonia-Oxidizing Bacteria
AR4	: Fourth Assessment Report
Bepa	: Turkish Biomass Energy Potential Atlas
BNR	: Biological Nutrient Removal Process
CFCs	: Chlorofluorocarbons
CH_4	: Methane
CI	: Confidence Interval
CO_2	: Carbon dioxide
CO_2eq	: Carbon dioxide Equivalent
COD	: Chemical Oxygen Demand
DNDC	: DeNitrification-DeComposition
EF	: Emission Factor
EMEP	: The European Monitoring and Evaluation Programme
FAO	: Food and Agriculture Organization of the United Nations
F_{CR}	: The Amount of N in Product Residues Including N-Fixing Crops
F_{ON}	: The Amount of Animal Manure Applied to Soils
$Frac_{lossMS}$	: The Amount of Lost Nitrogen for The Category of Livestock
F_{SN}	: Synthetic N-Containing Fertilizer Applying to Soil
F_{SOM}	: Equal to Amount of N in Mineral Soils.
Gg	: Gigagram
GHG	: Greenhouse Gases
GIS	: Geographic Information Systems
GWP	: Global Warming Potential
H_2O	: Water Vapour
IPCC	: Intergovernmental Panel on Climate Change
IR	: Infrared Radiation
L_{fire}	: Amount of Greenhouse Gas Emissions from Fire
MC	: Monte Carlo Simulation
MS	: The Ratio of Total Nitrogen Excretion for Managed Live Species
N	: Nitrogen
N_2	: Dinitrogen
N_2O	: Nitrous Oxide

NH_3	: Ammonia
NH_4	: Ammonium
Ninput	: Direct N_2O–N Emissions from N inputs to Managed Soils
NO	: Nitric Oxide
NO_2	: Nitrogen Dioxide
NO_3	: Nitrate
Nos	: Direct N_2O–N Emissions from Managed Organic Soils
Nprp	: Direct N_2O–N Emissions from Urine and Dung in Grazed Soils
Nrate	: N Excretion for Animal Type
$O(^1D)$	: Excited Oxygen Atoms
O_3	: Ozone
PDF	: Probability Density Function
PFCs	: Perfluorocarbons
pH	: Potential of hydrogen
ppbv	: Parts Per Billion by Volume
SAR	: Second Assesment Report
SF_6	: Sulphur Hexafluoride
SRT	: Solids Retention Time
TAM	: Animal Mass
TURKSTAT	: Turkish Statistical Institute

SYMBOLS

σ	**:**	Standard Deviation
μ	**:**	Mean

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NATIONAL INVENTORY OF N_2O EMISSIONS FROM AGRICULTURE AND WASTE SECTORS: EMISSION ESTIMATION AND UNCERTAINTY ANALYSIS

SUMMARY

One of the factors that make greenhouse gases important is that its contribution to climate change. They can absorb energy from infrared (IR) radiation and gas molecules are gained extra energy thereafter, molecules give up energy by emitting another infrared photon. This process causes trapping heat in the atmosphere. The increase in the temperature of the Earth causes climate change.

Climate change began to become evident in the 18th century with the industrial revolution. When it comes day by day from the industrial revolution, a slight increase is observed every year in the average temperature of the world. International organizations are striving to prevent global warming and climate change and/or to reduce the most. Various agreements have been signed with the participation of the states. The first climate change agreement The United Nations Framework Convention on Climate Change was held in Rio de Janeiro in 1992 with the participation of countries. The primary aim of this deal is to create a global response to climate change. Turkey had also signed the agreement in 2004. The United Nations subsequently signed the Kyoto Protocol. The difference between the treaties is that the legal procedures and processes are opened in the Kyoto Protocol.

The latest agreement on these aims is the Paris Climate Change Agreement, signed by 195 countries. An important goal of the agreement is to ensure that global temperature increases are kept below 2 degrees until the end of the century.

There are many types of greenhouse gases in the atmosphere and the heat holding capacities are different from each other. All greenhouse gases have a global warming potential that characterizes their ability to hold heat concerning CO_2. For example, nitrous oxide is 298 equivalents of carbon dioxide while methane is calculated as 24 equivalents of carbon dioxide. The primary greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), water vapor (H_2O), chlorofluorocarbons (CFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6).

Countries calculate national greenhouse gas emission inventories, which are estimated to understand the effects of climate change. In addition, international agreements are being made with the participation of governments to prevent climate change.

When calculating emissions of greenhouse gases, the Intergovernmental Panel on Climate Change (IPCC) has a guideline for the calculation method. There is also some software available. It seems that countries have also developed their own programs and/or methods to develop calculation methods for national emission calculations. In the calculation method of IPCC, Tier 1, Tier 2 and Tier 3 are separated for find out more representative results. In Tier 1, some parameters and input factors are country specific and emission factor are used as default values suggested by the IPCC. In Tier 2, the data and the emission factors that are used to calculate the national emissions are specific values. In Tier 3, more complex structures and models are used for emission calculations. After the calculation is made, the uncertainty analysis is performed to determine how certain the results are. In this context, emission uncertainty is usually calculated using the Monte Carlo methodology. The Monte

Carlo method generates input and output probability distribution functions by iterating randomly using the probability distributions of the inputs.

In this study, a greenhouse gas, N_2O emissions were calculated and uncertainty analysis was performed. N_2O emissions from managed soils, and waste sector were calculated for Turkey. The calculation method of IPCC Tier 1 was used. Uncertainty and sensitivity analysis were performed via @RISK programme. Emission factors, and input activity data had been obtained from previous studies, IPCC Guidelines, Turkey Statistical Institute. In addition, the data published by institutions such as the Ministry of Food, Agriculture and Livestock were also used.

Indirect emission sources can produce emission in these processes by depositing in the atmosphere, leaching and runoff.

In this study, both indirect and direct emission sources were calculated between 2011 and 2015. Calculated values of the United Nations Food and Agriculture Organization (FAO) and the Turkey Statistical Institute (TURKSTAT) were compared. The resulting from agricultural emissions were 54.44, 64.55, 66.79 Gg N_2O/year for the FAO, TURKSTAT and our study respectively, in 2011. In the calculation of emissions from manure management, 0.47, 8.68, 9.11 Gg N_2O/year were found respectively. It is estimated that the difference is high due to selected manure management systems. When the results of the burning of crop residue (agricultural waste) were compared, it was 0.25, 0.28, 0.29 Gg N_2O/year respectively. Three results in this parameter appear to be consistent within themselves. In the waste sector, results compared with TURKSTAT data these were the amount of emissions resulting from the compost, wastewater treatment plant and compost. The amount of emissions from wastewater treatment plants were 6.25, 5.34 Gg N_2O/year, the amount of emissions from compost 0.04 and 0.04 Gg N_2O/year, respectively. The amount of emissions generated by open burning of waste were 0.01 and 0.01 Gg N_2O/year, respectively. The amount of emission from the total waste sector was 6.30 Gg N_2O/year in TURKSTAT and the calculated value in this study was 5.39 Gg N_2O/year. When the total obtained values were examined in 2015, FAO 67.15, TURKSTAT 87.59 and 88.05 Gg N_2O/year were found when managed soils (agricultural soils + manure management + open burning of crop residue) were calculated. Emissions from the waste sector (wastewater treatment plant + compost + open burning of waste) were calculated as TURKSTAT 6.84 for 2015 and 7.04 Gg N_2O/year for this study. The difference arises from the difference in the results of wastewater emissions.

In general, when the results are compared, the results obtained differences are less than 3% with the TURKSTAT data. On the other hand, according to the FAO data, it is seen that the differences have grown even more and have resulted in different results of about 30-35%. There was a difference between the results when FAO and TURKSTAT were compared. The reason for this difference is thought to be due to the different input data generated in the fertilizer management calculation mentioned above.

In the calculations, the total values of direct and indirect emissions from agricultural and waste sector were calculated. Total direct and indirect emission amounts were 116.21 Gg N_2O/year. In 2011, emission amounts are 34629.07 Gg CO_2eq/year. The year of 2012 emissions amounts 125.05 Gg N_2O/year and 37263.92 Gg CO_2eq/year, the year 2013 values were 128.56 Gg N_2O/year and 38311.22 Gg CO_2eq/year. The values were 128.81 Gg N_2O/year and 38385.46 Gg CO_2eq/year for 2014. The calculated amounts of emissions were 130.27 Gg N_2O/year and 38819.16 Gg CO_2eq/year for 2015. The calculations made were compared to TURKSTAT and FAO data.

In the estimated amounts of N_2O emissions for the year 2011, the provinces with the highest total direct emissions were Konya, Ankara and Şanlıurfa. Calculated values were 5141, 3843 and 2476 tons/year, respectively.

Konya, Ankara and Erzurum had the most indirect N_2O emissions. Their calculated amounts were 1531, 968 and 791 tons/year in 2011, respectively.

The amount of total emissions were calculated for cities in the year 2015, the highest direct emissions were from Konya, Ankara and Şanlıurfa. Calculated values were 6420, 4271 and 3239 N_2O tons/year respectively. Compared with 2011, there were 25%, 11% and 16% increase in the emissions.

Konya, Ankara and Erzurum had the most indirect N_2O emissions of 1614, 914 and 755 tons/year in 2015, respectively. Compared to 2011, there were changes in the emissions of 5%, -5% and -4% respectively.

When the total N_2O emissions for 2015 were examined, FAO reported 67.151 TURKSTAT reported 87.592 and this study calculated 88.058 Gg N_2O/year for managed soils (agricultural soils + manure management + open burning of agricultural residue). Emissions from the waste sector (wastewater treatment plant + compost + open burning of waste) were calculated as 7.049 Gg N_2O/year for 2015. When compared with TURKSTAT estimation (6.843 Gg N_2O/year), our emisisons was slightly higher.

Uncertainty analysis was performed using the Monte Carlo method with the @RISK program. Direct N_2O emissions were estimated for managed soil, manure management, waste and total, with the uncertainty expressed as 95% confidence intervals. Total emission mean was 98.04 Gg N_2O/yr with 95% confidence interval of (31.40-230.39). Emission from managed soil was 85.39 Gg N_2O/yr with 95% confidence interval of (20.81-216.49). Emission from manure management was 14.38 Gg N_2O/yr with 95% confidence interval of (3.62-35.78). Emission from waste sector was 7.29 Gg N_2O/yr with 95% confidence interval of (2.01-15.75). 95% confidence interval for the total N_2O emission estimate was given between -68% to 135%.

According to the Spearman rank correlation coefficient for sensitivity analysis, emission factors were found as the most influencing inputs to emission calculations. These are EF_1 emission factor for N_2O emissions from N inputs and EF_{1fr} the emission factor for N_2O emissions from N inputs to flooded rice. Spearman rank correlation coefficients were 0.72 and 0.54 for EF_1 and EF_{1fr}, respectively. Another important parameter was the default N excretion rate (per 1000 kg animal mass).

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ÖZET

Dünya'nın atmosferinde bulunan bazı gazlar güneşten gelen ve yeryüzünden yansıyan kızıl ötesi ışınları tekrar dünya yüzeyine yansıtması nedeniyle dünya sıcaklığının artmasına neden olmaktadır ve bu ısınmaya neden olan etkiye sera etkisi, gazlara ise sera gazları denilmektedir. Dünya'nın ısısının artması ise iklim değişikliğine neden olmaktadır.

İklim değişikliği 18. yüzyılda endüstri devrimi ile birlikte belirgin olmaya başlamıştır. Endüstri devriminden günümüze gelindiğinde Dünya'nın ortalama sıcaklığında her geçen sene bir miktar artış gözlemlenmektedir. Küresel ısınmayı ve iklim değişikliğini önlemek ve/veya en aza indirgemek için uluslararası kuruluşlar çaba sarf etmektedir. Bu konuda devletlerin katılımı ile çeşitli anlaşmalar imzalanmıştır. İlk iklim değişikliği anlaşması Birleşmiş Milletler İklim değişikliği Çerçeve Sözleşmesi Rio de Jenerio kentinde 1992 yılında ülkelerin katılımıyla gerçekleşmiştir. Bu anlaşmanın temel amacı iklim değişikliğine karşı küresel bir tepki oluşturmaktır. 2004 yılında Türkiye de anlaşmayı imzalamıştır. Daha sona yine Birleşmiş Milletler tarafından Kyoto protokolü imzalanmıştır. Anlaşmalar arasındaki fark Kyoto protokünde hukuki işlem ve süreçlerin önü açılmıştır.

Bu amaçlar ile ilgili en son imzalanan anlaşma Paris İklim Değişikliği anlaşması olup 195 ülke tarafından imzalanmıştır. Anlaşmanın önemli bir hedefi küresel sıcaklık artışının yüzyılın sonuna kadar 2 derecenin altında tutulması sağlamaktır.

Atmosferde birçok sera gazı çeşidi bulunmaktadır ve ısı tutma kapasiteleri birbirinden farklıdır. Bütün sera galarıi, kendilerinin CO_2'ye oranla ısı tutma kabiliyetlerini nitelendiren bir küresel ısınma potansiyeline sahiptir. Örneğin nitrosoksit 298 eşdeğer karbondioksit iken metan 24 eşdeğer karbondioksit olarak hesaplanmıştır. Başlıca sera gazları karbondioksit (CO_2), metan (CH_4), nitros oksit (N_2O), ozon (O_3), su buharı (H_2O), kloroflorokarbon (CFCs), perflorokarbon (PFCs), sülfür hekzaflorür (SF_6).

İklim değişikliğine etkisi olan sera gazlarını ülkeler miktar olarak salınımı hesaplamaktadırlar. Bunun için kendilerine ait emisyon envanterleri oluşturmaktadırlar.

Sera gazları hesaplanırken Hükümetlerarası İklim Değişikliği Paneli (IPCC) hesaplama yöntemi kullanılmaktadır. Ayrıca bazı emisyon hesaplama yazılımları mevcuttur. Ülkeler bu program ve/veya yöntemleri geliştirerek kendi hesaplama yöntemlerini de oluşturduğu görülmektedir. IPCC nin hesaplama yönteminde Kademe 1, Kademe 2 ve Kademe 3 olarak ayrılmaktadır. Kademe 1'de giriş verileri ülkeye özgü bazı parameter ve emisyon faktörleri ile IPCC nin belirlediği varsayılan değer kullanılmaktadır. Kademe 2'de ise veriler ve emisyon faktörü de hesaplanan ülke verilerine özgü değerler kullanılır. Kademe 3'de ise daha karmaşık yapılar ve modeler kullanılır. Hesaplama yapıldıktan sonra belirsizlik analizi yapılarak elde edilen sonucun ne kadar tutarlı olduğu ölçülür. Bu kapsamda emisyon belirsizliğinde genellikle Monte Carlo metodolojisi kullanılarak hesap yapılır. Monte Carlo yöntemi girdilerin olasılık dağılımlarını kullanarak rassal değişim yöntemi ile iterasyon yaparak sonuç verisi için olasılık dağılım fonksiyonu oluşturmasıdır.

Bu çalışmada sera gazlarından N_2O emisyonu hesaplanmıştır ve belirsizlik analizi yapılmıştır. Türkiye'de tarımsal topraklar ve atık sektöründen oluşan N_2O emisyonları hesaplanmıştır. IPCC nin hesaplama yöntemi kullanılmıştır. Hesaplama yapılırken IPCC, Türkiye İstatistik Kurumu, T.C. Gıda Tarım ve Hayvancılık Bakanlığı gibi kurumların yayınladığı veriler, daha önce yapılan çalışmalar ve bazı makalelerden veriler temin edilmiştir.

N_2O emisyonu, yönetilen topraklar başlığı altında tarımdan ve gübre yönetiminden ve anızların yakılmasından kaynaklanan emisyonlar olmak üzere üçe ayrılır. Atık sektörü ise atıksu arıtma tesisleri, kompostlar ve atıkların açıkta yakılması olarak ayrıca hesaplanmıştır. Bu sözü edilen emisyon kaynakları doğrudan emisyon kaynaklarıdır.

Dolaylı emisyon kaynakları ise bu proseslerde üretilen emisyonun atmosferde depolanma, toprakta yüzeysel akış ve yıkanma yoluyla emisyon kaynağını oluşturabilmektedir.

Bu çalışmada 2011 ve 2015 yılları arası hem dolaylı hem de doğrudan emisyon kaynakları hesaplanmıştır. Hesaplanan değerler, Birleşmiş Milletler Gıda ve Tarım Örgütü (FAO) ve Türkiye İstatistik Kurumu (TURKSTAT) ile kıyaslanmıştır. Elde edilen sonuçlarda 2011 yılında tarımsal kaynaklı emisyonların sonucu FAO, TURKSTAT ve yapılan çalışmada sırasıyla 54.44, 64.55, 66.79 Gg N_2O/yıl bulunmuştur. Gübre yönetimi kaynaklı emisyon hesaplamasında ise sırasıyla 0.47, 8.68, 9.11 Gg N_2O/yıl bulunmuştur. Aradaki farkın yüksek olması seçilen gübre yönetimi sistemlerinden kaynaklı olduğu tahmin edilmektedir. Anız yakılması (tarım artıkları) sonuçları kıyaslandığında ise sırasıyla 0.25, 0.28, 0.29 Gg N_2O/yıl olmuştur. Bu parametrede üç sonuç kendi içinde tutarlı olduğu görülmektedir. Atık sektöründe ise karşılaştırma TURKSTAT ile yapılmıştır. TURKSTAT ve yapılan çalışmada bulunan 2011 yılı atıksu arıtma tesisi, kompost ve atıkların yakılması sonucu oluşan emisyon miktarları; sırasıyla atıksu arıtma tesisi için 6.25, 5.34 Gg N_2O/yıl, kompost kaynaklı emisyon miktarı 0.04 ve 0.04 Gg N_2O/yıl atıkların yakılması ile oluşan emisyon miktarı ise sırasıyla 0.01 ve 0.01 Gg N_2O/yıl hesaplanmıştır. Toplam atık sektörü kaynaklı emisyon miktarı TURKSTAT hesaplanan değer 6.30 ve bu çalışmada hesaplanan değer 5.39 Gg N_2O/yıl olmuştur. 2015 yılı toplam elde edilen değerler incelendiğinde yönetilen topraklar (tarımsal topraklar + gübre yönetimi + anız yakılması) hesaplandığında FAO 67.15, TURKSTAT 87.59 ve yapılan çalışmada 88.05 Gg N_2O/yıl bulunmuştur. Atık sektörü kaynaklı (atıksu arıtma tesisi + kompost + atıkların yakılması) emisyonların 2015 yılı için TURKSTAT 6.84, bu çalışmada elde edilen değer ise 7.04 Gg N_2O/yıl olarak hesaplanmıştır. Aradaki fark atıksu emisyonlarının sonuçları farklılığından kaynaklanmaktadır.

Genel olarak sonuçlar karşılaştırıldığında çalışma sonucu elde edilen değerler TURKSTAT verileri ile fark %3'ün altında olmaktadır. Öte yandan, FAO verilerine göre, farklılıkların daha da büyümesi ve yaklaşık %30-35 oranı arasında farklı sonuç verdiği görülmüştür. Verilerde FAO ve TURKSTAT karşılaştırıldığında sonuçlar arasında fark bulunmuştur. Bu farklılığın nedeni yukarıda sözü edilen gübre yönetimi hesaplanmasında ortaya çıkan farklı giriş verileri nedeniyle olduğu düşünülmektedir.

Hesaplamalarda Türkiye'de oluşan tarımsal kaynaklı ve atık sektörü kaynaklı doğrudan ve dolaylı emisyonların toplam değerleri hesaplanmıştır. Ayrıca hesaplanan değerler Türkiye'nin şehirleri için ayrı ayrı emisyon kırılımları için hesaplanarak harita üzerinde emisyon miktarları gösterilmiştir. Toplam doğrudan ve dolaylı emisyon miktarları 2011 yılı için 116,21 Gg N_2O/yıl aynı zamanda 34629,07 CO_2 eşdeğeri/yıl'dır. 2012 yılı 125,05 Gg N_2O/yıl ve 37263,92 CO_2 eşdeğeri/yıl, 2013 yılı değerleri 128,56 Gg N_2O/yıl ve 38311,22 CO_2 eşdeğeri/yıl'dır. 2014 yılı için hesaplanan değerler 128,81 Gg N_2O/yıl ve 38385,46 CO_2 eşdeğeri/yıl'dır. 2015 yılı için hesaplanan emisyon miktarları ise 130,27 Gg N_2O/yıl ve 38819,16 CO_2 eşdeğeri/yıl'dır.

2011 yılı şehirler için hesaplanan emisyon miktarlarına bakıldığında toplam doğrudan en çok emisyon miktarına sahip olan iller Konya, Ankara and Şanlıurfa dır. Hesaplanan değerleri ise sırasıyla 5141, 3843 ve 2476 ton/yıl dır.

2011 yılı için hesaplanan dolaylı emisyon kaynaklı miktarlara bakıldığında, Konya, Ankara ve Erzurum en çok dolaylı N_2O emisyonuna sahip olan illerdir. Sırasıyla 1531, 968 ve 791 ton/yıl dır.

2015 yılı şehirler için hesaplanan emisyon miktarlarına bakıldığında toplam doğrudan en çok emisyon miktarına sahip olan iller Konya, Ankara and Şanlıurfa dır. Hesaplanan değerleri ise sırasıyla 6420, 4271 ve 3239 ton/yıl dır. 2011 yılı ile kıyaslandığında %25, %11 ve %16 emisyon artışı görülmektedir.

2015 yılı için hesaplanan dolaylı emisyon kaynaklı miktarlara bakıldığında, Konya, Ankara ve Erzurum en çok dolaylı N_2O emisyonuna sahip olan illerdir. Sırasıyla 1614, 914 ve 755 ton/yıl dır. 2011 yılı ile kıyaslandığında 5%, -5% and -4% emisyon miktarında değişim görülmektedir.

Önceki araştırma çalışmalarında kullanılan @RISK programı ile Monte Carlo yöntemi kullanılarak belirsizlik analizi yapılmıştır. Yapılan belirsizlik analizi sonuçlarına bakıldığında toplam emisyon değerinin ortalaması ve %95 güven aralığı sonuçları bulunmuştur. Ortalama değer 98,04 Gg N_2O/yıl, %95 güven aralığı değerleri ise 31,40 ve 230,39 Gg N_2O/yıl dır. Gübre yönetimi kaynaklı emisyon belirsizliğinde ise 14,38 Gg N_2O/yıl %95 güven aralığı değerleri ise 3,62 ve 35,78 Gg N_2O/yıl dır. Atık sektörü kaynaklı emisyon değeri 7,29 Gg N_2O/yıl %95 güven aralığı değerleri ise 2,01 ve 15,75 Gg N_2O/yıl olarak hesaplanmıştır. Toplam N_2O emisyonlarında %95 güven aralığı değerleri -68% ve 135%'tir.

Hesaplanan belirsizlik değerleri İngiltere ve Finlandiya için yayınlanan makaleler ile kıyaslandığında % 95 güven aralığında N_2O emisyon tahmininde belirsizlik değeri (%-68, %135) İngiltere için (%-59, %124), Finlandiya için (%-52, %70) olarak hesaplanmıştır. Finlandiya'nın belirsizliğinin düşük olmasının nedeni kendi emisyon faktörünü kullanarak Kademe 2 ile hesaplama yapılmasının sonucudur. İngiltere ve bu çalışmada Kademe 1 kullanılarak belirlenmiş emisyon faktörü kullanılmıştır.

Hesaplamanın ardından yapılan hassasiyet analizi Spearman rank korelasyon katsayısının sonucu emisyon faktörlerinin, elde edilen sonucu en fazla etkileyen parametre olduğu ortaya çıkmıştır. EF_1 "azot girdilerinden N_2O emisyonları için emisyon faktörü" ve EF_{1fr} "çeltik alanlarının azot girdilerinden N_2O emisyonları için emisyon faktörü" olup Spearman rank korelasyon katsayıları sırasıyla 0,72 ve 0,54'tür. Diğer etkili parametre "1000 kg hayvan başına günlük azot atılımı" dır.

1. INTRODUCTION

Greenhouse gases (GHG) are defined as the gases that are absorbing infrared radiation in the atmosphere, hence trapping and holding the heat in the atmosphere. The result from the warming of the surface called the greenhouse effect and causes anthropogenic global warming.

Nitrous oxide (N_2O) is the third most important long-lived greenhouse gas contributing to global warming and consequently, cause climate change. Natural sources of N_2O emissions are major microbial processes of nitrification and denitrification in the soil, oceans, other aquatic systems, and wetlands. Anthropogenic sources of N_2O are generally resulting from agricultural soils.

Thus, it is necessary to calculate the amount of N_2O emissions, which is the source of N_2O concentrations in the atmosphere, and an inventory can be created and the necessary reductions and importance can be determined.

1.1 Aim and Scope

Greenhouse gases' levels in the atmosphere have been increased over the years. Anthropogenic sources have an impact on this rising. One of the factors that makes greenhouse gases important is that its contribution to climate change. GHG can absorb energy from infrared (IR) radiation and gas molecules gains extra energy. Thereafter, molecules give up energy by emitting another infrared photon. This process causes trapping of heat in the atmosphere. The main greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), water vapor, and chlorofluorocarbons.

The CO_2 equivalent of N_2O as a greenhouse gas is calculated as 298, and N_2O concentrations in the atmosphere are ranked as 3rd after CO_2 and CH_4. The sectors that cause N_2O emission sources are waste, energy, and agriculture including manure management within the managed soils.

The emission estimation is done by the multiplication of the activity data with appropriate emission factors. Country, province or sector specific values have to be estimated in order to make an accurate estimation of the focused greenhouse gas inventory. There are emission calculation methods developed by the IPCC, individual research studies or by national agencies. Emission estimation can be made using various activity data using a top-down or a bottom-up approach.

The representativeness of the activity data is very important for the calculation of emissions. In addition, the specificity and appropriateness of the emission factors also contribute to the correct estimation approach. Accurate estimation of emissions or use of default factors threatens the precise and accurate emission estimation. For this reason, to understand the ranges instead of the absolute emission estimation values, uncertainty analysis should be carried out to investigate the consistency of emission calculations. In uncertainty analysis, statistical methods are used. These can be used as either statistical formulas for theoretical estimation or using statistical software esigned explicitly for uncertainty estimation. When studies on emission uncertainty are examined, mostly Monte Carlo statistical analysis technique is used. Monte Carlo simulations are used to estimate the probability of different outcomes in a process that cannot easily be predicted due to the intervention of random variables. Various software programs have been developed for Monte Carlo simulation such as Crystal Ball by Oracle, or @RISK by Palisade.

In this study, the following tasks were performed:

-the N_2O emission prediction for the managed soils and waste-sector as a first step for Turkey, Emission was estimated using the input data and the default values.

-in the second step, uncertainty and sensitivity analysis of the N_2O emission were estimated with Monte Carlo simulation with @RISK program.

2. BACKGROUND INFORMATION

Earth's temperature has the balance related to incoming energy and outgoing energy from the solar radiation in the system of the planet. Earth's atmosphere is a key role for absorbing infrared heat radiation via greenhouse gases and some radiation reflect the systems. Effect roles of greenhouse gases are natural and essential to maintain Earth life. Because Earth's temperatures would drop without the greenhouse gas effect and the average surface temperature would be about minus 18°C. This effect keeps the average surface temperature of the planet at 15 °C (2017a).

Earth's temperature has risen steadily in the century years. Greenhouse gas effects are attributing to earth's temperature due to human activity since the beginning of the industrial revolution (2016a).

Greenhouse gases (GHG) are defined that gases are absorbing infrared radiation in the atmosphere, hence trapping and holding heat in the atmosphere then resulting from the warming of the surface called the greenhouse effect and take place anthropogenic global warming after industrial revolution (2016b). Greenhouse gas effect was shown in Figure 2.1.

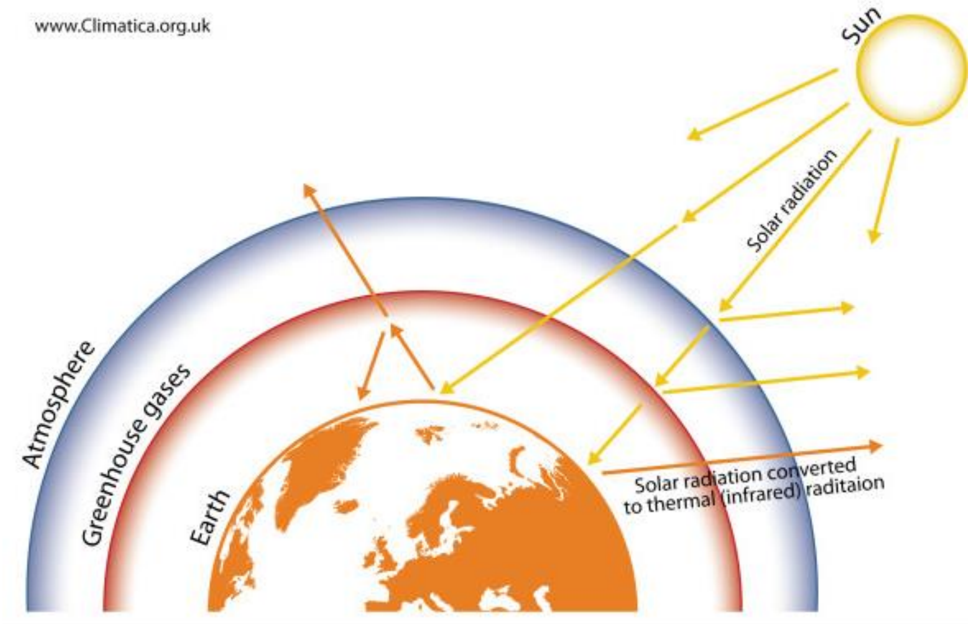

Figure 2.1 : Greenhouse gas effect (adapted from 2016b).

The main greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), water vapour (H_2O), chlorofluorocarbons (CFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) (2017b).

According to IPCC 2014 Synthesis Report, total anthropogenic GHG emissions have risen transparently over 1970 to 2010. GHG emission was approximately 27 (Gt-CO_2-eq/yr) in 1970 (Figure 2.2). It was calculated as 49 (Gt-CO_2-eq/yr) in 2010. Carbon dioxide made the greatest contribution. Emissions of CO_2 from fossil fuel combustion and industrial processes contributed about 78% of the total GHG emissions increased. Methane and nitrous oxide emissions have increased level 16% and 6.2% respectively (Pachauri et al., 2014).

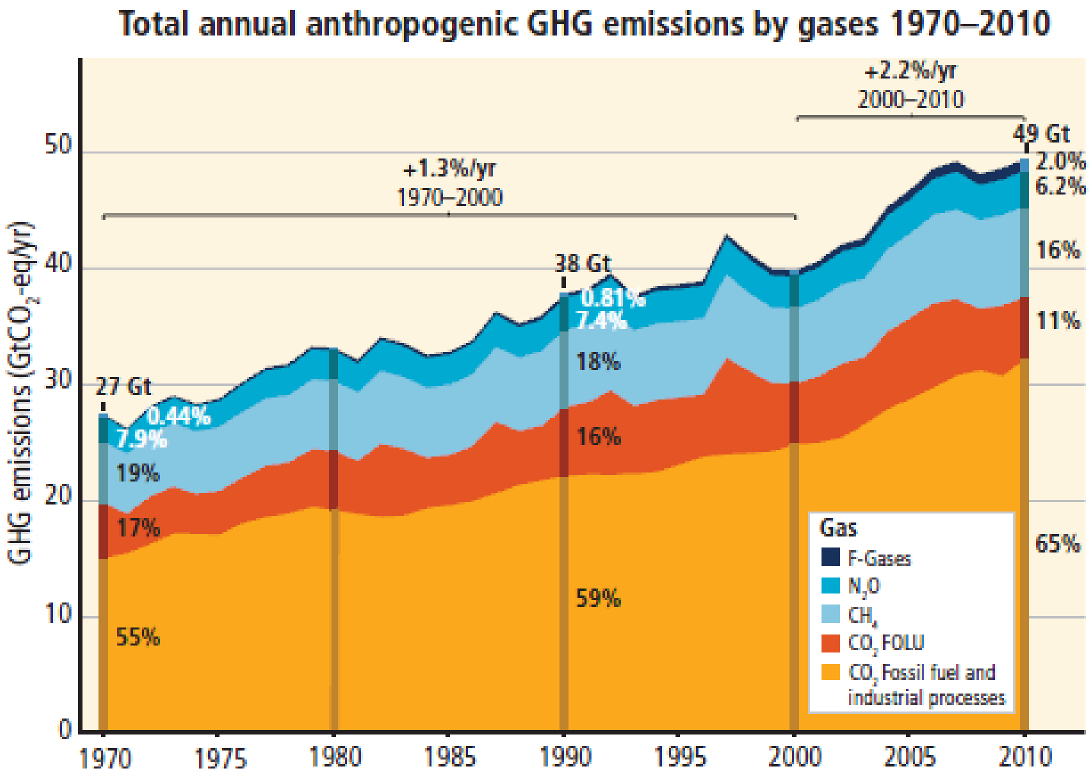

Figure 2.2 : Total antropogenic GHG emissions between 1970 and 2010 (adapted from Pachauri et al., 2014).

Anthropogenic greenhouse gas sources based on human activities are responsible for GHG emissions. Global warming potential (GWP) and atmospheric lifetimes are important due to attributing to climate change. A commonly used metric is the Global Warming Potential (GWP). GWP has defined that simple measure of the heating capacity of radiative forcing designated time horizon depending on reference gas CO_2. Figure 2.2 is shown the global warming potentials in 100 year time published from second assessment report (SAR) and fourth assessment report (AR_4) of IPCC. Generally, greenhouse gases are calculated as CO_2-equivalent (CO_2eq) emission based on GWP-100 horizon Greenhouse gases global warming potential was shown in Table 2.1. (2016b).

Table 2.1 : Certain greenhouse gases global warming potential.

Greenhouse Gases	Chemical Formula	GWP Second Assesment Report (SAR)	GWP Fourth Assesment Report (AR4)
Carbon Dioxide	CO_2	1	1
Methane	CH_4	21	25
Nitrous Oxide	N_2O	310	298
CFC-12	CCl_2F_2	8100	10900
HCFC-123	$CHCl_2CF_3$	90	70
Sulfur hexafluoride	SF_6	23900	228000

2.1 Natural and Anthropogenic Sources of Greenhouse Gases

Greenhouse gas naturally can be found in the atmosphere and biosphere due to carbon or nitrogen cycle between atmosphere, terrestrial biota and water. Natural events as volcanic eruption may cause greenhouse gas emissions. Anthropogenic sources occur by human activity. Anthropogenic greenhouse gas sources are originated from energy sector include thermal power plant, heat production, industrial process, agriculture, land use changing, waste sector includes solid, wastewater (2006a).

Figure 2.3 is shown that the percentage distribution of anthropogenic sources of global greenhouse gas emissions. Electricity and heat production was the highest percentage of GHG emission sources based on the 2010 year. 24% of GHG emissions were produced from agriculture, forestry and other land use in the graph. The third percentage of main greenhouse gas emission source was the industry at 21%.

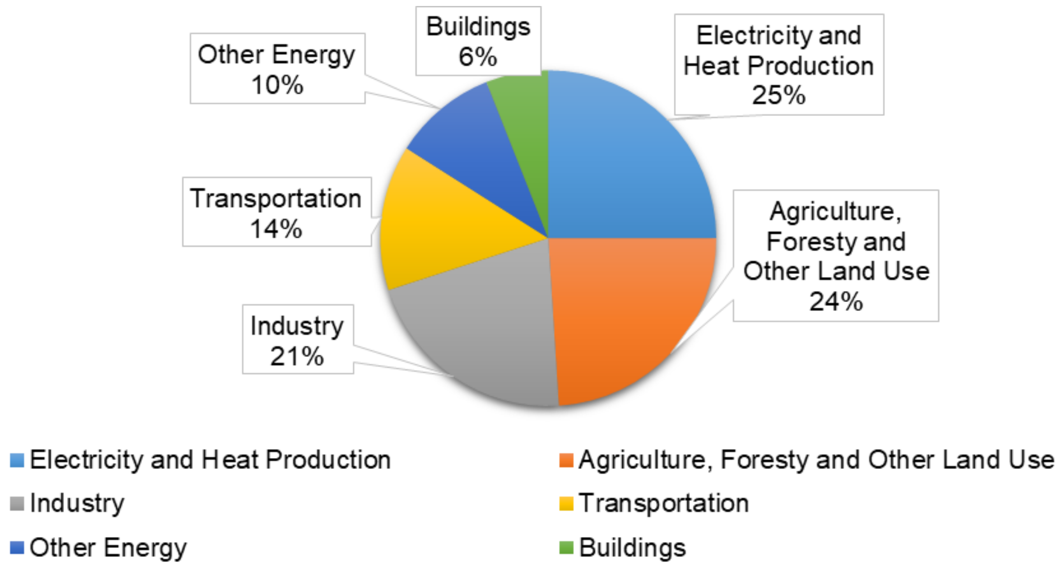

Figure 2.3 : Global greenhouse gas emission from anthropogenic sources (2017c).

Anthropogenic greenhouse gas emissions sources of Turkey are considered the energy sector with the highest overall percentage of GHG emissions (60%). The second source was Industrial processes 13%. Agriculture, transport and waste were other greenhouse gas resources in Turkey in 2010 in Figure 2.4 (2017f).

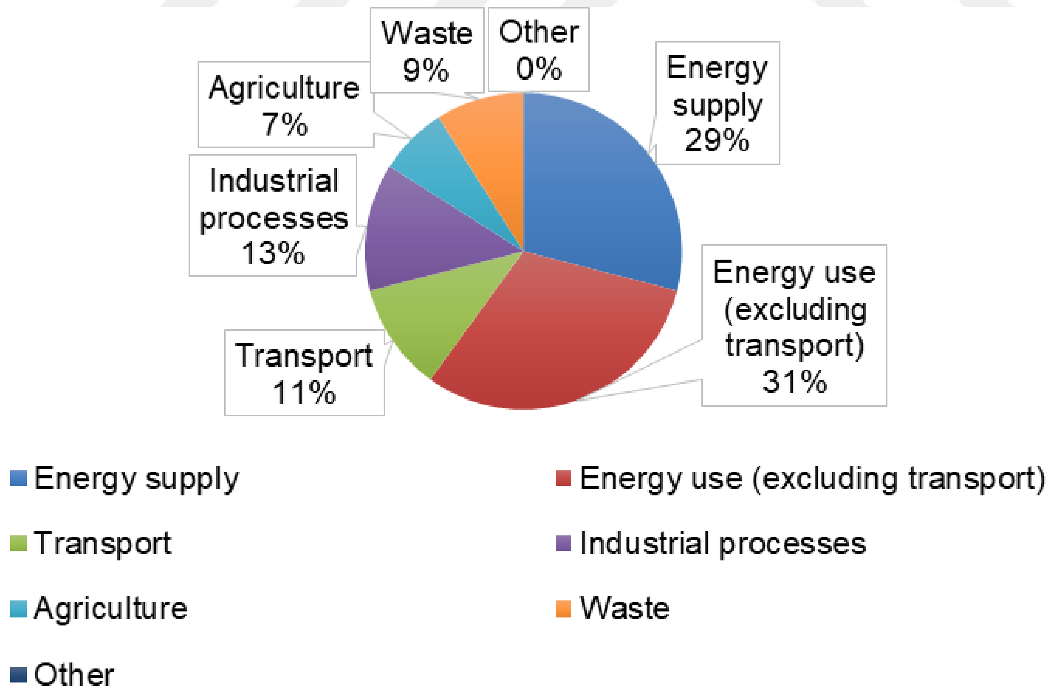

Figure 2.4 : Greenhouse gas emissions by sectors in Turkey (2017c).

2.2 Nitrous Oxide Emissions

Nitrous oxide (N_2O) is the third most important, long-lived, the greenhouse gas contributing to global warming, consequently causes climate change. Another essential environmental effect of N_2O gas is to cause ozone depletion. In the stratosphere, the reaction of N_2O with $O(^1D)$ (excited Oxygen Atom) contributed to the production of nitric oxide (NO). Afterward, NO goes into various reactions to form the stratospheric nitrogen reservoir and thereby participate to ozone-depletion. (Syakila and Kroeze, 2011).

The global lifetime of N_2O is approximately 114 years and global warming potential of N_2O has 298 times that of CO_2 for a 100-year timescale (2018). The atmospheric concentration of N_2O has been increasing as a result of human activities, disruptive the natural nitrogen (N) cycle. Since the pre-industrial times, the global atmospheric N_2O concentration has risen by about 16%, from 270 to 319 ppbv (Syakila and Kroeze, 2011). N_2O emission has been increased over the years on the global scale and the largest contribution was provided by agricultural soils. It is predicted that the amount of emissions will rise when considering the long-term period. Agricultural soils and agricultural other sources had been the largest sources for N_2O emissions (Signor et al., 2013).

Nitrous oxide (N_2O) can be produced from biological sources in widely soils, sediments and water bodies by both natural and anthropogenic processes. Natural sources are soils under natural vegetation process, oceans, atmospheric reactions. Non-biological N_2O sources occur from industrial process and fuel combustion including waste incineration. Many factors affect the formation of N_2O emissions such as agricultural production qualifications, combustion technologies, waste management implementation, industrial characteristics, and climate and weather conditions (Ussiri and Lal, 2013c) (Figure 2.5).

Anthropogenic N_2O emission sources consist of 67% agriculture, 10% biomass burning, 10% fossil fuel combustion and industrial processes, 9% atmospheric deposition, 3% human sewage. Natural sources consist of 60% soils under natural vegetation, 35% oceans, 5% atmospheric chemical reactions (2007).

The N_2O emission rate of Turkey has risen over the years. The figure is shown changing of N_2O emission in Turkey between 1990 and 2014 by TURKSTAT. It is originated from agriculture overwhelmingly (Figure 2.6). The other sources are energy, fuel combustions, industrial processes and product use and waste sectors. In 2014, N_2O emission was calculated 78,1 thousand tons (2017f).

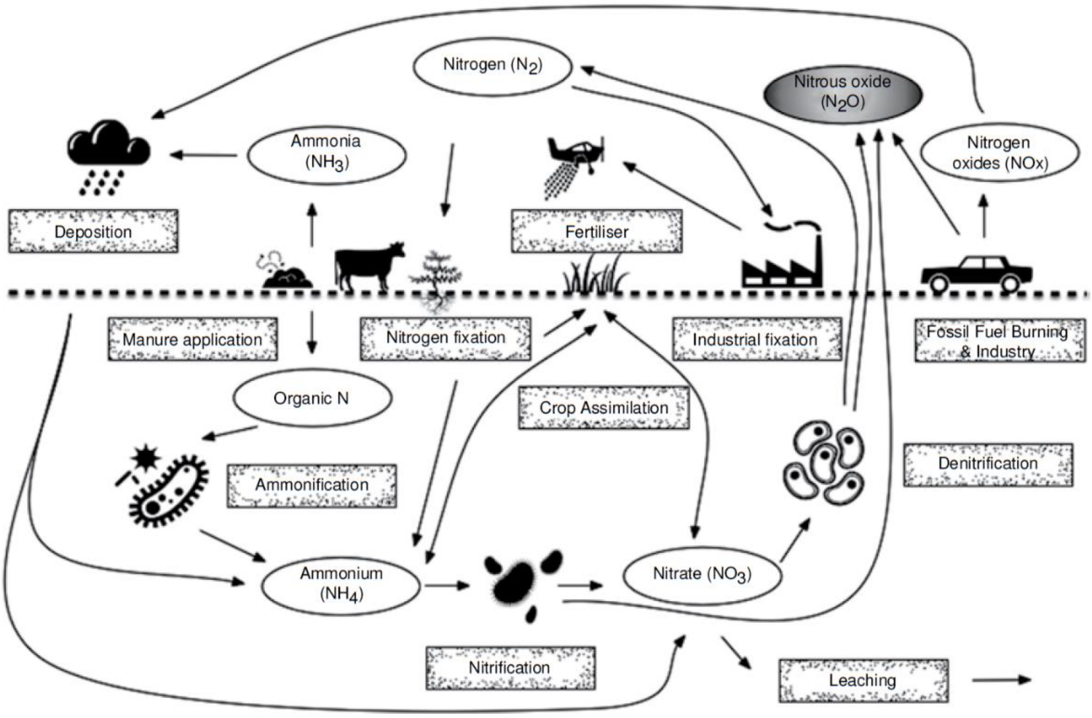

Figure 2.5 : Production of nitrous oxide from agriculture (adapted from Reay, 2015).

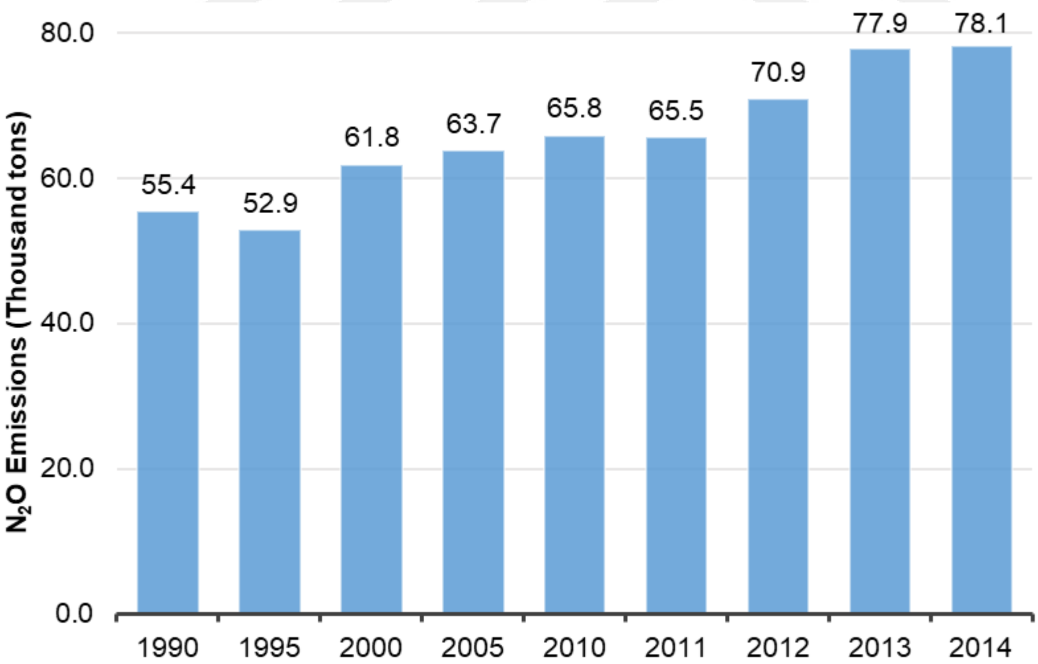

Figure 2.6 : N_2O emission trends in Turkey from TURKSTAT (2017f).

2.3 N_2O Production Processes

Natural sources of N_2O emissions are major microbial processes of nitrification and denitrification in the soils, oceans, and other aquatic systems and wetlands. Anthropogenic sources of N_2O are generally from agricultural soil area, especially due to use of manure and synthetic N fertilizers, cultivation of N-fixing crops, manure by livestock in grasslands and/or grazed pastures, and land use change (Ussiri and Lal, 2013b).

Anthropogenic nitrogen supplement to soils occurs through both direct and indirect pathways. Direct N_2O emission consists of the application of organic and synthetic nitrogen fertilizers, Incorporation of crop residues, and production of nitrogen fixing crops. Indirect pathways are nitrogen volatilization, surface run-off, and leaching (2000).

Nitrification is an essential process in the nitrogen cycle. Nitrification is an aerobic process (O_2 present) that responsible to convert ammonium (NH_4) into nitrate (NO_3) with N_2O as a by-product. In some cases, nitrifying bacteria use nitrite for electron acceptor when oxygen deficiency (Ward, 2013). When such process takes place, N_2O can come out as a product. Although nitrification is known to be an aerobic process, some research has been shown to have substantial proof that it can also happen under anaerobic conditions. Nitrifying bacteria have been shown to produce NO and N_2O (2000).

Denitrification is an anaerobic process that reduces nitrate or nitrite to N_2. The process is biological and it provides fixed nitrogen return to atmosphere, by that N cycle is completed (Braker and Conrad, 2011).

Figure 2.7 shows that which processes contribute to N_2O emissions in soils (Butterbach-Bahl et al., 2013) :

— During ammonia oxidation and heterotrophic nitrification, N_2O can be formed chemical decomposition of hydroxylamine.

— Chemodenitrification of soil nitrite and abiotic decomposition of ammonium nitrate in the presence of light, humidity and reacting surfaces, like the process of the chemical decomposition of nitrite, which is very common in soil under acidic conditions produces mainly NO but also N_2O and N_2.

— Nitrifier-denitrification within the same nitrifying micro-organism that the oxidation of ammonia to nitrite and its subsequent reduction via NO to N_2O by the same autotrophic ammonia-oxidizing bacterium.

— Coupled nitrification–denitrification by distinct micro-organisms attribute to form of N_2O emissions.

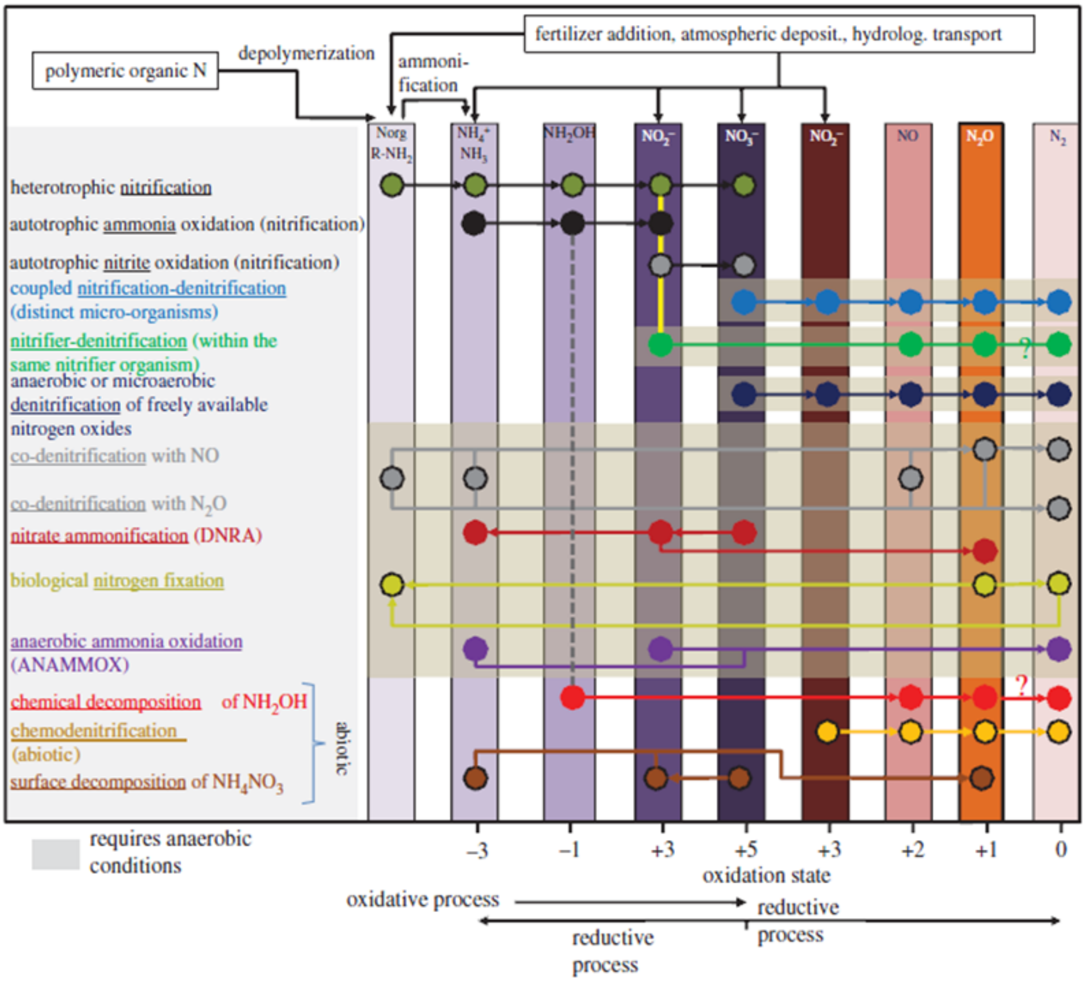

Figure 2.7 : Production processes of N_2O emissions (adapted from Butterbach-Bahl et al. 2013).

2.3.1 Agriculture

N_2O emission has risen significantly in the worldwide. Agriculture plays an essential role in this increase. Livestock and agriculture are necessary to supply the need for humans. The more they are consumed, the more emissions will be generated. In agricultural soils, N_2O emission was primarily produced from mineral N originating from applied N fertilizers and manures, mineralization of soil organic N including crop residues, and biologically fixed N (Eckard, 2010).

The world's total agricultural N_2O emissions in 2014 are about 2.31 billion tons of CO_2 equivalent according to FAO. The manure left on pasture has been the significant nitrous oxide emission sources. It had a contribution of 36.5% with 845 million tons. Synthetic fertilizer has been the second largest source with approximately 659 million tons (Figure 2.8).

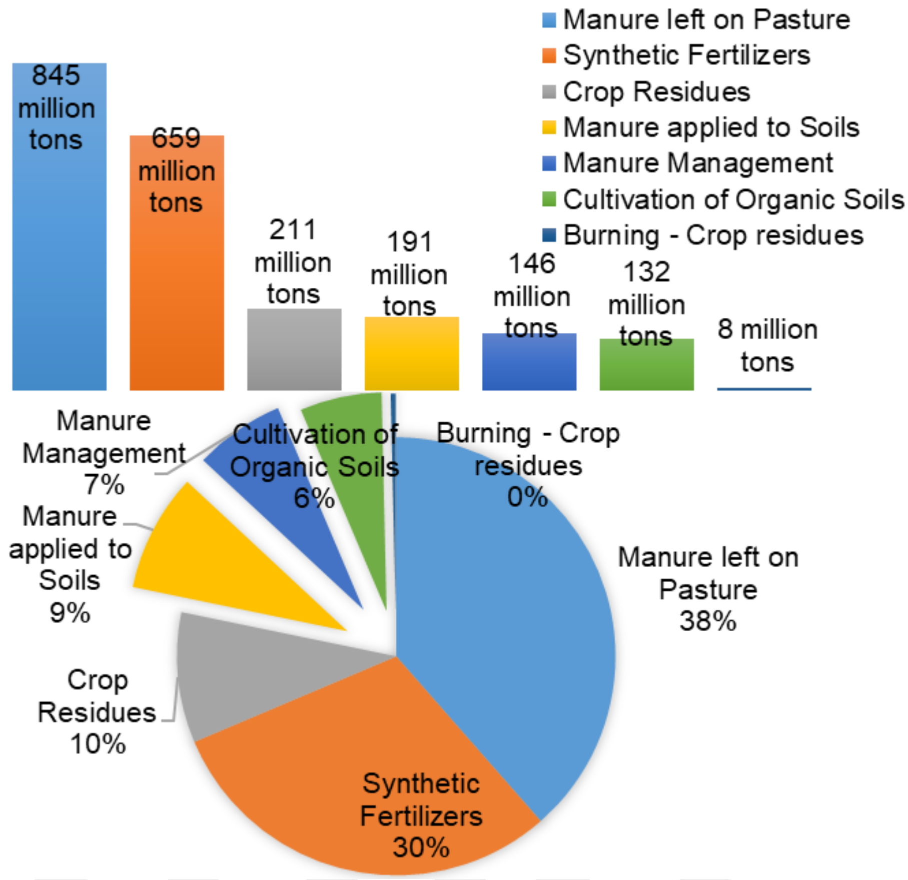

Figure 2.8 : Global scale N_2O emission from agriculture in 2014 (Francesco N. Tubiello, 2014).

The important parameters affecting nitrification and denitrification are soil moisture and temperature. Soil temperature and humidity affect the diffusion rate in the atmosphere as well as N_2O production. N_2O emissions increase with increasing soil temperatures (0-50°C). N_2O emissions increase as soil humidity increases, both nitrification and denitrification process being affected by moisture, but the emission of N_2O is reduced at very high soil moisture contents. N_2O emissions are increasing due to the changes in successive dry and wet periods (Signor et al., 2013).

2.3.2 Wastewaster

N_2O emissions from wastewater treatment are due to denitrification and nitrification processes and have a similar production with the managed soils. N_2O emission have been occurred in generally activated sludge from wastewater treatment plants (Kampschreur et al., 2009). Another alternative formation of N_2O has been generated in secondary clarifier, sludge storage tank, anaerobic sludge digester.

In the biological nutrient removal process (BNR), emissions are observed during the nitrogen removal process. It supports high level nitrogen removal from wastewater by nitrification and denitrification with BNR process and has various configurations. N_2O is a known obligatory intermediate in the heterotrophic denitrification pathway and is also produced by autotrophic nitrifying bacteria, mainly ammonia-oxidizing bacteria (AOB) as a by-product (Law et al., 2012).

When the parameters affecting N_2O production in the wastewater process is investigated, some parameters become important. The optimum pH condition for producing NO_2 and N_2O is about 8.5. Secondly, emission production rates by AOB have been increased in the presence of NO_2 The lack of biodegradable organic carbon is an important factor governing N_2O production during denitrification. The availability of organic carbon is typically measured as chemical oxygen demand (COD). For complete denitrification, COD to N ratio above 4 is required. Under conditions of limited carbon sources, the various denitrification enzymes (NO_3 reductase, NO_2 reductase, NO reductase and N_2O reductase) compete for electrons, potentially resulting in incomplete denitrification (Law et al., 2012).

The other important indirect emission source parameter in this respect is nitrite (NO_2^-). Short solids retention time (SRT), toxic compounds (like increased sulphide concentration), low temperatures, high salinity, and increased ammonium concentrations have been related to increased N_2O emissions (Kampschreur et al., 2009).

2.3.3 Solid waste

N_2O emissions from solid waste generally consist of the landfill disposal, composting, and incineration processes. The composting of organic waste result in N_2O either during the processor by the nitrification and denitrification of reactive nitrogen leaving the composting process in the form of ammonia emissions, nitrate or organic matter. It is possible to produce additional N_2O with reactive nitrogen which is frequently lost during composting and reactive nitrogen from the finished compost (Barton and Atwater, 2002)

2.4 Uncertainty in Emission Estimates

In order to reduce the effects of global climate change, greenhouse gas emissions must be estimated timely and accurately with alternative procedures. Practices to control climate change require that the atmospheric concentrations of greenhouse gases are kept at a certain level and it is important to be aware of the amounts absorbed by terrestrial and aquatic systems apart from the atmospheric release of greenhouse gases (Ometto et al., 2014).

Direct and continuous measurement of emissions can be achieved in very few systems, for instance, emissions of greenhouse gases from industrial plants. Other emission estimates are often handled using emission factors and activity data. There is an approximation of the emission to be calculated for each individual source, a connection between activity data and emissions (Rypdal and Winiwarter, 2001).

Greenhouse gas uncertainties can be divided into scientific uncertainty and forecast uncertainty. The actual emission value is unknown in scientific uncertainty, and it is the same as in the case of the same unit conversion process through the GWP value to approach (Ometto et al., 2014).

General uncertainty, on the other hand, can be divided as follows: Model uncertainty is based on mathematical parameters that connect parameters and emission processes related with some value such as measurement errors, sampling errors or systematic errors in the model process. Parameter uncertainty is connected with input such as activity data, inappropriate variable or emission factors etc. in the model (2014).

Various mathematical methods or software programs are used to estimate the uncertainty caused by these reasons. Monte Carlo uncertainty analysis was most commonly used in estimating GHG emissions when the recent research studies (Firestone and Fenner-Crisp, 1997).

2.4.1 Monte Carlo analysis

Monte Carlo analysis is a computer-based method that was invented by an atomic nuclear scientist named Stanislaw Ulam in 1940. That is a mathematical technique uses statistical random sampling. The principle of Monte Carlo analysis is that it generates the emission factors or input parameters randomly using the computer-generated uncertainty data repeatedly by the computer when the emission is being calculated (Lieberman et al., 2007) (Figure 2.9).

Some terms are using for calculating uncertainty emission. Probability density function (PDF) describes the range of possible values of the unknown quantity, such as the annual total ammonia emissions. Random error is a distinct concept compared to systematic error. Systematic error is another term for bias that is lack of accuracy. Uncertainty is described as the lack of knowledge of the true value of a variable. Variability is defined as changing of a variable over time, space or members of a population.

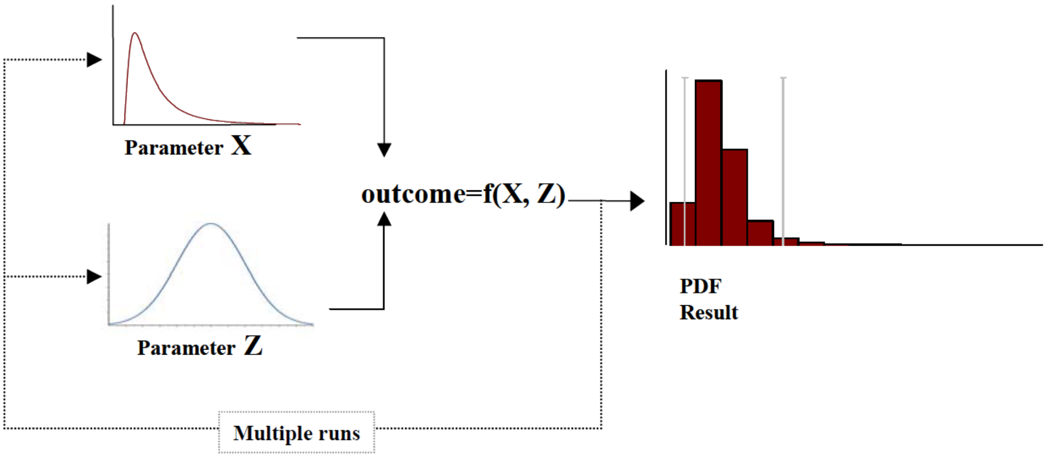

Figure 2.9 : Monte Carlo analysis to a model parameters and outcome PDF result (adapted from Ramírez et al. 2006).

Monte Carlo simulations are based on probability distribution, range and correlation to data. MC analysis is flexible and available through computer software packages such as @RISK or Crystal Ball (Ramírez et al., 2006).

The application of MC method in the uncertainty of greenhouse gas emissions is shown below (Figure 2.10). Emission uncertainty is calculated by multiplying the emission data of the activity data with the PDF distribution.

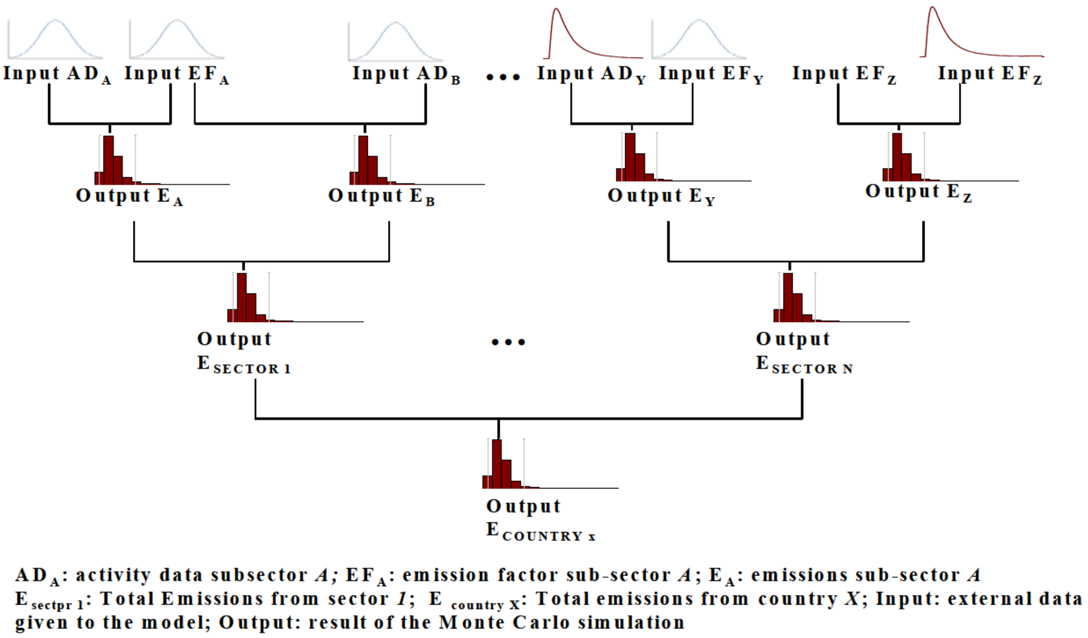

Figure 2.10 : The application of the monte carlo method in the uncertainty (adapted from Ramírez et al. 2006).

Probability density function describes the random variable that allows calculating the probability event in a continuous distribution. PDF's can take a number of standard forms such as normal, lognormal, triangular.

3. LITERATURE REVIEW

Most of the governments in the world prepare the national inventory of greenhouse gases. National inventories need to be generated to reach for a more definitive conclusion. Many researchers work on sources of nitrous oxide (N_2O) emission in global and national scale. N_2O emission calculations have been made in various forms. Some studies only focus on direct emissions or indirect emissions via IPCC or different methods, originated from variable land use, crop types, livestock production etc. N_2O emission from agriculture has been widely investigated.

In emission calculations, it is also important how accurately the calculated emission amount and how representative it could be. Emission calculations are made by both modeling and experimental studies. Therefore, statistical uncertainty analysis is performed to analyze the errors in the calculations. Monte Carlo simulation is usually used for uncertainty analysis in calculating greenhouse gas emissions (Ussiri and Lal, 2013a). There were significant research available on this subject Milne et al., 2014, Ramírez et al., 2008, Winiwarter and Muik, 2010, Wójcik-Gront and Gront, 2014.

Lilly et al. (2003) selected two areas for spatial and temporaril calculation of N_2O emission from agricultural basin in Scotland. Geographic information system (GIS) was used when the emission were calculated. GIS has been used to distribute short-term emissions measurements over longer distances and local measures more broadly. For measurements of N_2O emission field chamber method were used. The calculated emission rates were applied to combinations of soil moisture, land use and multiplied by the total area of each soil /land use type. The other research had been about how is the effect of manure management on nitrous oxide emission rate and emission factor in a Scottish farmland. The changes in the amount of manure and the season of manure application are examined. The result has been compared with IPCC methodology estimate (Bell et al., 2016).

Direct N_2O emissions from Canadian agroecosystems are calculated with IPCC methodology and DeNitrification-DeComposition method between 1981 and 2001. Results using DNDC method was higher than the IPCC methodology when the methods were compared. The results have also been compared for province level.

Uncertainty analysis had been performed and the results have been evaluated. Monte Carlo Simulation has been used to determine the uncertainty related to emission estimates in 2001 for both IPCC and DNDC methodologies (Hutchinson et al., 2006)

Agricultural direct and indirect N_2O and CH_4 emission have been estimated with their uncertainty. IPCC methodology was used for research to the calculation of emission. Uncertainty estimate of agricultural CH_4 and N_2O emissions were selected from Finland in 2002. Total uncertainty in agriculture was calculated using Monte Carlo simulation. According to the results were found CH_4 emissions are more confidential than those of N_2O (Monni et al., 2007).

Direct and indirect N_2O emissions from agricultural area in Russia between from 1990 to 2004 were calculated in respect to IPCC Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories report based on their national parameters. Total N_2O emission has decreased by 54% which include both direct and indirect emission. Researchers were regarded for this main reasons that the volumes of mineral fertilizers implementation reduced distinctly and decreased of the total number of cattle (Romanovskaya, 2008).

N_2O emissions uncertainty estimation from U.S. cropland soils between 1999 and 2007 were done by Del Grosso et al. (2010). Daycent model which is process-based was used to calculate N_2O emissions. Monte-Carlo simulation was used for the uncertainty of N_2O emissions in this study and ecosystem model simulations were used to estimate emissions and uncertainties from major crops. When the model was used, it gave some outputs involve daily N gas flux (N_2O, NOx, N_2), plant growth rates, and other ecosystem parameters. Process-based models, DAYCENT can be used to estimate N_2O emissions relevant to agricultural soil management, and results showed the uncertainties range from about −35% to +50% about the estimate in a large-scale application (Del Grosso et al., 2010).

Nitrous oxide emissions were calculated using an empirical model in Germany. When model results were compared with the empirical models in the literature, the cropland N_2O emission was heavily influenced by climate and soil conditions (Dechow and Freibauer, 2011). Another research was related to agricultural N_2O emission in Germany, Nitrous oxide emission estimated as 53.58 Gg N_2O-N from agricultural soils in Germany. Their emission factors were used in the research. Climate classes and soil aeration conditions are considered in the calculation of emissions with uncertainty. GIS-based calculation was made by dividing the results by regions in

Germany and a spatial distribution of the emisisons was presented (Brocks et al., 2014).

Agricultural N_2O emission from Chinese cropland – paddy field and upland - was calculated between 1980 and 2007. Direct N_2O emission had increased due to agriculture in China. At the same time, the national N_2O emission from Chinese cropland was compared with different studies. In addition, emission factors were used in the estimate by found statistical approach result (Gao et al., 2011).

Zhuang et al. (2012) have investigated to obtain N_2O inventory by using a different approach with artificial neural networks technique. Besides that, they have also performed an uncertainty analysis. Scientists focused on global N_2O emissions from natural ecosystem soils. Simulated of N_2O emission has shown great spatial and seasonal variability due to changes in soil, vegetation and climatic conditions. The results obtained with the neural network method were estimated on average 3.37 Tg N yr^{-1} with an uncertainty range of 1.96-4.56 Tg N yr^{-1} in 2000.

Variability of N_2O emission has been examined related to N applied to soil with organic or synthetic fertilizer. For this search, statistical methods have been developed and used. IPCC Tier 1 uncertainty has been compared to the uncertainty they have calculated. The previous data was used on the global scale for calculation. This uncertainty analysis could help to reduce IPCC Tier 1 uncertainty (Philibert et al., 2012).

Milne et al. (2014) aimed to investigate uncertainties in the estimates of nitrous oxide and methane emissions in the UK's greenhouse gas inventory for agriculture and focused on country level divided by four regions. UK's N_2O emissions from agricultural area decreased from 34.7 Tg CO_2-eq $year^{-1}$, with 95% confidence interval of 15.14-84.32 to 28.1 Tg CO_2-eq $year^{-1}$, with 95% confidence interval of 12.3-67.3 between 1990 and 2010. IPCC Tier 1 method was used for N_2O emission and Monte Carlo simulation was done for analysis of parameters. In addition, the critical parameter of emission factors was found by sensitivity analysis. Uncertainty related to emissions factor from N inputs which was affected the most in England and Scotland, on the other hand in Wales and Northern Ireland, N leaching and runoff emission factor had more significant effect (Milne et al., 2014).

Calculation of uncertainty of greenhouse gases emissions from livestock has been studied in Africa, Latin America and Europe. MITERRA-Global model was used for the estimate of uncertainty. MC simulation approach was used in the model estimation. Production of meat and milk from sheep, goats, cattle or cows contributed to the uncertainty (Zhu et al., 2015).

The uncertainty of New Zealand (NZ) N_2O inventory was estimated by statistically evaluating the input information and output calculations by two methods: analytical and Monte Carlo. Their results were compared with each other, conclusion was similar. EF uncertainty was the principal determinant of uncertainty for NZ's inventory. An estimated 95% and 83% of the emission uncertainty of NZ's inventory was attributed to correlation between N input and EF was 0 and 0.4, respectively (Kelliher et al., 2017).

In a study conducted at the Jungryan municipal wastewater treatment plant (WWTP) in Seoul, South Korea, the aim was to calculate the emission factor of N_2O and CH_4 in each process within activated sludge and anaerobic/anoxic/aerobic. When the emissions were calculated, the gases were collected from the surface using the flux chamber method. Measured concentration of N_2O and CH_4 emissions factors were related to removed BOD_5 and total nitrogen (TN) in the WWPT. The total N_2O and CH_4 emission factors measure from activated sludge and advanced treatment process were 1.256 g N_2O/g TN, 3.734 g CH_4/g BOD_5, and 1.605 g N_2O/g TN, 4.022 g CH_4/g BOD_5, respectively. N_2O emissions were measured highest level in the aeration process, and the sludge thickener process were with highest CH_4 emissions (Hwang et al., 2016).

In Turkey, some research was done on the calculation of N_2O emission from manure management and agriculture. Kulcu et al. (2010) worked on spatiotemporal patterns of N_2O and CH_4 emission from livestock and poultry production in Turkey by regions between 1961 and 2007. Researchers used IPCC methodology, especially focused on Tier 1. They found the special coefficient of intercept for Turkey livestock and poultry production and then calculated using improved intercept parameter for emission estimation. N_2O (animal waste management) emissions were 26.9 Gg in 1982, and 16.4 Gg N_2O in 2004. The reasons for the decrease in N_2O emissions were generally management practices such as enhanced feeding property, improved animal breeding.

When calculating of greenhouse gases from sources of the waste sector in Turkey based on IPCC 2006 regulation, total emissions have been found 17,455 kton CO_2eq in 2016. Calculated emissions have been separated category to the solid waste landfill, composting, open burning area and wastewater treatment plant. When the results of N_2O emissions sources are evaluated 2.060, 9.34 and 0.70 kton CO_2eq emissions were calculated from landfill area, wastewater treatment plant, compost and open burning area, respectively (Doğan et al., 2017).

The main greenhouse gases produced by livestock were been N_2O and CH_4. The total produced in the agriculture & livestock CH_4:N_2O ratio varies from country to country, but have been reported as %85:%15 in Turkey. There are fertilizer management practices such as the raising of animal breeds with high level of utilization of feed from animals, the use of high quality and high energy feeds, the addition of some healthy additives to feeds in greenhouse gas reduction from livestock. At the same time, a variety of efficient applications for greenhouse gas reduction can be produced by conducting an economic analysis of the applications (Özkan, 2013).

4. MATERIAL AND METHODS

Calculation methodology of N_2O emissions are divided by measurement methods and modelling approach. These methods are enhanced to understand their measurable quantity, efficiency and environmental impact of land. Measurement methods involve flux chamber method that is static chambers seal a specific volume of the atmosphere above the soil surface area for a predetermined time to allow GHG to accumulate to a concentration above the ambient, that can be determined by gas chromatography or directly by infrared analysis. Another measurement method is the micrometeorological approach that is conceptually measuring GHG emission over large ecologically uniform areas without changing the physical condition of the observed surface. The modelling approach is separated into three section which are empirical, process-based and metamodels (Ussiri and Lal, 2013c).

Model estimates used to input data such as soil properties, animal characteristics etc. Models generally simulate the GHG exchange at a given site based on the underlying processes, i.e. the dominant physicochemical, plant and microbial processes involved in ecosystem carbon and nitrogen cycling.

DNDC (DeNitrification-DeComposition) processes can be given an example of process-based models. This model is a computer simulation model of carbon and nitrogen biogeochemistry in agro-ecosystems. DNDC can be used for guess crop growth, soil temperature and moisture regimes, soil carbon dynamic and also can be given result of certain gases emissions such as nitrous oxide (N_2O), nitric oxide (NO), dinitrogen (N_2), ammonia (NH_3), methane (CH_4) and carbon dioxide (CO_2) (Giltrap and Ausseil, 2016).

Using IPCC calculation methods which are empirical, as well as some models that are used for calculation of N_2O emission. Models estimate emissions based on input data such as meteorological information, soil texture, land use properties etc. The model aims to increase the knowledge and decrease the uncertainty to gaseous emissions estimates. Providing temporal and spatial output data where the calculate emission estimates (Ussiri and Lal, 2013c).

All methods need national information for greenhouse gas emissions calculation for each region or country. When considering the calculation of N_2O emission according to IPCC 2006 guidelines for national greenhouse gas inventories, priory direct and indirect resources are determined. Direct N_2O emission sources consist of managed soils livestock and waste sectors. Managed soils include microbial processes in soils; emissions derive from applied synthetic fertilizers, animal waste, biological fixation, crop residues, and sewage sludge. (2006b)

2006 IPCC guidelines for national greenhouse gas inventory volume 4 chapter 11 include N_2O emission from management soils through calculation of direct emission and indirect emission.

IPCC 2006 guidelines for national greenhouse gas inventory volume 4 chapter 10 consist of manure management. Estimation of N_2O and CH_4 emission are calculated in this chapter. Manure management type is important to the estimation of emission in the country which is calculated.

IPCC 2006 guidelines for national greenhouse gas inventory volume 5 include waste sector. Wastewater treatment and discharged, biological treatment of solid waste and open burning area particularly solid waste were the main component in this chapter. N_2O emission and CH_4 emission are estimated from waste. The waste sector has also direct and indirect emission of calculation.

Most of the data provided by Turkish Statistical Institute (TURKSTAT). Turkey Statistical Institute was collected many national information data and it was kept in the database, published and informed to the public.

TURKSTAT enables us to get data for calculation of N_2O emissions such as the number of animals they are a dairy cow, other cattle, sheep, goats, camels, swine, horses and poultry include duck, turkey and chicken. Type of crop consists of wheat, barley, oat, maize, potato, rye, sorghum and bean for calculating the amount of the manure and the nitrogen fertilizers.

BEPA (Turkish Biomass Energy Potential Atlas) supplies to national and especially local information by Directorate General of Renewable Energy related to Ministry Of Energy And Natural Resources. Bepa provide to the number of livestock and poultry, forestry area in local scale for calculation of N_2O emission as to IPCC Tier 1.

EarthStat.org serves by providing geographic data clusters to address the major challenges of the growing population by reducing the impact of agriculture on the environment. EarthStat is a collaboration between the Global Landscapes Initiative at

The University of Minnesota's Institute on the Environment and the Ramankutty Lab at The University of British Columbia, Vancouver.

4.1 Managed Soils

Denitrification and nitrification rates in the soils have an impact on N_2O emission. The increase of the N ratio in the soil due to the influence of the human causing the increase of the N_2O emission. Direct N_2O emission occurs due to using synthetic and organic fertilizer, crop residue including N-fixing crops, management of organic soils and through land use changing loss of soil organic matter.

Direct N_2O emissions from managed soils Tier 1 method include using synthetic and organic fertilizer, crop residue including N-fixing crops, management of organic soils and through land use changing loss of soil organic matter. Indirect emission from deposition and leaching of managed soils. These are input parameters for calculation. The calculation is the result of the inputs parameters and emission factors multiplying. The emission factor is taken default value from IPCC 2006 guidelines for Tier 1 method. Afterward, the result is multiplied 44/28 to the conversion of N_2O-N emission to N_2O emission.

Direct N_2O emissions from managed soils are estimated using equation (4.1) and indirect N_2O emissions from managed soils are estimated using equations (4.2) and (4.3). N_2O emissions from direct management soils are separated into three main sources. These are direct N_2O–N emissions produced from managed soils using equation (4.4). Synthetic fertilizer applied to soils, animal manure applied to soils, total sewage N applied to soils, amount of total compost applied to soils, amount of other organic amendments used as fertilizer, amount of N in crop residues related to equation (4.5) and amount of N in mineral soils due to result of land use change related to equation (4.5). Second sources are area of managed organic soils in forestland, grassland and cropland equation (4.6). Third sources are urine and dung deposited by grazing animals on pasture, range and paddock equation (4.7).

$$N_2O\ Direct - N = N_2O\ Ninput + \ N_2O\ Nos + \ N_2O\ Nprp \tag{4.1}$$

$$N_2O(ATD) - N = \left[(Fsn \times FracGASF) + \left((Fon + Fprp) \times FracGASM\right)\right] \times EF4 \tag{4.2}$$

$$N_2O(L) - N = (Fsn + Fon + Fprp + Fcr + Fsom) \times Fracleach \times EF5 \tag{4.3}$$

$$N_2O\ Ninput = \left[\left[(Fsn + Fon + Fcr + Fsom) \times EF1\right] + \left[(Fsn + Fon + Fcr + Fsom\right] \times EF1fr\right] \quad (4.4)$$

N_2O Direct–N = annual direct N_2O–N emissions produced from managed soils (kg N_2O–N yr^{-1})

N_2O–N Ninputs = annual direct N_2O–N emissions from N inputs to managed soils (kg N_2O–N yr^{-1})

N_2O–N_{OS} = annual direct N_2O–N emissions from managed organic soils (kg N_2O–N yr^{-1})

N_2O–N_{PRP} = annual direct N_2O–N emissions from urine and dung inputs to grazed soils (kg N_2O–N yr^{-1})

N_2O(ATD)-N = annual amount of N_2O–N produced from atmospheric deposition of N volatilised from managed soils

N_2O(L)-N = annual amount of N_2O–N produced from leaching and runoff of N additions to managed soils in regions where leaching/runoff occurs

Fsn = annual N_2O emission from synthetic N-containing fertilizer applying to soil

Fon = annual amount of organic N fertiliser applied to soils other than by grazing animals

Fprp = annual amount of urine and dung N deposited on pasture, range, paddock and by grazing animals

Fcr = annual amount of N in crop residues (above and below ground), including N-fixing crops, and from forage/pasture renewal, returned to soils annually

Fsom = the net annual amount of N mineralised in mineral soils as a result of loss of soil carbon through change in land use or management

FracGASM = fraction of applied organic N fertiliser materials (FON) and of urine and dung N deposited by grazing animals (FPRP) that volatilises as NH_3 and NO_x, kg N volatilised

FracGASF= fraction of synthetic fertiliser N that volatilises as NH3 and NOx, kg N volatilised

Fracleach = fraction of all N added to/mineralised in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff

EF4 = emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces

EF5 = emission factor for N_2O emissions from N leaching and runoff

EF1 = the emission factor for N_2O emissions from N inputs [kg N_2O–N (kg N input)$^{-1}$]

$EF1_{FR}$ = the emission factor for N_2O emissions from N inputs to flooded rice, [kg N_2O–N (kg N input)$^{-1}$]

When calculated of annual N_2O emission from synthetic N-containing fertilizer applying to soil (F_{SN}), the amount of fertilizer was used which crop type from the Republic Of Turkey Ministry Of Food, Agriculture And Livestock (www.tarım.gov.tr) and Turkey's land area covered by crops grown in the city and yield information were taken between 2011 and 2015 from Turkish Statistical Institute. In this calculation, wheat, barley, maize, oat, rye and rice crop types were used. The data used for these parameters were given in Table 4.1.

Table 4.1 : Amount of fertilizer used according to crop types.

Region/Crop Type	Wheat	Barley	Maize	Oat	Rye	Rice
	kg N*daa^{-1}	kg N*daa^{-1}	kg N*daa^{-1}	kg N*daa^{-1}	kg N*daa^{-1}	kg N*daa^{-1}
Central Anatolia Region	15	14	16	4.5	4	18
Marmara Region	16	10	20	4.5	4	17
Black Sea Region	16	10	17	4.5	4	18
Thrace Region	16	10	18	4.5	4	18
Southeastern Anatolia Region	15	10	16	4.5	4	16
Eastern Anatolia Region	11	10	14	4.5	4	-
Aegean Region	16	15	18	4.5	4	20
Region of Lakes	16	10	17	4.5	4	17
Mediterranean Region	17	13	18	4.5	4	18

When the calculation of F_{ON} the annual amount of animal manure applied to soils, it was assumed that all animal manures were processed to the soil. When these parameters were calculated, the assumption was that the N from the components compost and wastewater was applied to the soil was not included. In this calculation, dairy cattle, other cattle, sheeps, goats, mules and asses, horses, camels, swine and poultry livestock species were used. The data used for these parameters were given in the table below (Table 4.2). Nrate parameter was N excretion for animal type, TAM parameter was indicated animal mass. MS was meant that the ratio of total annual nitrogen excretion for each managed live species. FraclossMS was indicated that the amount of lost nitrogen for the category of livestock in the manure management system.

Table 4.2 : The parameters for calculation of the annual amount of animal manure applied to soils.

Livestock Species / Parameter	Nrate	TAM	MS	$Frac_{lossMS}$
	kg N (1000 kg animal mass)$^{-1}$ day^{-1}	(kg animal)$^{-1}$	-	%
Other cattle	0.33	391	1	40.00
Dairy cattle	0.48	550	1	50.00
Sheeps	0.85	28	1	15.00
Goats	1.28	30	1	15.00
Mules and asses	0.26	130	1	15.00
Horses	0.26	238	1	15.00
Camels	0.38	217	1	15.00
Swine	0.68	50	1	50.00
Poultry	0.38	1	1	50.00

F_{CR} was calculated based on the amount of N (above-ground and below-ground) in product residues including N-fixing crops (kg N/year) in equation (4.5).

$$Fcr = \sum_T \{cropT \times FracrenewT \times [(AreaT - AreaburntT \times Cf) \times RagT \times NagtT \times (1 - FracremoveT) + AreaT \times Rbg \times Nbg]\} \quad (4.5)$$

When F_{CR} was included crop yields for chosen crop types of information from TURKSTAT for Turkey crop type equation (4.6). Wheat, barley, maize, oat, rye, rice, potato, sorghum and bean were selected for sources of calculation of product. Default values were that slope, intercept, Nagt, Nbgt and Rbg-bio were used for calculation from 2006 IPCC Guidelines for National Greenhouse Gas Inventories. These parameters were given in the table below (Table 4.3). The parameter of Cf defined as combustion factor, Fracrenew and Fracremove parameters are the fractions of the total area under crop T that is renewed annually and the fraction of above-ground residues of crop T removed annually for purposes such as feed, bedding and construction, respectively. The area is equal to total annual area harvested of the crop. Area burnt is equal to the annual area of crop.

Table 4.3 : The parameters for calculation of the annual amount of N in product residue.

Parameter/ Crop Type	DRY (dry matter fraction)	slope[1]	intercept[1]	Nagt (N content of above-ground residue)	Nbgt (N content of below-ground residue)	$R_{bg\text{-}bio}$[1] (Ratio below-ground residues to above ground biomass)
Wheat	0.89	1.51	0.52	0.006	0.009	0.24
Barley	0.89	0.98	0.52	0.007	0.014	0.22
Maize	0.87	1.03	0.61	0.006	0.007	0.22
Oat	0.89	0.91	0.89	0.007	0.008	0.25
Rye	0.88	1.09	0.88	0.005	0.011	0
Rice	0.89	0.95	2.46	0.007	0	0.16
Potato	0.22	0.1	1.06	0.019	0.014	0.2
Sorghum	0.89	0.88	1.33	0.007	0.006	0
Bean	0.9	0.93	1.35	0.01	0.01	0

[1]R_{AG} was calculated using slope and intercept parameter.

F_{OS} = annual area of managed/drained organic soils, ha (Note: the subscripts CG, F, Temp, Trop, NR and NP refer to Cropland and Grassland, Forest Land, Temperate, Tropical, Nutrient Rich, and Nutrient Poor, respectively)

EF_2 = emission factor for N_2O emissions from drained/managed organic soils, kg $N_2O–N\ ha^{-1}\ yr^{-1}$

The F_{OS} parameter was not calculated as a consequence of the organic soils namely histosols in Turkey in equation (4.6).

$$N_2O - N_{os} = [(F_{OS,CG,Temp}) * (EF_{2CG,Temp}) + (F_{OS,CG,Trop}) * (EF_{2CG,Trop}) + (F_{OS,CG,Temp,NR}) * (EF_{2CG,Temp,NR}) + (F_{OS,CG,Temp,NP}) * (EF_{2CG,Temp,NP}) + (F_{OS,F,Trop}) * (EF_{2F,Trop})] \quad (4.6)$$

There are 32 major soil types in the world according to FAO World Soil Resources Reports. They reflect the environment in which they are formed, their age, and the ecosystem. These are Histosols, Solonchaks, Planosols, Gypsisols, Cambisols, Anthrosols, Gleysols, Stagnosols, Calcisols, Arenosols, Technosols, Andosols, Chernozems, Retisols, Fluvisols, Cryosols, Podzols, Kastanozems, Acrisols, Regosols, Leptosols, Plinthosols, Phaeozems, Lixisols, Solonetz, Nitisols, Umbrisols, Alisols,Vertisols, Ferralsols, Durisols and Luvisols (FAO, 2015).

Estimation of emission from organic soils, considering territorial structure within organic soils described histosol.

Territorial structure of Turkey distribution are involved leptosol, calcisol, cambisol, vertisol, luvisol, andosol, fluvisol, arenosol, kastanozem and its derivatives (Aksoy et al., 2010).

F_{SOM} is equal to the annual amount of N in mineral soils that is mineralized, in association with loss of soil C from soil organic matter as a result of changes to land use or management (kg N/year). This parameter was not calculated due to lack of data for Turkey. The amount of soil carbon loss of land use changes in the research could not be calculated for turkey

F_{PRP} = Annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock, kg N yr^{-1} (Note: the subscripts CPP and SO refer to Cattle, Poultry and Pigs, and Sheep and Other animals, respectively)

Fprp that occurs after deposition of N via urine and dung during the circulation of the grazing animals in the grassland, pasture, paddock. This parameter was calculated by livestock number within the category related of these information was given TURKSTAT. Other sources, default value etc. was provided by 2006 IPCC Guidelines for National Greenhouse Gas Inventories. These parameters were given in the table below (Table 4.4).

$$N_2O - Nprp = [(Fprp, cpp \times EF3, cpp) + (Fprp, so \times EF3prp, so)] \quad (4.7)$$

EF_{3PRP} = Emission factor for N_2O emissions from urine and dung N deposited on pasture, range and paddock by grazing animals, kg N_2O–N (kg N input)$^{-1}$

Table 4.4 : The parameter for calculation of annual amount of N deposited pasture, paddock and range.

Animal Type	Nrate kg N (1000 kg animal mass)$^{-1}$ day^{-1}	TAM (kg animal)$^{-1}$	MS -
Other cattle	0.33	391	1
Dairy cattle	0.48	550	1
Sheeps	0.85	28	1
Goats	1.28	30	1
Mules and asses	0.26	130	1
Horses	0.26	238	1
Camels	0.38	217	1
Swine	0.68	50	1
Poultry	0.38	1	1

Burning of agriculture section was calculated common crop types that were maize, wheat and rice via equation (4.8) according to IPCC methodology. Area burnt, combustion factor and mass of fuel available for combustion and emission factor (Table 4.5). These are input parameter for calculation of burning of residue. In this calculation, 10% of the burned area was counted according to TURKSTAT data.

$$Lfire = A \times Mb \times Cf \times Gef \times 10^{-3} \quad (4.8)$$

L_{fire} = amount of greenhouse gas emissions from fire, tonnes of each GHG e.g., CH_4, N_2O, etc.

A = area burnt, ha

M_B = mass of fuel available for combustion, tonnes ha^{-1}. This includes biomass, ground litter and dead wood. When Tier 1 methods are used then litter and dead wood pools are assumed zero, except where there is a land-use change

C_f = combustion factor, dimensionless

G_{ef} = emission factor, g kg^{-1} dry matter burnt

Table 4.5 : The parameter for calcution of burning of crop residue.

Parameter	Wheat	Maize	Rice
Mb*Cf	4	10	5.5

4.1.1 Manure management

In this section based on using manure management system among these anaerobic digesters, deep bedding, composting and its derivation, aerobic treatment, poultry with and without litter, solid storage, liquid/slurry. The using manure management system was determined and according to this system, the appropriate data was obtained from the IPCC report and calculation was made according to its guidelines. The calculation was assumed to be manure management systems in Turkey for livestock species. When calculated manure management emission estimation, default values were selected Western Europe data in guidelines for Turkey and another management system was used the specific data model that was chosen in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 10-Emissions from Livestock and Manure Management. Livestock species and numbers were used the same parameter as in the F_{PRP} and F_{ON}. The equation of emission calculated from manure management is given below equation (4.9). Indirect emission was calculated using equation (4.10) based on volatilization in forms of NH_3 and NO_x from manure management systems.

$$N_2O_{D(mm)} = \left[\sum_S \left[\sum_T \left(Nt \times Next \times MS(t,s)\right)\right] \times EF3(s)\right] \times 44/28 \quad (4.9)$$

$$Nvolatilization - mms = \left[\sum_S \left[\sum_T \left(Nt \times Next \times MS(t,s) \times \left(\frac{Fracgasm}{100}\right)\right)\right](t,s)\right] \quad (4.10)$$

4.1.2 Waste

Waste sector divided by wastewater, compost and open burning of waste in 2006 IPCC Guidelines for National Greenhouse Gas Inventories volume 5. The advanced biological treatment plant was selected for the estimation of wastewater emissions. Data about advanced biological treatment and population data was taken as TURKSTAT for this calculation. The parameter of fraction of nitrojen in protein was

$$N_2O = (Pop * Nwwratio/100 * EF1) + [\{((protein * Nwwratio/100 * FracNPR * Pop) - Nwwt - Nsludge)\} * EF2 * 44/28] \quad (4.11)$$

taken FAO data for Turkey. Scheehle and Doorn (2009) research were used to estimation emission of from wastewater. The equation (4.11) used is given below.

The parameters used in the calculation of the emissions from wastewater are given in Table 4.6. Pop=population, FracNPR=Fraction of nitrogen in protein, Nwwratio=Fraction of population using WWTPs, Nsludge=Quantity of sewage sludge N not entering aquatic environments, Nwwt=Quantity of wastewater nitrogen removed by WWT processes, $EF_{1,2}$=emission factor 1 and 2.

Table 4.6 : The parameter for calculation of wastewater emission.

Protein	$Frac_{NPR}$	Nwwratio
kg/person/yr	kg N/kg of protein	%
36	0.16	47

Calculation of emissions from composting while the compost produced in Turkey are provided quantities of Turkey Statistical Institute data. Composting process was carried out in certain cities in Turkey. For this reason, emissions from compost were calculated for specific cities. The amount of annual compost was calculated by multiplying the emission factor obtained.

Open burning of the waste emission was calculated for Turkey. Emission estimation was performed by providing data similar to the compost emission calculation. Input data was provided by TURKSTAT. Emission factor was provided by IPCC.

4.1.3 Other indirect emissions

Indirect emission from managed soils and manure management have been calculated in the previous section. This stage leads to deposition of NO_x and NH_3 emissions in the atmosphere due to nitrogen compounds of fuel combustion, industrial processes, burning of crop residues and agricultural waste.

The European Monitoring and Evaluation Program (EMEP) data has been obtained for this calculation. Total deposition reduced nitrogen and total oxidized nitrogen data have been downloaded from EMEP MSC-W modelled air concentrations and depositions. The equation (4.12) used in the calculation is given below.

$$N_2O_{(i)} = [(NO_x - N_i) + (NH_3 - N_i)] * EF4 * 44/28 \tag{4.12}$$

$N_2O_{(i)}$ = N_2O produced from atmospheric deposition of N from NO_x and NH_3 emissions from source i, in Gg

NO_x-$N_{(i)}$ = Nitrogen content of NO_x emissions from source i assuming that NOx is reported in NO_2 equivalents (Gg NO_x-N or Gg NO_2 • 14/46)

NH_3-$N_{(i)}$ = Nitrogen content of NH_3 emissions from source i (Gg NH_3-N or Gg NH_3 • 14/17)

EF_4 = Emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces (kg N_2O-N/kg NH_3-N or NO_x-N emitted).

4.2 Uncertainty Analysis

The estimated emissions are considered to be uncertain due to the reasons listed below. For this reason, uncertainty analysis used in the calculation of the emission.

These are the reasons for uncertainty;

Lack of completeness: This is a case where measurement or other data are not available.

Model: The use of models to estimate data can introduce uncertainty, including both bias and random error, for a variety of reasons: (i) Models are not exact (ii) Interpolation is the application of a model within a range of inputs. (iii) Extrapolation can lead to uncertainty; (iv) Alternative formulations of the model may result in different estimates; (v) Model inputs are generally approximated based on limited information that creates additional uncertainties.

Lack of data: In some situations, there only may not yet be data available

Lack of representativeness of data: This uncertainty is associated with lack of complete correspondence between conditions associated with the available data and the conditions associated with real-world emissions/removals or activity.

Statistical random sampling error: This uncertainty is associated with data that are a random sample of finite size.

Measurement error: Measurement error, which may be random or systematic Misreporting or misclassification: Uncertainty here may be due to the incomplete, unclear, or faulty definition.

Missing data: Uncertainties may result where no value was available. This cause of uncertainty can lead to both bias and random error.

The principle of the Monte Carlo analysis is to calculate the inventory with randomly selected computer data (by the computer) within the distribution of uncertain emission factors or model parameters every time by the computer and initially uncertainties determined by the user. The uncertainties in emission factors and/or activity data are generally significant and may not have normal distributions. The solution can be found by creating an uncertainty distribution for the inventory estimation which is consistent with Monte Carlo analysis, emission factors, model parameters and input uncertainty distributions over activity data.

In the thesis, input data and emission factor distribution have chosen for implementation based on paper research and IPCC materials.

Some conditions have been determined to estimate the emission and Monte Carlo analysis. These conditions were set up based on previous paper. The conditions specified in the uncertainty analysis using the @RISK program. @RISK can be used for the problem of uncertainty, from financial calculations in wide to scientific calculations. Allows the creation of possible scenarios. It can be used in many industries such as healthcare/pharmaceutical, shipping/transport, and telecommunications, banking, including companies of cash flows & financial analysis, six sigma / quality analysis and more. The program works as an add-on in excel. The provides convenience for the users. The input properties are entered into the properties program, and the program generates the probability distributions of the input data with your rules Iteration etc. output data and their probability distributions to analyze via their uncertainties or risks. The input properties are entered into the program. Programme are generated by the probability distributions of the input data with your requested rules such as Iteration etc. As well as the programme gives to analysis of uncertainties or risks output data and their probability distribution function.

The programme are classified below. The classification was used for analysis.

- Number of iterations: 50.000

- Sampling type: Monte Carlo

- Standard recalculation: True EV

- Random generator seed: Choose randomly

Figure 4.1 was shown the selected classification in @RISK programme.

Sampling Type: Sets the type of sampling used during an @RISK simulation. Describes that sampling types differ in how they draw samples from a distribution They are Latin Hypercube sampling and Monte Carlo sampling. Monte Carlo sampling refers to the traditional technique for using random or pseudo-random numbers to sample from a probability distribution. By contrast, Latin Hypercube sampling stratifies the input probability distributions. A significant difference between the Latin Hypercube method and the MC method is that real results can be achieved with less sampling with Latin Hypercube method (2017e).

This option specifies how distribution functions are evaluated during a regular Excel recalculation. @Risk provides 3 options: Expected value (causes distribution functions to return expected or mean value during a recalculation); Monte Carlo (causes to return a random sample value) and True EV (causes to return expected or mean value during a recalculation) (2017e).

This option allows the entry of a seed value for the random number generator. There are three options: Choose randomly (@Risk randomly pick a new seed in each simulation), Fixed (@Risk uses the same seed in each simulation) and Multiple simulations used different seed values (2017e).

Uncertainty is quoted as the 2.5^{th} and 97.5^{th} percentiles i.e. bounds around a 95 percent confidence interval. Emission factors were selected lognormal and normal distribution based on in previous literature studies.

Input parameters have many distribution types such as normal, triangular and uniform and their range values have been implemented (Figure 4.2).

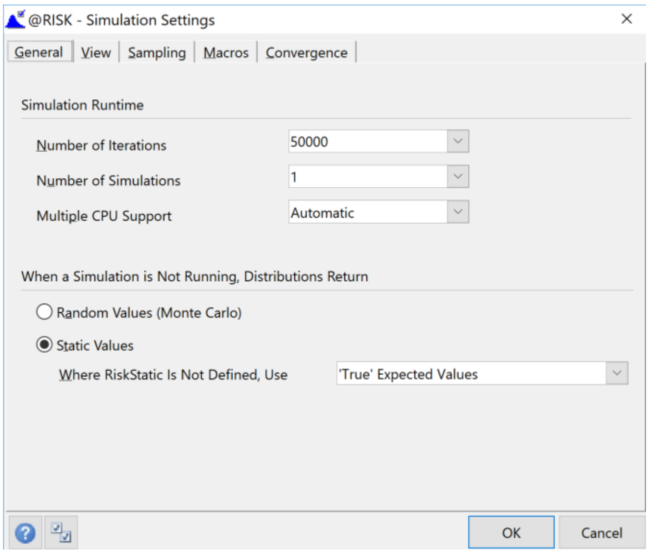

Figure 4.1 : @RISK programme sample of simulation settings.

@RISK programme provides to sensitivity analysis for calculations. The programme enables us to work with Excel and the programme create tornado graphs and spider charts as a tool to help make more informed decisions. Programme give us to what the five different types of tornado graphs are, some of their additional features, and how they can be used to figure out which, and how much, the individual input variables impact the output variables that you are most interested. The approach used here is Sperman Rank correlation. Generally, two type of correlations are used Pearson correlations and Sperman Rank correlations.

Table 4.7 and Table 4.8 show the properties of input parameters and emission factors for calculation of uncertainty. The input parameters are given in detail in Appendix (Table A.1).

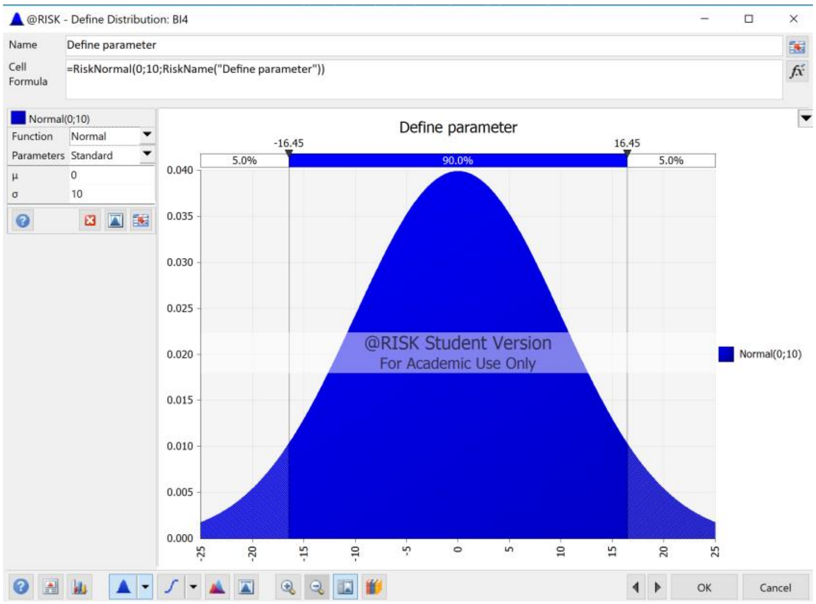

Figure 4.2 : Identified distribution for the input parameter in @RISK.

Table 4.7 : Definitions of emission factors and their values and distribution types.

Parameter	Description	Default value	Distribution Type	Relevant to	References
EF_1	Direct emission from N inputs	0.01	Lognormal	Total fertiliser applied, N fixed by crops, N in returned crop residues	IPCC 2006* Milne et al., 2014
EF_{1FR}	Emission from N inputs to flooded rice	0.003	Lognormal	Total fertiliser applied, N fixed by crops, N in returned crop residues	IPCC 2006 Milne et al., 2014
$EF_{PRP,CPP}$	Emission from animal type of cattle, poultry and pigs	0.02	Lognormal	N urine and dung deposited by grazing animals on pasture, range and paddock	IPCC 2006 Milne et al., 2014
$EF_{PRP,SO}$	Emission from animal type of sheep and other animals	0.01	Lognormal	N urine and dung deposited by grazing animals on pasture, range and paddock	IPCC 2006 Milne et al., 2014
$EF_{3\ (other)}$	Emission from manure management of solid storage and other	0.005	Lognormal	Total amount of N excreted in each waste management category	IPCC 2006 Milne et al., 2014
$EF_{3\ (poultry)}$	Emission from manure management of liquid slurry and other	0.002	Lognormal	Total amount of N excreted in each waste management category	IPCC 2006 Milne et al., 2014
EF_{ww1}	Emissions from municipal WWTPs (activated sludge or secondary)	4	Normal	N changed to N_2O from sewage	Scheehle and Doorn, 2009
EF_{ww2}	Emission from waste water	0.01	Normal	N changed to N_2O from sewage	Scheehle and Doorn, 2009,
$EF_{compost}$	Emission from compost	1.2	Normal	Total amount of N in compost	IPCC 2006, TURKSTAT GHG Emissions Inventory Report ,
$EF_{open.burn.area}$	Emission from open burning area	0.015	Normal	Total amount of N open burning area (waste)	IPCC 2006, TURKSTAT GHG Emissions Inventory Report
$Ef_{agr.burn.area}$	Emission from agricultural crop residue burning	0.07	-	Total amount of N open burning area (waste)	IPCC 2006

Table 4.8 : Input parameters and properties used in uncertainty analysis.

Parameter	Description	Range	Distribution Type	References
Area	Harvested area	25%	Normal	Yan and Boies, 2013 www.tarım.gov.tr
Yield	Crop yield	based on type	Triangular	Yan and Boies, 2013 www.tarım.gov.tr
N_{animal}	Animal numbers	15%	Normal	Milne et al., 2014
Nrate	Nitrogen excreted kg of animal	50%	Normal	IPCC 2006
TAM	Animal mass for livestock	25%	Normal	IPCC 2006
Fracloss	Amount of managed manure nitrogen for livestock	10-65	Triangular	IPCC 2006
N_{person}	Population in country	15%	Normal	Turkish Statistical Institute GHG Emissions Inventory Report
Protein	Annual protein consumption	30-42	Uniform	Kim, 2014
$N_{wwratio}$	Ratio of municipal population served with WWPT to total population	15%	Normal	Turkish Statistical Institute GHG Emissions Inventory Report

5. RESULTS AND DISCUSSION

Direct and indirect N_2O emissions from managed soils and waste sector were calculated in Turkey. Their emissions uncertainty estimation was performed using Monte Carlo simulations.

5.1 Emission Estimation

N_2O emissions from agriculture were calculated according to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories based on Tier 1 methodology. Annual national emissions from agriculture were calculated between 2011 and 2015 in Turkey. It was divided into major sections to observe from which processes the emissions from agriculture originate. These are agricultural soils, manure management, and burning crop residues.

Given the proportion of calculated direct emission sources in 2015, agricultural soils have 87.31%, manure management has 12.35% and burning crop residue contributed have 0.34% (Figure 5.1).

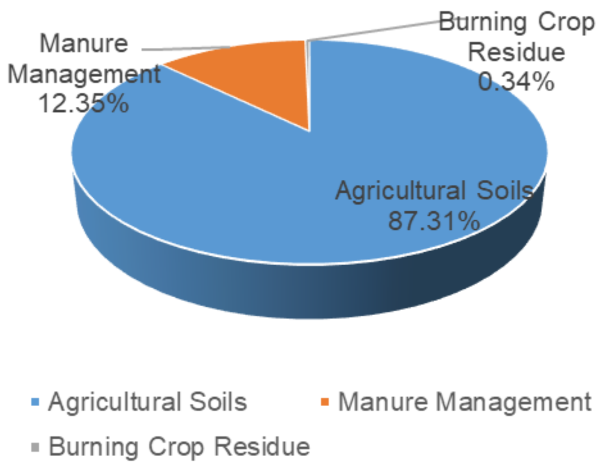

Figure 5.1 : Total direct emissions sources saperated in 2015.

Our study results were then compared with the emission data published by the United Nations Food and Agriculture Organization (FAO) and greenhouse gas emissions statistics of Turkey from TURKSTAT. The other two emission estimates from FAO and TURKSTAT used the same methodology with our study. The given table compares three emission results from managed soils that are calculated by FAO, TURKSTAT and our study between 2011 and 2015 (Table 5.1).

Table 5.1 : Direct N_2O emissions results from managed soils.

References	Year	Agricultural Soils (Gg/year)	Manure Management (Gg/year)	Burning Crop Residue (Gg/year)	Managed Soils Total (Gg/year)
FAO	2011	54.443	0.477	0.259	55.179
	2012	59.401	0.516	0.259	60.175
	2013	65.541	0.564	0.267	66.372
	2014	64.821	0.609	0.269	65.699
	2015	66.264	0.615	0.272	67.151
TURKSTAT	2011	64.559	8.680	0.281	73.502
	2012	70.822	9.844	0.244	80.910
	2013	76.600	10.303	0.266	87.169
	2014	75.690	10.517	0.231	86.439
	2015	76.770	10.551	0.271	87.592
Our study	2011	66.799	9.114	0.292	76.205
	2012	71.300	10.255	0.283	81.838
	2013	76.338	10.747	0.296	87.381
	2014	75.041	10.939	0.298	86.278
	2015	76.885	10.872	0.302	88.058

When the three results were compared, the amount of emissions have increased over the years for FAO, TURKSTAT and our study. When we compare our study results with the TURKSTAT, the difference was less than 3%. However, the manure management estimations are higher in our study than TURKSTAT. On the other hand, FAO emissions, especially manure management section growth the differences become further. Total emissions of FAO are lower than our studies and the differences are between 30-35%. Similar results were found when FAO and TURKSTAT emissions are compared (Figure 5.2).

Manure management data result of FAO was significantly lower than other calculations. The difference was huge possibly because of the manure management systems selected differently. Our study and Ersoy (2017) had the similar results for calculation of emissions from manure management which supports our findings.

As is observed from the results, burning crop residue were found to be approximately the same. When three studies are compared, there are differences in the maximum of 2014 estimates in this parameter and the gap between was maximum 28%. The emission amount was increasing in all three studies.

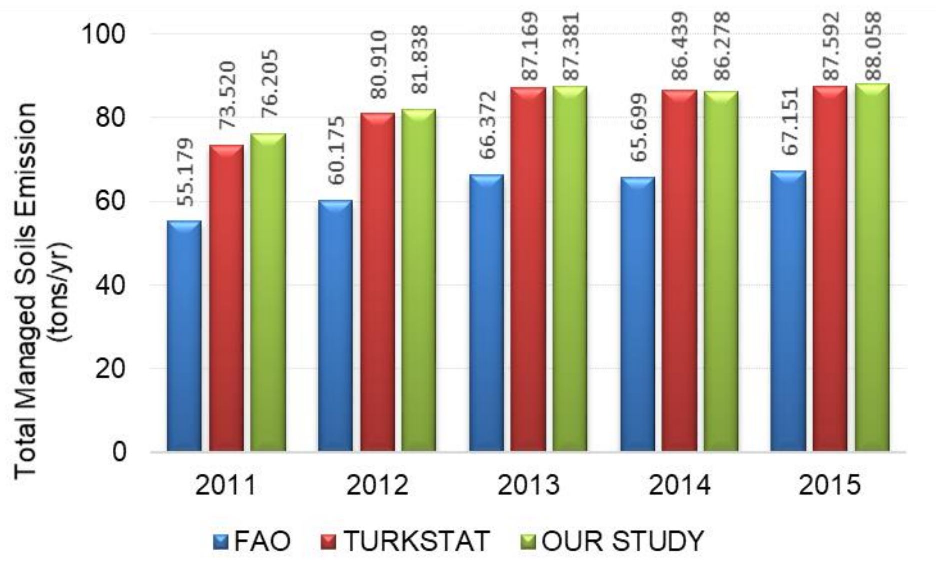

Figure 5.2 : Total managed soils emissions comparison with FAO, and TURKSTAT.

It has been determined that the change of emission estimates in agricultural soils over the years were the same in all three studies. As the years progressed from the year 2011 to 2015, the emission rate increased, except for a decrease in the 2014 data from all three emission value.

Three categories have been separated while calculating the emissions from the waste sector. These are wastewater, compost, open burning of waste (Table 5.2).

Table 5.2 : Direct N_2O emissions results from waste sector.

References	Year	Wastewater (Gg/year)	Compost (Gg/year)	Open Burning of Waste (Gg/year)	Waste Total (Gg/year)
TURKSTAT	2011	6.254	0.040	0.012	6.306
	2012	6.520	0.038	0.010	6.568
	2013	6.640	0.022	0.005	6.667
	2014	6.730	0.023	0.000	6.753
	2015	6.821	0.022	0.000	6.843
OUR STUDY	2011	5.348	0.047	0.001	5.395
	2012	6.115	0.037	0.001	6.153
	2013	6.115	0.037	0.001	6.153
	2014	7.019	0.030	0.001	7.049
	2015	7.019	0.030	0.001	7.049

Data for the waste sector was obtained from TURKSTAT on province basis. In the published TURKSTAT data that were calculated for every other two years, especially for compost and open burning parameters. For this reasons, 2011 data was valid in

2012 data, and the results were the same. The similar implementation for 2014 and 2015 results are observed in our study (Figure 5.3).

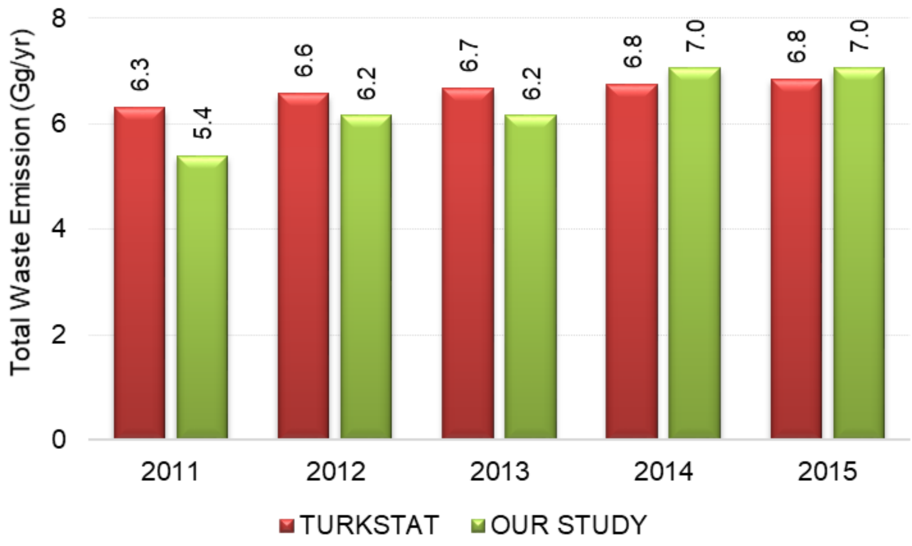

Figure 5.3 : Total the waste sector emissions compare with TURKSTAT and our study.

Given the proportion of calculated direct emission sources from waste sector in 2015, wastewater have 99.56%, compost has 0.43% and open burning of waste has 0.01% (Figure 5.4).

When the subcategories in the waste sector are compared, the highest emission contribution comes from the wastewater treatment plants. The contribution of the other two emission sources was negligible.

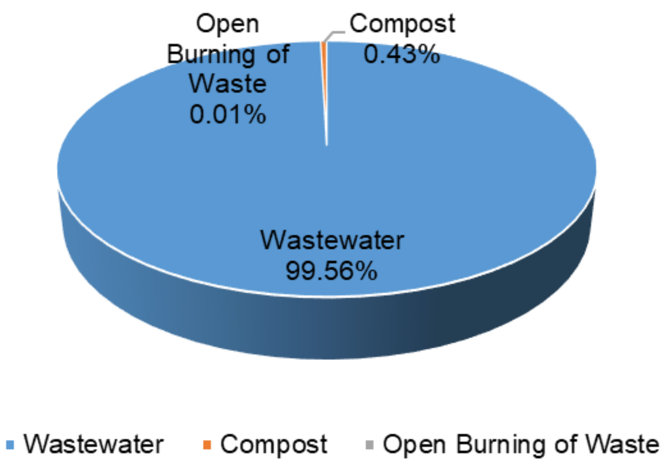

Figure 5.4 : Total direct N_2O emissions sources saperated in 2015.

Emission values from the waste sector were compared with the TURKSTAT. Our study result has the difference value concerning TURKSTAT. The data except for the wastewater used in our study is published every two years so the result for 2012-2013 and result for 2014-2015 was the same value. Wastewater calculation differed from IPCC methodology. The calculation methodology was used for wastewater estimation emission. Open burning of the waste parameter had a difference of 30% roughly between the TURKSTAT results. Emission result from compost had the difference from TURKSTAT (Scheehle and Doorn, 2009).

Indirect emission sources were divided into managed soil, manure management and other sources. Indirect N_2O emissions have occured from volatilisation and leaching/run off form of NH_4^- and NO_3^-. Emission resources were atmospheric deposition of nitrogen on soils and water surface. Other indirect resources were included atmospheric deposition of nitrogen compounds from all other sources of NO_x and NH_3 emissions, such as fuel combustion, industrial processes, and burning of crop residues and agricultural wastes. FAO was calculated indirect N_2O emission. When comparing the manure management section differed from our study result like as direct emission calculation. Indirect emissions from managed soils have risen gradually between 2011 and 2015 (Table 5.3). Our study data has also variability.

Table 5.3 : Indirect N_2O emissions results from managed soils.

References	Year	Indirect of Managed Soils (Gg/year)	Indirect of Manure Management (Gg/year)	Other Indirect Sources (Gg/year)	Indirect Total (Gg/year)
OUR STUDY	2011	17.53	5.57	2.40	25.49
	2012	18.66	5.57	2.57	26.80
	2013	15.65	6.46	2.17	24.28
	2014	15.86	6.52	2.17	24.54
	2015	15.66	6.46	2.17	24.29
FAO	2011	15.42	0.08	-	15.50
	2012	16.85	0.08	-	16.94
	2013	18.60	0.09	-	18.69
	2014	18.40	0.09	-	18.50
	2015	18.85	0.09	-	18.94

Comparison of the total amount of direct emissions from the managed soil and waste sector and the total amount of indirect emissions are given in Figure 5.5.

The most significant sources of emissions were total direct emissions from managed soils, which accounted for two-thirds of the emission amount, while total direct emissions from waste sectors generated the least amount of emissions in 2015. The proportion of direct emissions from managed soils were approximate 73.75%, direct emissions from the waste sector were 5.90% and total indirect emissions percentage were 20.34%.

The Indirect emission source ratio was the considerable amount of contributes to the emission it was at 20.34%.

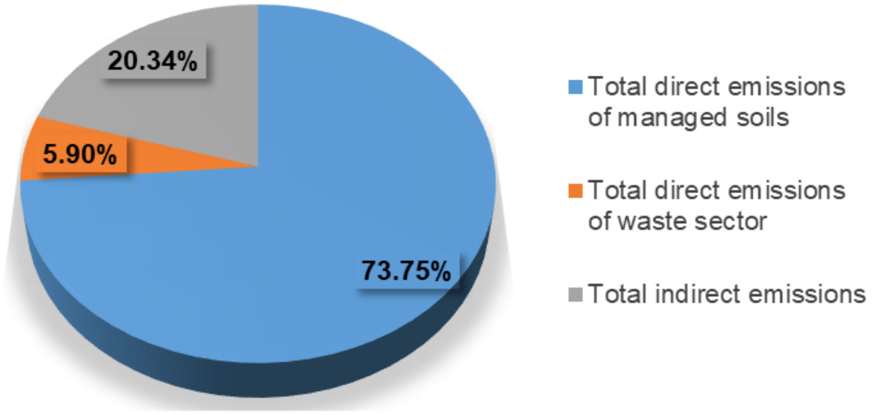

Figure 5.5 : Total direct and indirect emissions distribution in 2015.

Direct and indirect emission results have been calculated from managed soils, manure management and other sectors that the result was 130.266 Gg/year N_2O emissions and 38,819.157 CO_2eq in 2015. The table was shown overall data from our study results (Table 5.4).

Table 5.4 : Direct and indirect emissions results from our study.

Sectors	OUR STUDY				
	2011	2012	2013	2014	2015
Managed Soils (direct+indirect) (Gg/year)	93.734	100.498	103.031	102.137	103.717
Manure Management (direct+indirect) (Gg/year)	14.679	15.825	17.207	17.457	17.333
Other Indirect Resorces (Gg/year)	2.396	2.570	2.170	2.167	2.167
Waste (direct) (Gg/year)	5.395	6.153	6.153	7.049	7.049
Overall (direct+indirect) (Gg/year)	116.205	125.047	128.561	128.810	130.266
CO_2eq (Gg/year)	34,629.069	37,263.919	38,311.218	38,385.459	38,819.157

The distribution of direct and indirect emissions amounts in provinces were given for the years 2011 and 2015 for comparison and showing the observed changes in five-years.

Indirect emission was calculated as 2.53 Gg N_2O in 2010 from Switzerland. The values were compared with Turkey, Switzerland study was focused on the semi-natural plants. Agricultural emissions had the most significant share. As for that in this study, agriculture, manure management and fuel combustion, industrial processes, burning of crop residues and agricultural waste for indirect emission calculations were performed for Turkey (Bühlmann et al., 2015).

In another study, N_2O emissions from manure management were calculated. In 2006, a value of 16.4 Gg N_2O was estimated. When compared emissions with results of emissions, our study calculated the emission of 9 Gg N_2O in 2011. The reasons of difference that originated from the methodology of calculation and the input activity data (Kulcu et al., 2010). In this study, indirect emission sources are calculated only through equation from IPCC.

In another thesis, N_2O emissions from manure management have been examined. The IPCC Tier 1 methodology was chosen for the calculation (Ersoy, 2017). The N_2O emission results from manure management and the result of N_2O emissions calculated in another master thesis are 17,30 Gg N_2O/year and 15,33 Gg N_2O/year, respectively. The reason for the difference is that different data are selected in the input parameter and there are also differences in the emission factor data selected in manure management.

Doğan et al. (2017) were estimated at N_2O, CH_4, and CO_2 emission from the waste sectors that contain wastewater treatment plant, open burning of waste and compost in Turkey. They found the result 6,9362 Gg N_2O/year according to using IPCC methodology in 2016. Compared to the calculated value of 7.09 Gg N_2O/year for 2015, the difference was approximately 0.26 Gg N_2O/year. The little difference reasons were likely to be since the calculation methods are different and the calculated year is one year later. It can show the possible increased value for the year.

N_2O emissions calculations made for Turkey covers the whole country. In this study, the N_2O emission values of the cities are calculated in Turkey. Emission values were calculated separately for 81 provinces. These parameters were managed soils, manure management and waste sectors for direct emissions. In addition to that indirect N_2O emissions were estimated for 81 provinces. Sub-sectors of indirect emissions contains that manure management, managed soils and other indirect such as fuel combustion, industrial processes, burning of crop residues and agricultural waste for indirect emission.

When analysed studies calculation of N_2O emission for Turkey, generally the direct sources for emission estimation was used. In this study, the direct N_2O emissions were estimated, besides that the indirect emissions sources were calculated by both the IPCC equations and the deposition modelling results with the data provided by the EMEP-modelled air concentrations and depositions-.

When the calculated values of the emulsions for cities are examined, overall direct emission results of 2011 were examined, the first three of the highest emission provinces were Konya, Ankara and Şanlıurfa and their emissions were 5141, 3843 and 2476 tons/year, respectively (Figure 5.6).

As direct emissions from managed soils were analyzed, the top three highest emissions were the same provinces for the total emission results: Konya, Ankara and Şanlıurfa. Their results were 4621, 2956 and 2274 tons/year respectively.

Besides the other emission type, manure management results were examined, the provinces in the first three were slightly different from the other results. Konya Erzurum and Balıkesir had 388, 343 and 337 tons of N_2O emission, respectively.

When the results of waste-based emissions were examined, Istanbul was the city that has contributed the most emissions with 1967 tons/yr. The second highest emissions belonged to the province of Ankara which was 719 tons/yr. İzmir had 501 tons/year N_2O emission in 2011.

When overall the direct emission results were examined, the first three of the highest emission have had cities that were Konya, Ankara and Şanlıurfa and their values were 6420, 4271 and 3239 tons/year, respectively in 2015. The city rank based on emission results were the same as the 2011 data. The change of emissions rate between 2011 and 2015, there was a 25%, 11% and 16% emission has increased respectively in Konya, Ankara and Şanlıurfa in Figure 5.7.

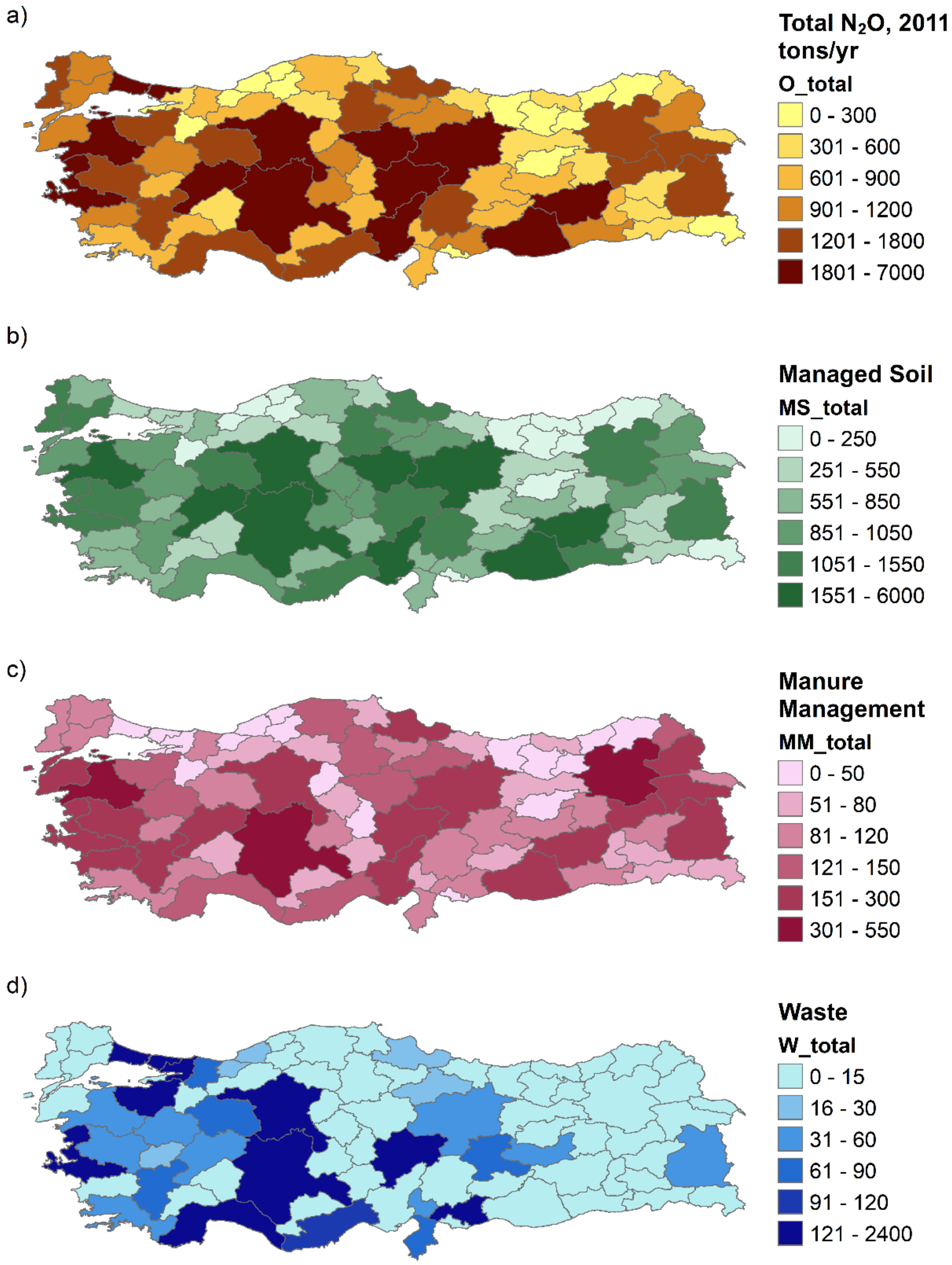

Figure 5.6 : a) Total direct N_2O emission b) Emission from managed soils c) Emission from manure management d) Emission from waste sector in Turkey tons/yr, 2011.

Direct emission from managed soils were analyzed the top three of the highest emission have had cities as in the same total emission results that were Konya, Ankara and Şanlıurfa respectively. Their results were 5860, 3338 and 3115 tons/year respectively. The change of emissions rate analyze between 2011 and 2015, there was a 26%, 12% and 36% emission has increased respectively in Konya, Ankara and Şanlıurfa.

When the other emission type, manure management results were examined, the cities in the first three were slightly different from the other results. Konya, Erzurum and İzmir had 532, 391 and 374 tons of N_2O emission, respectively. The city with the third highest emission was in İzmir in 2015. The rates of change emissions in Konya and Erzurum increased by 37% and 14% respectively.

When the results of waste-based emissions were examined, Istanbul was the city that has contributed the most emissions values was 2312 tons/yr. The second highest emission result belongs to the province of Ankara which was 776 tons/yr. İzmir had 620 tons/year N_2O emission in 2015. Emission increased rate in Istanbul, Ankara and İzmir between 2011 and 2015 were 17%, 7% and 24% respectively.

When overall indirect emissions results were examined, the first three of the highest emission have had cities that were Konya, Ankara and Erzurum and their values were 1531, 968 and 791 tons/year, respectively in 2011.

Indirect emissions from managed soils were analyzed the top three of the highest emission have had cities as in the same total emission results that were Konya, Ankara and Erzurum respectively. Their results were 1139, 723 and 349 tons/year respectively in Figure 5.8.

When the results of manure management indirect emissions were examined, Konya was the city that has contributed the most emissions values was 233 tons/yr. The second highest emission result belongs to the province of Erzurum which was 232 tons/yr. Balıkesir had 230 tons/year N_2O emission in 2011.

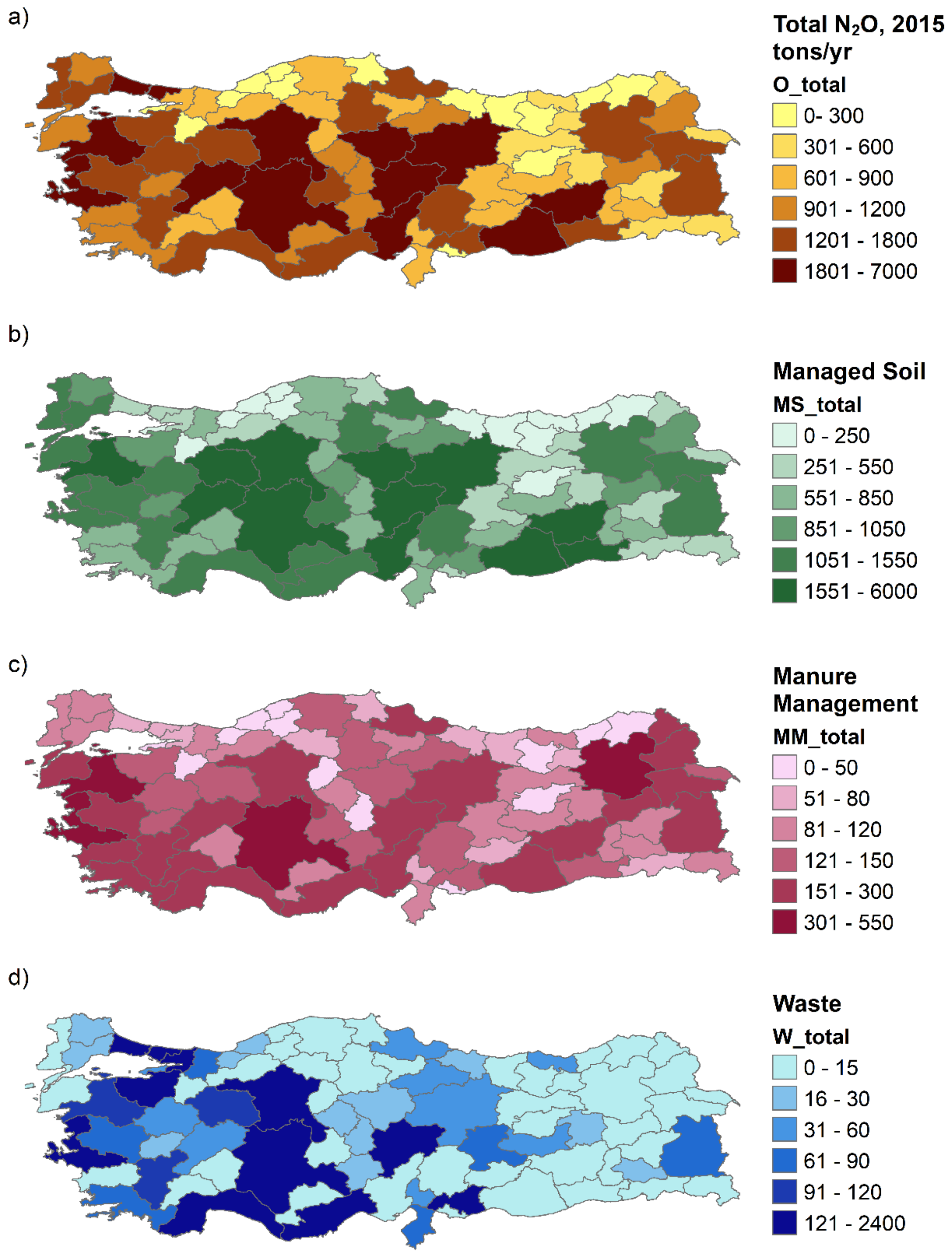

Figure 5.7 : a) Total direct N_2O emission b) Emission from managed soils c) Emission from manure management d) Emission from waste sector in Turkey tons/yr, 2015.

When the other indirect emission type results were examined, the cities in the first three were slightly different from the other results. Erzurum, Van and Konya had 210, 165 and 158 tons of N_2O emission, respectively.

When overall indirect emissions results were examined, the first three of the highest emission had cities that were Konya, Ankara and Erzurum and their values were 1614, 914 and 755 tons/year, respectively in 2015 in Figure 5.9. The city rank based on emissions results were differed the 2011 data. Analyzed at the rate of change of emissions between 2011 and 2015. There was a 5%, -5% and -4% emission has changed respectively in Konya, Ankara and Şanlıurfa.

Indirect emissions from managed soils were analyzed in the top three of the highest emission had cities as in the same total emission results that were Konya, Ankara and Şanlıurfa respectively. Their results were 1101, 628 and 594 tons/year respectively (Figure 5.9). The rates of change emissions in Konya, Ankara and Şanlıurfa have changed by -3% and -13% and 7% respectively.

When the results of manure management indirect emissions were examined, Konya was the city that have contributed the most emissions values was 323 tons/yr. The second highest emission result belongs to the province of Erzurum which was 257 tons/yr. Balıkesir had 249 tons/year N_2O emission in 2015. Emission increased rate in Konya, Erzurum and Balıkesir between 2011 and 2015 were 4%, 2% and 8% respectively.

When the other indirect emission type results were examined, the cities in the first three were slightly different from the other results. Erzurum, Van and Konya had 190, 189 and 146 tons of N_2O emission, respectively. The rate of change emissions analyzes between 2011 and 2015, there was a -9%, 14% and 7% emission have had discrepancy respectively in Konya, Ankara and Şanlıurfa.

It has been observed that there was the decrease in indirect emissions when the variation was calculated. On the other hand, there were increasing parameters such as manure management.

According to the process and results, the total emission was observed to be about the same amount when the emission results of 5 years were examined. Direct and indirect emission results were shown an increase or decrease in parallel with each other. City of Konya, Ankara ve Erzurum have more producing the emissions.

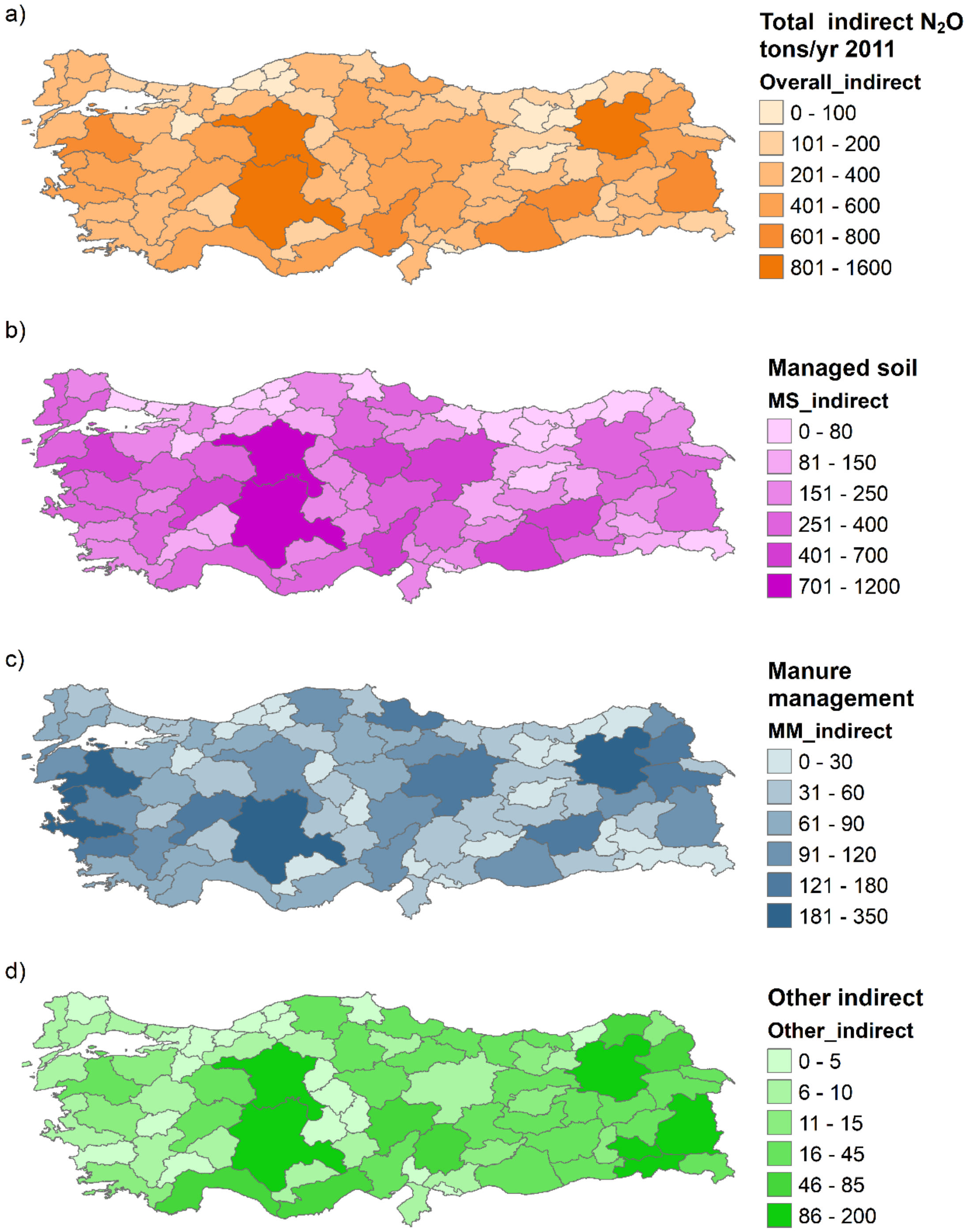

Figure 5.8 : a)Total indirect N_2O emission b) Indirect emission from managed soils c) Indirect emission from manure management d) Indirect emission from other indirect resources in Turkey tons/yr, 2011.

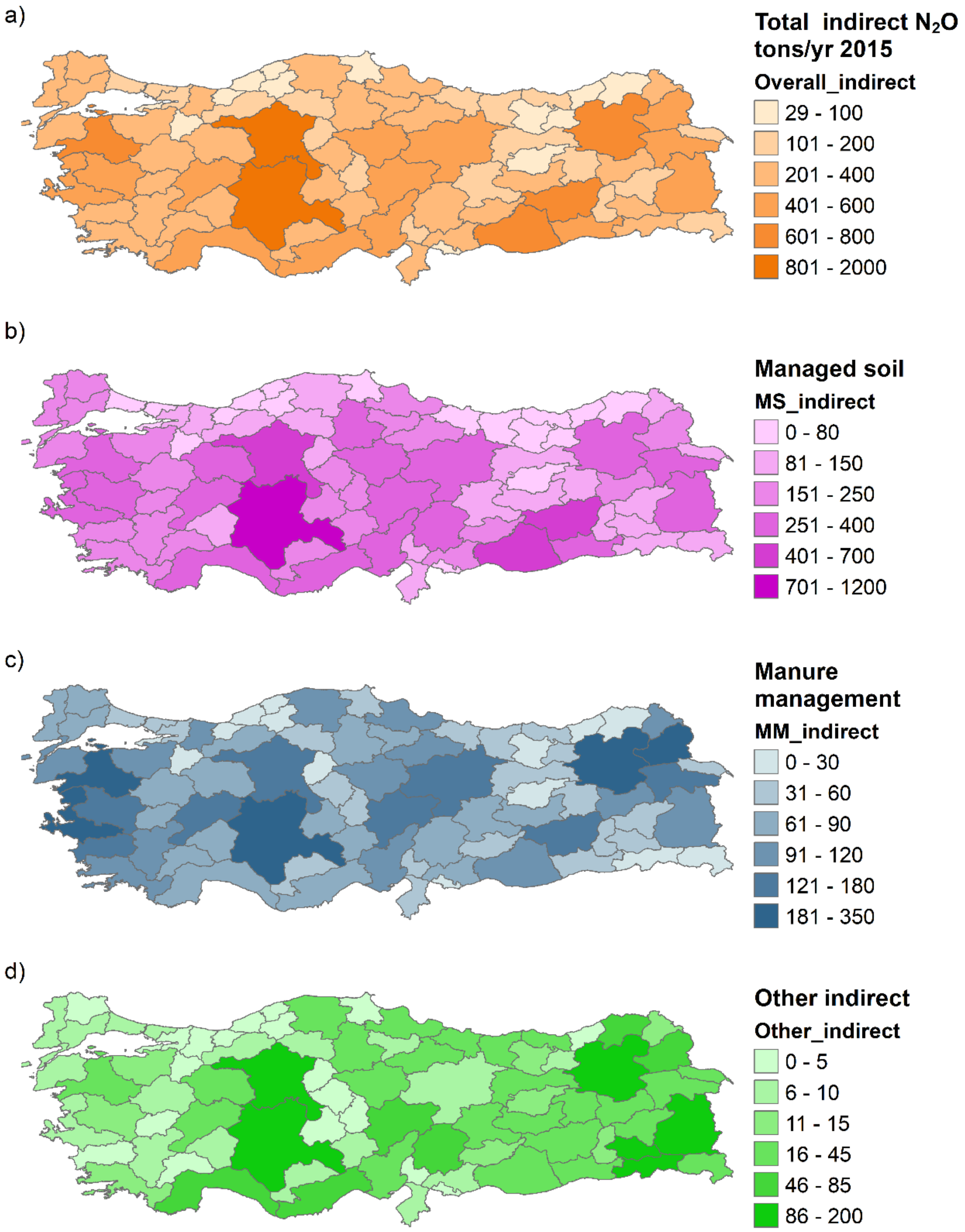

Figure 5.9 : a)Total indirect N_2O emission b) Indirect emission from managed soils c) Indirect emission from manure management d) Indirect emission from other indirect resources in Turkey tons/yr, 2015.

5.2 Uncertainty Analysis

The results of the uncertainty analysis made according to various rules were given below. Uncertainty analysis was calculated by direct N_2O emissions from managed soils, manure management and waste sector. Input parameters were shown in the Appendix A. Total N_2O emission was shown the empirical distribution of the estimate calculated in Turkey in 2015. The distribution was skewed because the emission factors for N_2O emissions are skewed (Figure 5.10). X-axes was implied frequency of emissions. Y axes were implied the amount of emission and their unit was in billion. The %95 confidence interval was used for analyzing. Overall N_2O emission of probability distribution function of 50000 iteration results was given in the graph.

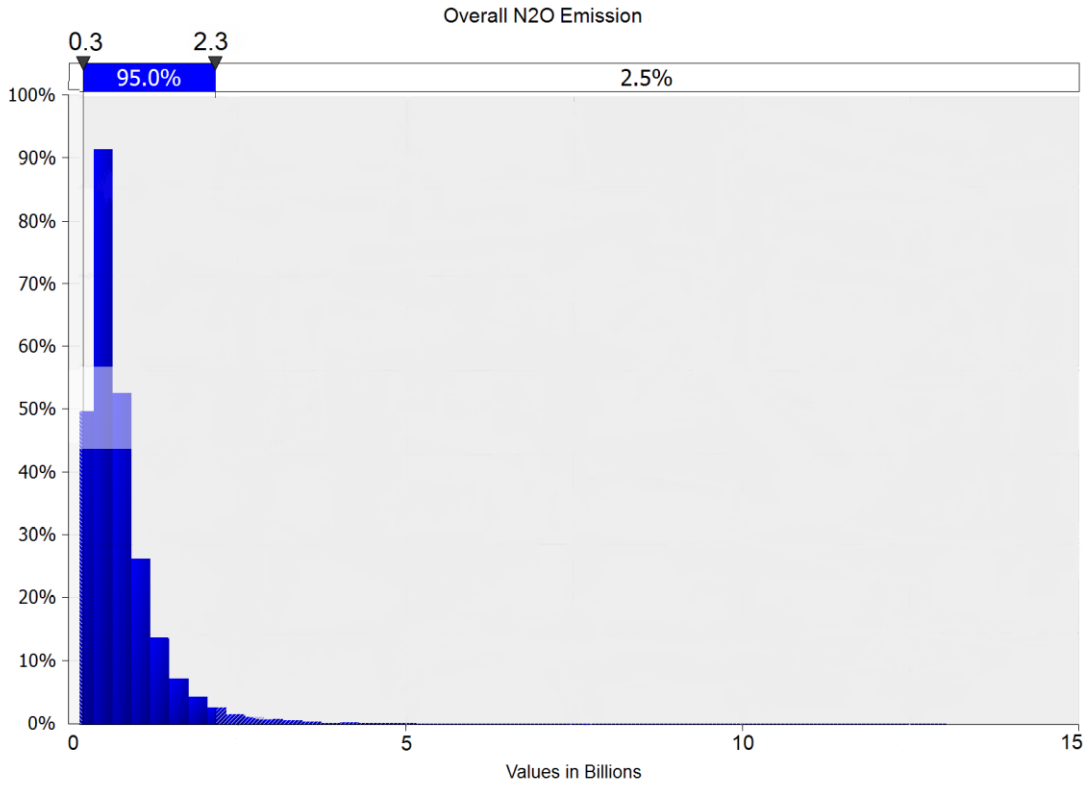

Figure 5.10 : Probability distribution functions of overall N_2O emissions.

Table 5.5 was showing the summary of the estimated direct N_2O emissions for managed soil, manure management, waste and total emission, with the uncertainty expressed as a 95% confidence interval. Total emission mean was 98.04 Gg N_2O/yr with 95% confidence interval of 31.40 to 230.39. Emission from managed soil was 85.39 Gg N_2O/yr with 95% confidence interval of 20.81 to 216.49. Emission from manure management was 14.38 Gg N_2O/yr with 95% confidence interval of 3.62 to 35.78. Emission from the waste sector was 7.29 Gg N_2O/yr with 95% confidence interval of 2.01 to 15.75. Output parameters results were shown in Appendix B.

Table 5.5 : Uncertainty analysis result of managed soils and its subcategory.

Source	Mean Estimates (Gg N_2O/yr)	Confidence Intervals (%5-%95)	
Managed Soil	85.39	20.81	216.49
Manure Management	14.38	3.62	35.78
Waste	7.29	2.01	15.75
Total Emission	98.04	31.40	230.39

The emissions of N_2O and CH_4 uncertainty and sensitivity analysis in the UK were calculated using Monte Carlo analysis and the @RISK program. IPCC Tier 2 methodology was used for methane emission from manure management and IPCC Tier 1 was used other emission calculations (Milne et al., 2014).

Estimated direct and indirect N_2O emissions for England, Wales, Scotland and Northern Ireland, with the uncertainty expressed as a 95% confidence interval. When looking at their results, N_2O emissions from agriculture in the United Kingdom between 1990 and 2010, emissions reduced from 34.7 N_2O emissions/Tg CO_2-eq year^{-1} (mean), with 95% confidence interval (range 15.14 and 84.32) to 28.1 Tg CO_2-eq year^{-1}, (mean) with 95% confidence interval (12.3, 67.3). In 2010, Direct emission result from agriculture mean value was 54.00 (Gg N_2O/yr). The uncertainty range value was between -55% and 113% with 95% confidence interval. The distribution was skewed because the emission factors for N_2O emissions were skewed (Milne et al., 2014). Output parameters were shown in Table B.1.

Estimated direct N_2O emission from Netherland was calculated 60.35 Gg N_2O /yr. The uncertainty range value was between -61% and 70% with 95% confidence interval. @RISK programme and MC methodology were used in this paper as our study. (Ramírez et al., 2008).

Another study in Finland that were N_2O from agricultural soils represents over 60% of CO_2-equivalent agricultural CH_4 and N_2O emissions, corresponding to 3.3 Tg CO_2 equivalents. The uncertainty range for this emission source was significant (1.6 to 5.6) (Monni et al., 2007). N_2O emission was calculated that mean value was10.65 (Gg N_2O/yr) and their 95% confidence interval value was -52% and 70%. Finland, Netherland, the UK, and compared the results of the study was given in Table 5.6.

Table 5.6 : Uncertainty analysis results comparison for country.

Source	Mean (Gg N_2O/yr)	Confidance Interval (%5-%95)		Uncertainty
Our Study (2015)	98.04	31.40	230.39	(-68%, 135%)
United Kingdom (2010)[1]	54.50	24.25	116.16	(-55%, 113%)
Finland (2007)	10.65	5.16	18.06	(-52%, 70%)
Netherland (2004)[2]	60.35	18.35	102.35	(-61%, 70%)

[1] In order to be able to make a comparison with the study, the UK data has been converted to Gg N_2O/year in 2010.

[2] In order to be able to make a comparison with the study, the Netherland data has been converted to Gg N_2O/year in 2004.

When the emission uncertainty ranges compared, it was the value ranges are abundant in our study. 95% confidence interval for the estimate of total N_2O emissions was (-68%, 135%). United Kingdom confidence interval, which is based on paper, was (-55%, 113%), Netherland was (-61%, 70%) whereas Finland is (-52%, 70%).

In the Finnish study, both the IPCC default value for emission factor and their own emission factors used. The UK has used the same IPCC Tier 1 default emission factor like in this study. It is understood that the uncertainty rate is higher for studies using the default emission factors. At the same time, variability of input parameters, correct data, used program data, etc. are lead to more different results.

The high uncertainties can be due to default emission factor values, lack of data or data errors, lack of completeness, program structure, model structure, lack of representativeness of the data.

Sensitivity analysis has been done to find out how much impact of the input results resides in emission estimates. @RISK enables us to work with Excel and the programme creates tornado graphs and spider charts as a tool to help in making more informed decisions. The approach used here is Sperman Rank correlation. Generally, two type of correlations used Pearson correlations and Sperman Rank correlations. Pearson assume linear distributions, but the vast majority of distributions are non-linear, and Spearman is usually more appropriate for non-linear distributions. The Spearman correlation coefficient based on the ranked values for each variable rather than the raw data. Spearman's correlation coefficient, measures the strength and direction of association between two ranked variables. The sensitivity analysis performed had the results shown below in Figure 5.11.

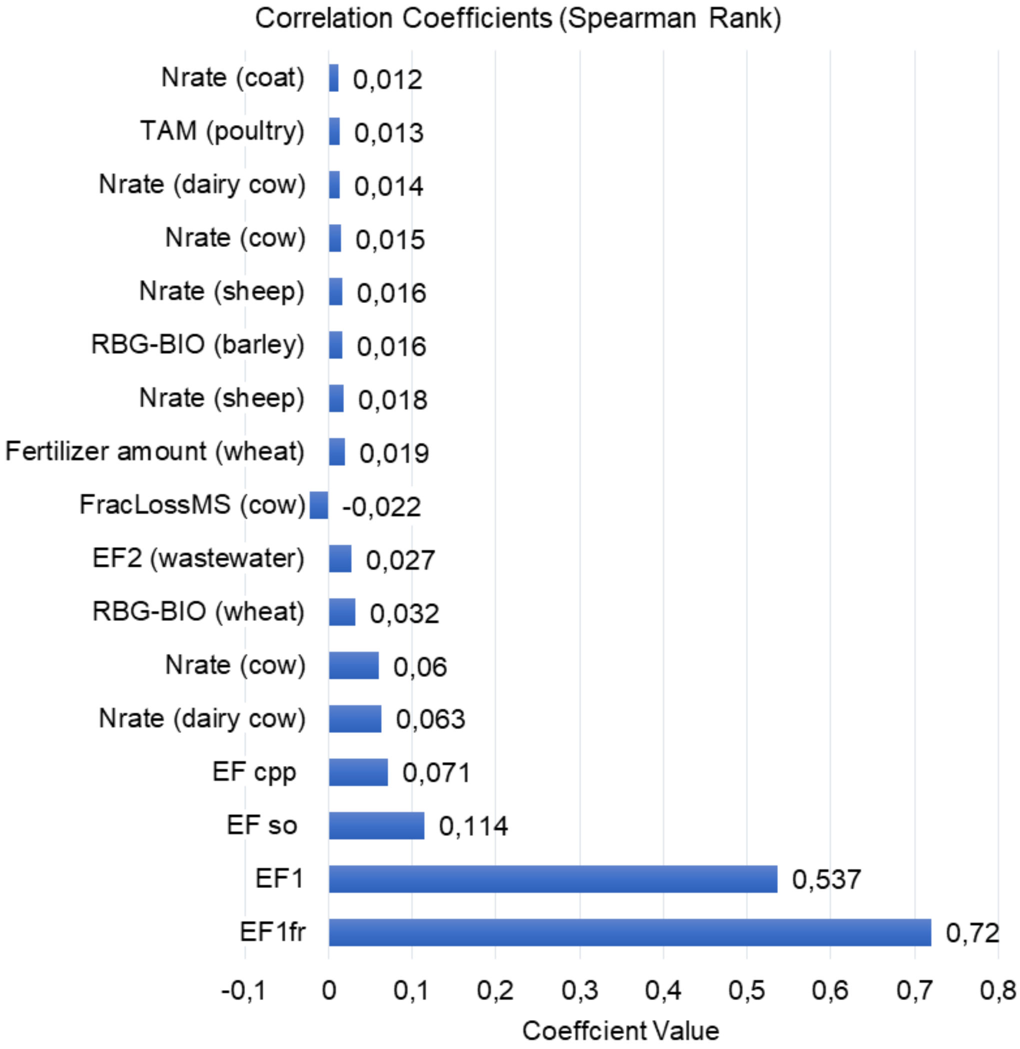

Figure 5.11 : Result of sensitivity analysis for N_2O emissions.

The inputs that most affected the uncertainty in N_2O emissions or the parameters most influence the calculations are listed above (Figure 5.11). According to the Spearman rank correlation coefficient, emission factors are influencing the calculations the most, especially EF1 the emission factor for N_2O emissions from N inputs and EF1fr the emission factor for N_2O emissions from N inputs to flooded rice. These correlation values are 0.72 and 0.537 respectively. The other emission factors have an impact on results that are EFcpp and EFso defined as emission from the animal type of cattle, poultry and pigs and Emission from the animal type of sheep and other animals. The other effective parameter is Nrate nitrogen excretion per 1000 kg of animal per day, which varies according to animal type. The dairy cow, cow and sheep are the most effective animal type on the result. The ratio of belowground residues to above-ground biomass parameter are used for the amount of N in crop residues (above-ground and below-ground), including N-fixing crops, returned to soils annually. Their uncertainty range ratios are too high so these parameters especially wheat and barley data have an impact on the result.

When the sensitivity analysis in the study for the United Kingdom investigated, the five inputs that most affect the uncertainty in N_2O emissions and 2010 these are the emission factor for emissions from the direct application of nitrogen fertilizer, the emission factor for nitrogen leaching and runoff, the fraction of nitrogen lost to leaching, the emission factor for animal waste management for pasture, range of paddock and the emission factor for nitrogen deposition. The emission factor EF1 has the largest impact on the uncertainty of N_2O emissions in England. The next most influential inputs were on nitrogen excretion of cows and sheep. Sensitivity analysis was performed for all parameters that they calculated.

When the sensitivity analysis of the UK and our study are compared, that is almost the same results are obtained. Emission factor and animal nitrogen excretion are the most influencing parameters.As can be understood from the above-mentioned, the most effective parameters are the emission factors.

6. CONCLUSIONS AND RECOMMENDATIONS

N_2O emissions are calculated between 2011 and 2015 in Turkey. Emission sources were selected according to IPCC methodology.They are defined as managed soils and waste sector. Three section divides managed soils these are agriculture, manure management and burning of crop residue. Waste sectors are comprised of includes the open burning of waste, wastewater treatment plant and compost. Furthermore, their uncertainties are estimated through Monte Carlo simulation.

When calculating of emissions results do not include from Land Use, Land Use Change and Forestry and industrial sectors. Data of Land Use, Land Use Change and Forestry based on soil type especially histosol. IPCC methodology contains histosol defined as organic carbon that is so high level in the soils. When examined soil types in Turkey Histosols soil type was not found therefore the parameter could not convenient for Turkey.

Although the carbon emissions from the industrial sector are very high, the contribution to nitrous oxide source is low according to TURKSTAT. Industrial processes and product use was generated 4.25% of N_2O emission sources, besides that agriculture has 78.43% and waste sector has 6.13% in 2015. Thus, considering the low contribution and intense activity data requirement, the N_2O emissions from the industrial process was not calculated in this study.

@ RISK program was used in calculating the emission uncertainty, but the use of this software in estimating emissions uncertainty is not frequent and software may not be entirely suitable for calculating emission uncertainty. However, the applications and methods provided by the software for the user are easy to calculate. Specific emission uncertainty programs may be developed for this purpose.

Uncertainty results found in our study is higher than in other studies. The fact that the precision of the data and the emission factor values are the parameters which have the most excellent effect on the uncertainty results. For this reason, countries will develop their activity data and emission factors and this will contribute to the reduction of uncertainty in their national inventories.

The default emission factor may not always be representative for the study region. For instance, some conditions are significant for determining emission factors such as local practices applied, agricultural characteristics and the agricultural product variety in the agricultural sector. When calculating the N_2O emissions, default emission factors may not be representative for Turkey entirely. Specific emission factors of agriculture sector for Turkey should give more accurate results. The accuracy of the input data is mostly dependent on the TURKSTAT data. The ability to compare source data can enable us to more reliable results.

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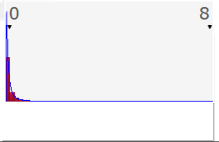
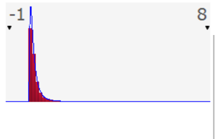
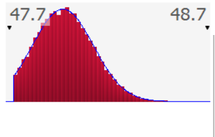
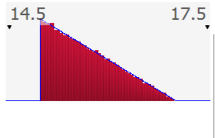
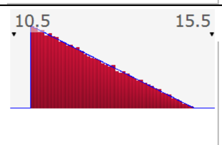
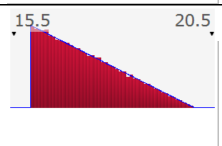
APPENDICES

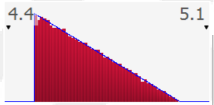
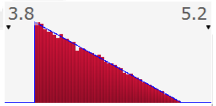
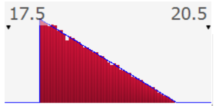
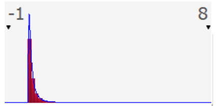
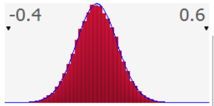
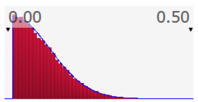
APPENDIX A: Input parameters for @RISK programme.

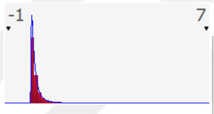
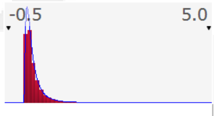
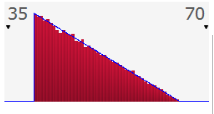
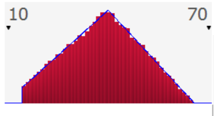
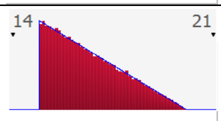
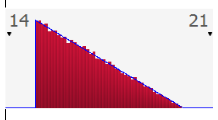
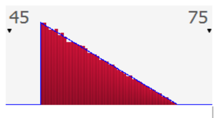
APPENDIX B: Output parameters for @RISK programme.

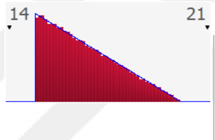
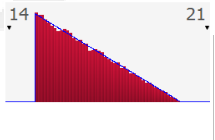
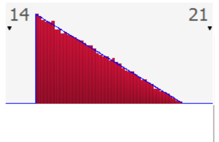
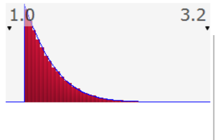
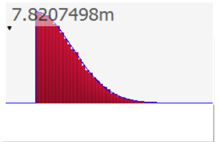
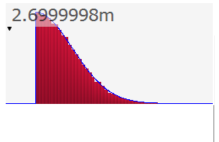
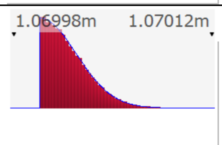
APPENDIX A: Input parameters for @RISK programme.

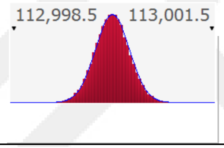
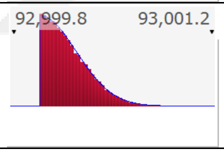
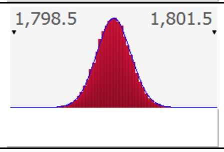
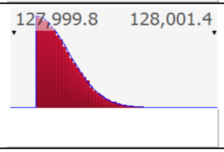
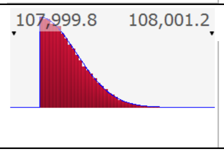
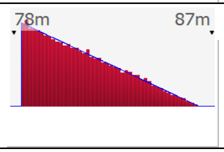
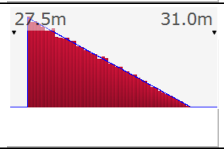
Table A.1 : Input parameters for @RISK programme.

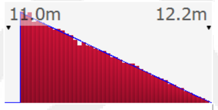
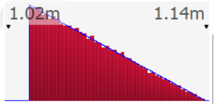
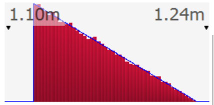
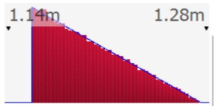
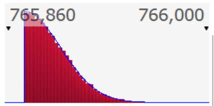
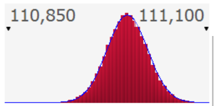
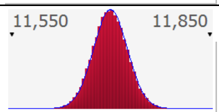
Name	Cell	Graph	Min	Mean	Max	5%	95%
EF1	C125		0,010	0,156	7,838	0,016	0,531
EF1fr	C126		0,007	0,250	7,165	0,045	0,697
avarage accesible population to ww / Uncertain Inputs	BR4		47,73792	47,99667	48,63245	47,7884	48,23056
Amount of fertilizer used per decare for wheat (ton/da) / Uncertain Inputs	D3		15,00002	15,66641	16,98697	15,05066	16,55344
Amount of fertilizer used per decare for barley (ton/da) / Uncertain Inputs	D6		11,000	12,334	14,978	11,102	14,108
Amount of fertilizer used per decare for mazie (ton/da) / Uncertain Inputs	D9		16,000	17,331	19,988	16,102	19,101

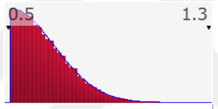
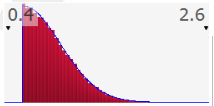
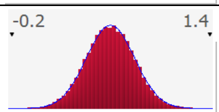
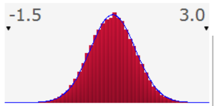
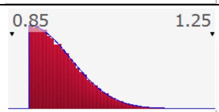
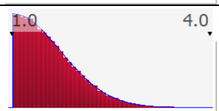
Name	Cell	Graph	Min	Mean	Max	5%	95%
Amount of fertilizer used per decare for rye (ton/da) / Uncertain Inputs	D12		4,5000	4,6676	4,9968	4,5129	4,8882
Amount of fertilizer used per decare for oats (ton/da) / Uncertain Inputs	D15		4,000	4,334	4,994	4,025	4,777
Amount of fertilizer used per decare for rice (ton/da) / Uncertain Inputs	D18		18,000	18,664	19,989	18,050	19,550
EF cpp	C130		0,002	0,202	5,633	0,025	0,628
EF so	C131		0,002	0,200	7,421	0,025	0,619
EF1 waste (kg N_2O/person.year) / Uncertain Inputs	BR7		-0,3677985	0,05096435	0,5241011	-0,1149605	0,2155232
EF2 (kg N_2O-N/kg sewage-Nproduce) / Uncertain Inputs	BR8		0,02000245	0,09983455	0,4596017	0,02620059	0,2169444

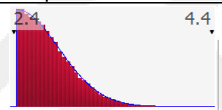
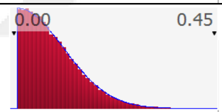
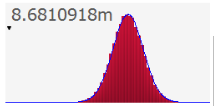
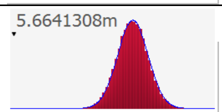
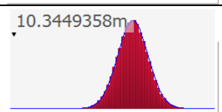
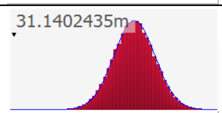
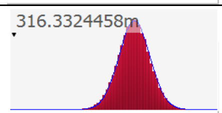
Name	Cell	Graph	Min	Mean	Max	5%	95%
EF3 (other) / Fprp total Kg N/yr)	C134		0,003	0,199	6,726	0,025	0,615
EF3 (poultry) / Fprp total Kg N/yr)	C135		0,006	0,250	4,853	0,045	0,691
FracLossMS cow/ Next (kg N/yr)	Z9		40,00038	48,35672	64,94304	40,65117	59,43143
FracLossMS goat/ Next (kg N/yr)	Z26		15,00114	38,80038	64,83283	20,31418	56,80959
FracLossMS sheep/ Next (kg N/yr)	Z34		15	16,6658	19,99459	15,12983	18,89594
FracLossMS poultry/ Next (kg N/yr)	Z42		15,00003	16,66142	19,96046	15,12727	18,86677
FracLossMS swine/ Next (kg N/yr)	Z50		50,00023	56,65321	69,97476	50,5075	65,53497

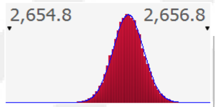
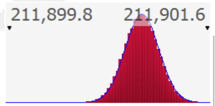
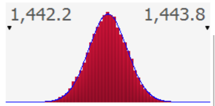
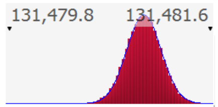
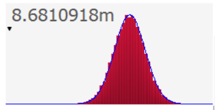
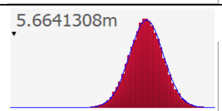
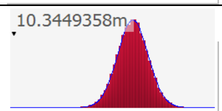
Name	Cell	Graph	Min	Mean	Max	5%	95%
FracLossMS asses and mules/ Next (kg N/yr)	Z58		15,00003	16,66897	19,9962	15,13113	18,90689
FracLossMS camel/ Next (kg N/yr)	Z66		15,00003	16,66045	19,98736	15,12436	18,8838
FracLossMS horse/ Next (kg N/yr)	Z74		15,00005	16,66631	19,98864	15,12511	18,87308
EF compost gN_2O/yr (dry basis) / Uncertain Inputs	BR11		1,200016	1,450452	3,170313	1,214671	1,897532
harvested area (ha) wheat/ Uncertain Inputs	O4		7.820.750	7.820.750	7.820.751	7.820.750	7.820.751
harvested area (ha) barley/ RAG (ration of above-ground residue for crop kg N/kg d.m.)	O18		2.700.000	2.700.000	2.700.001	2.700.000	2.700.001
harvested area (ha) maize/ RAG (ration of above-ground residue for crop kg N/kg d.m.)	O32		1.070.000	1.070.020	1.070.103	1.070.002	1.070.049

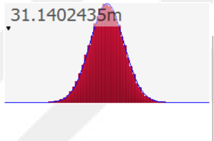
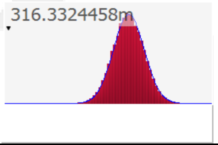
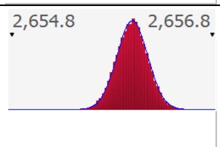
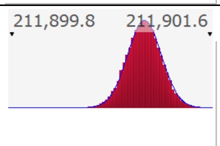
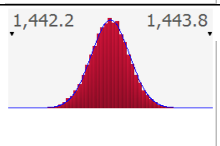
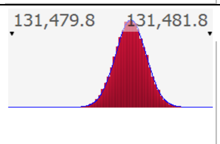
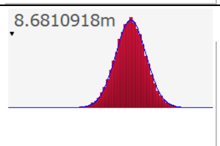
Name	Cell	Graph	Min	Mean	Max	5%	95%
harvested area (ha) rye/ RAG (ration of above-ground residue for crop kg N/kg d.m.)	O46		112.999	113.000	113.001	113.000	113.000
harvested area (ha) oats/ RAG (ration of above-ground residue for crop kg N/kg d.m.)	O60		93.000	93.000	93.001	93.000	93.000
harvested area (ha) sorghum/ RAG (ration of above-ground residue for crop kg N/kg d.m.)	O74		1.799	1.800	1.801	1.800	1.800
harvested area (ha) patato/ RAG (ration of above-ground residue for crop kg N/kg d.m.)	O88		128.000	128.000	128.001	128.000	128.001
harvested area (ha) rice/ RAG (ration of above-ground residue for crop kg N/kg d.m.)	O102		108.000	108.000	108.001	108.000	108.001
harvested area (da) wheat/ Uncertain Inputs	D4		78.464.880	81.089.470	86.271.980	78.660.500	84.548.900
harvested area (da) barley/ Uncertain Inputs	D7		27.780.690	28.709.040	30.548.840	27.850.010	29.930.040

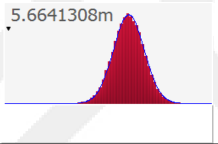
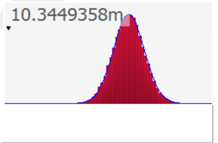
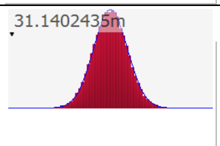
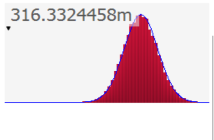
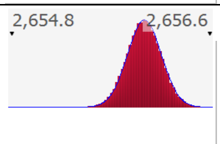
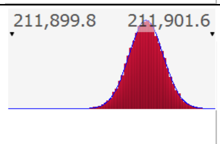
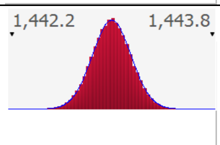
Name	Cell	Graph	Min	Mean	Max	5%	95%
harvested area (da) maize/ Uncertain Inputs	D10		11.086.910	11.456.440	12.187.910	11.114.760	11.947.060
harvested area (da) rye/ Uncertain Inputs	D13		1.034.486	1.068.863	1.137.420	1.037.155	1.114.601
harvested area (da) oats/ Uncertain Inputs	D16		1.119.689	1.157.006	1.231.323	1.122.539	1.206.656
harvested area (da) rice/ Uncertain Inputs	D19		1.158.562	1.197.221	1.273.842	1.161.508	1.248.770
harvested area (ha) %10 wheat/ Uncertain Inputs	AV3		765.873	765.893	765.982	765.875	765.922
harvested area (ha) %10 maize/ Uncertain Inputs	AV6		110.886	111.000	111.099	110.959	111.041
harvested area (ha) %10 rice/ Uncertain Inputs	AV9		11.599	11.700	11.812	11.659	11.741

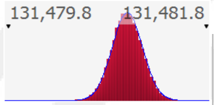
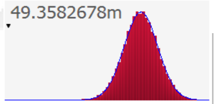
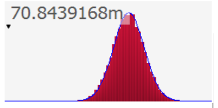
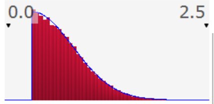
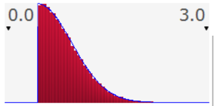
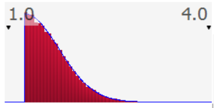
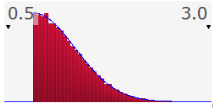
Name	Cell	Graph	Min	Mean	Max	5%	95%
Intercept / Crop wheat(kg dry matter/ha)	O9		0,5200021	0,6555687	1,225551	0,530827	0,8534859
Intercept / Crop barley (kg dry matter/ha)	O23		0,5900019	0,9188886	2,399173	0,6153356	1,397628
Intercept / Crop maize (kg dry matter/ha)	O37		-0,181934	0,5999938	1,346361	0,2879694	0,9125223
Intercept / Crop rye (kg dry matter/ha)	O51		-1,20	0,88	2,79	0,06	1,69
Intercept / Crop oats (kg dry matter/ha)	O65		0,890001	0,9537311	1,212932	0,8949539	1,046117
Intercept / Crop sorghum (kg dry matter/ha)	O79		1,330004	1,545602	2,428801	1,347631	1,860912
Intercept / Crop patato (kg dry matter/ha)	O93		1,060009	1,619972	3,945505	1,104464	2,431426

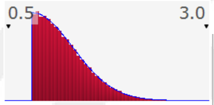
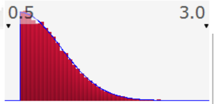
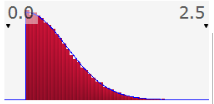
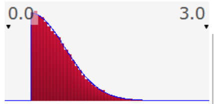
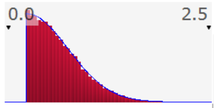
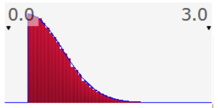
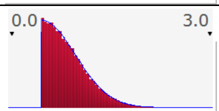
Name	Cell	Graph	Min	Mean	Max	5%	95%
Intercept / Crop rice (kg dry matter/ha)	O107		2,460013	2,786319	4,323441	2,485274	3,261637
EF open burning area kgN_2O/yr / Uncertain Inputs	BR17		0,01500025	0,09448691	0,4206099	0,0212565	0,2107084
Cow-number of head (kg N/yr) / Uncertain Inputs	Z4		8.681.092	8.681.093	8.681.094	8.681.093	8.681.093
Dairy cow-number of head (kg N/yr) / Next (kg N/yr)	Z13		5.664.132	5.664.132	5.664.133	5.664.132	5.664.132
goat-number of head (kg N/yr) / Next (kg N/yr)	Z21		10.344.940	10.344.940	10.344.940	10.344.940	10.344.940
sheep-number of head (kg N/yr) / Next (kg N/yr)	Z29		31.140.240	31.140.250	31.140.250	31.140.240	31.140.250
poultry-number of head (kg N/yr) / Next (kg N/yr)	Z37		316332400	316332400	316332400	316332400	316332400

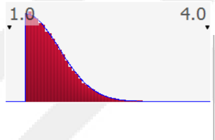
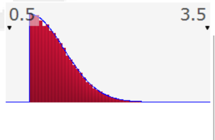
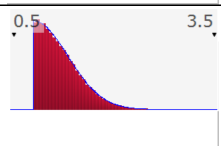
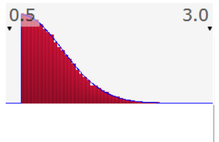
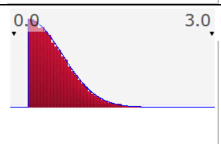
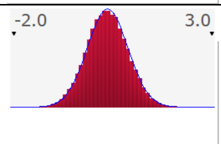
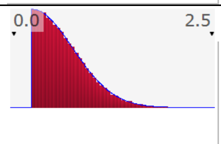
Name	Cell	Graph	Min	Mean	Max	5%	95%
swine-number of head (kg N/yr) / Next (kg N/yr)	Z45		2.655	2.656	2.657	2.656	2.656
asses and mules-number of head (kg N/yr) / Next (kg N/yr)	Z53		211.900	211.901	211.902	211.901	211.901
camel-number of head (kg N/yr) / Next (kg N/yr)	Z61		1.442	1.443	1.444	1.443	1.443
horses-number of head (kg N/yr) / Next (kg N/yr)	Z69		131.480	131.481	131.482	131.481	131.481
cow-number of head (kg N/yr) / Uncertain Inputs	AK4		8.681.092	8.681.093	8.681.094	8.681.093	8.681.093
dairy cow-number of head (kg N/yr) / Next (kg N/yr)	AK10		5.664.132	5.664.132	5.664.133	5.664.132	5.664.132
goat-number of head (kg N/yr) / Next (kg N/yr)	AK16		10.344.940	10.344.940	10.344.940	10.344.940	10.344.940

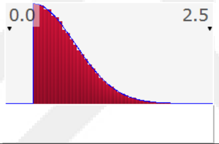
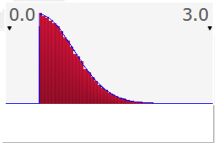
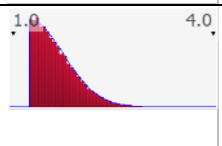
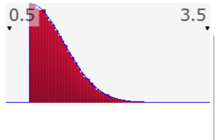
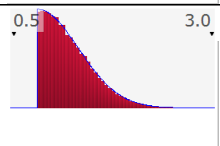
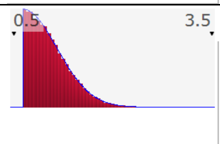
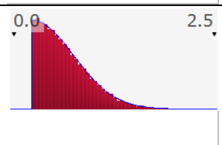
Name	Cell	Graph	Min	Mean	Max	5%	95%
sheep-number of head (kg N/yr) / Next (kg N/yr)	AK22		31.140.240	31.140.250	31.140.250	31.140.240	31.140.250
kümes-number of head (kg N/yr) / Next (kg N/yr)	AK28		316332400	316332400	316332400	316332400	316332400
swine-number of head (kg N/yr) / Next (kg N/yr)	AK34		2.655	2.656	2.657	2.656	2.656
Asses and mules-number of head (kg N/yr) / Next (kg N/yr)	AK40		211.900	211.901	211.902	211.901	211.901
camel-number of head (kg N/yr) / Next (kg N/yr)	AK46		1.442	1.443	1.444	1.443	1.443
horse-number of head (kg N/yr) / Next (kg N/yr)	AK52		131.480	131.481	131.482	131.481	131.481
cow-number of head (kg N/yr) / Uncertain Inputs	BG4		8.681.092	8.681.093	8.681.094	8.681.093	8.681.093

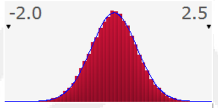
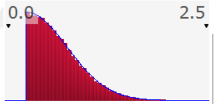
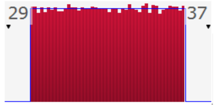
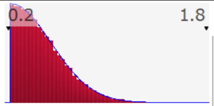
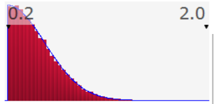
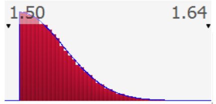
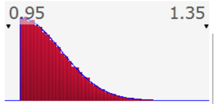
Name	Cell	Graph	Min	Mean	Max	5%	95%
Dairy cow-number of head (kg N/yr) / Next (kg N/yr)	BG10		5.664.132	5.664.132	5.664.133	5.664.132	5.664.132
goat-number of head (kg N/yr) / Next (kg N/yr)	BG16		10.344.940	10.344.940	10.344.940	10.344.940	10.344.940
sheep-number of head (kg N/yr) / Next (kg N/yr)	BG22		31.140.240	31.140.250	31.140.250	31.140.240	31.140.250
poulrty-number of head (kg N/yr) / Next (kg N/yr)	BG28		316332400	316332400	316332400	316332400	316332400
swine-number of head (kg N/yr) / Next (kg N/yr)	BG34		2.655	2.656	2.657	2.656	2.656
Asses and mules-number of head (kg N/yr) / Next (kg N/yr)	BG40		211.900	211.901	211.902	211.901	211.901
camel-number of head (kg N/yr) / Next (kg N/yr)	BG46		1.442	1.443	1.444	1.443	1.443

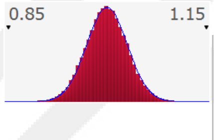
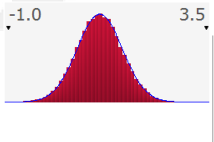
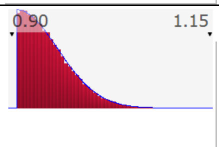
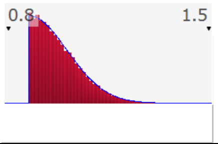
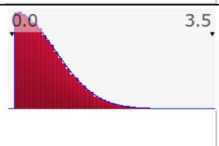
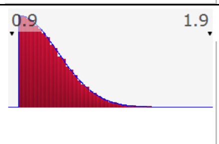
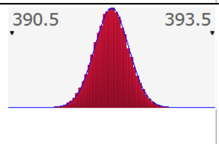
Name	Cell	Graph	Min	Mean	Max	5%	95%
horse-number of head (kg N/yr) / Next (kg N/yr)	BG52		131.480	131.481	131.482	131.481	131.481
N-person (wastewater) / Uncertain Inputs	BR3		49.358.270	49.358.270	49.358.270	49.358.270	49.358.270
N-person (open burning area) / Uncertain Inputs	BR13		70.843.920	70.843.920	70.843.920	70.843.920	70.843.920
Nrate cow (kg N/day) / Uncertain Inputs	Z6		0,3300023	0,7301487	2,423584	0,3597288	1,309822
Nrate dairy cow(kg N/day) / Next (kg N/yr)	Z15		0,4800069	0,8790612	2,550264	0,5114823	1,460252
Nrate goats(kg N/day) / Next (kg N/yr)	Z23		1,280009	1,678571	3,581779	1,311698	2,262629
Nrate sheep(kg N/day) / Next (kg N/yr)	Z31		0,8500158	1,250435	2,93229	0,8813082	1,832191

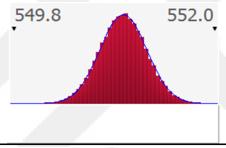
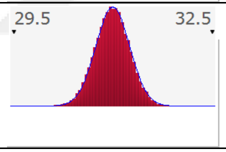
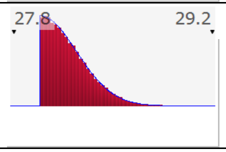
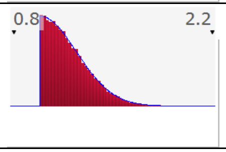
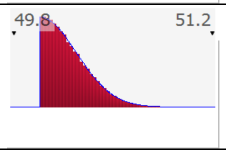
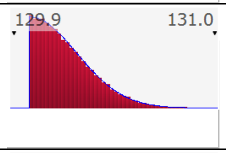
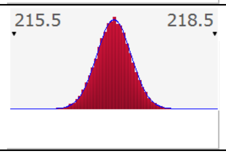
Name	Cell	Graph	Min	Mean	Max	5%	95%
Nrate poultry(kg N/day) / Next (kg N/yr)	Z39		0,8300024	1,229779	2,942817	0,8621112	1,814305
Nrate swine(kg N/day) / Next (kg N/yr)	Z47		0,6800208	1,076545	2,965301	0,7112619	1,651317
Nrate asses and mules (kg N/day) / Next (kg N/yr)	Z55		0,2600198	0,6575974	2,330108	0,2903852	1,242174
Nrate camel(kg N/day) / Next (kg N/yr)	Z63		0,3800144	0,7779577	2,674666	0,4115556	1,367042
Nrate horse(kg N/day) / Next (kg N/yr)	Z71		0,2600853	0,6584654	2,303926	0,2901179	1,241951
Nrate cow (kg N/day) / Uncertain Inputs	AK6		0,3300009	0,7273081	2,75847	0,3607211	1,311086
Nrate dairy cow(kg N/day) / Next (kg N/yr)	AK12		0,48001	0,8786636	2,530986	0,5108368	1,460056

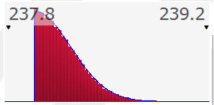
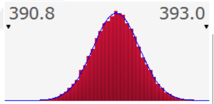
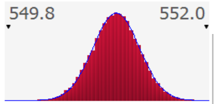
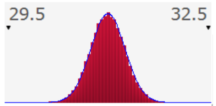
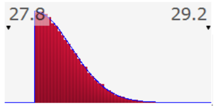
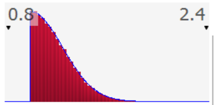
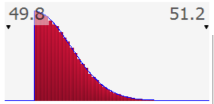
Name	Cell	Graph	Min	Mean	Max	5%	95%
Nrate goats(kg N/day) / Next (kg N/yr)	AK18		1,280005	1,678076	3,557611	1,311567	2,262762
Nrate sheep(kg N/day) / Next (kg N/yr)	AK24		0,8500078	1,249508	3,096508	0,8812879	1,830141
Nrate poultry(kg N/day) / Next (kg N/yr)	AK30		0,8300204	1,228942	3,032919	0,86256	1,809331
Nrate swine(kg N/day) / Next (kg N/yr)	AK36		0,6800478	1,077511	2,722866	0,7108431	1,662076
Nrate asses and mules (kg N/day) / Next (kg N/yr)	AK42		0,2600119	0,6576372	2,528026	0,2904981	1,238297
Nrate camel(kg N/day) / Next (kg N/yr)	AK48		-1,664245	0,3766135	2,771105	-0,4490263	1,204803
Nrate horse(kg N/day) / Next (kg N/yr)	AK54		0,2600012	0,6588921	2,295084	0,2918645	1,2371

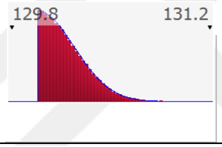
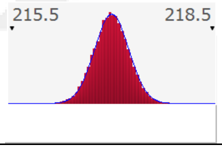
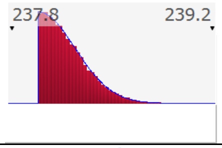
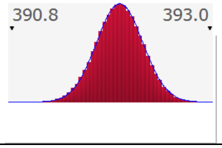
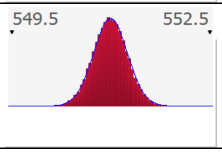
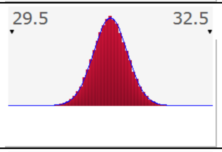
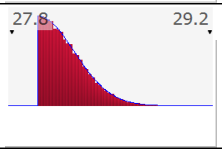
Name	Cell	Graph	Min	Mean	Max	5%	95%
Nrate cow (kg N/day) / Uncertain Inputs	BG6		0,330027	0,7292495	2,376004	0,3610173	1,310655
Nrate dairy cow(kg N/day) / Next (kg N/yr)	BG12		0,4800208	0,8807343	2,802082	0,5104832	1,470634
Nrate goats(kg N/day) / Next (kg N/yr)	BG18		1,280019	1,677645	3,585506	1,311622	2,261724
Nrate sheep(kg N/day) / Next (kg N/yr)	BG24		0,8500034	1,250631	3,00449	0,8811623	1,828965
Nrate poultry(kg N/day) / Next (kg N/yr)	BG30		0,8300002	1,229742	2,839309	0,8626401	1,811496
Nrate swine(kg N/day) / Next (kg N/yr)	BG36		0,6800041	1,081538	3,079086	0,7114445	1,658909
Nrate asses and mules (kg N/day) / Next (kg N/yr)	BG42		0,2600071	0,655982	2,42001	0,2911076	1,225958

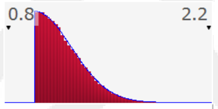
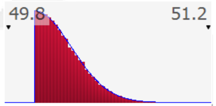
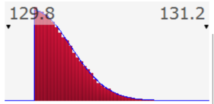
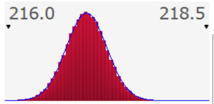
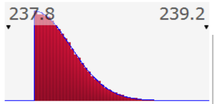
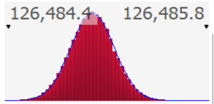
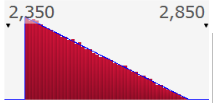
Name	Cell	Graph	Min	Mean	Max	5%	95%
Nrate camel(kg N/day) / Next (kg N/yr)	BG48		-1,575656	0,3796035	2,350192	-0,4423851	1,200288
Nrate horse(kg N/day) / Next (kg N/yr)	BG54		0,2600057	0,659116	2,395457	0,2917565	1,241141
protein (kg/person/yr) / Uncertain Inputs	BR5		30,00007	33,0057	35,99987	30,2966	35,6988
RBG-BIO wheat/ RAG (ration of above-ground residue for crop kg N/kg d.m.)	O12		0,2400004	0,4959461	1,65896	0,2599733	0,869851
RBG-BIO barley/ RAG (ration of above-ground residue for crop kg N/kg d.m.)	O26		0,22	0,48	1,81	0,24	0,87
Slope / Crop wheat (kg dry matter/ha)	O8		1,51	1,533915	1,636431	1,511877	1,568897
Slope / Crop barley (kg dry matter/ha)	O22		0,9800031	1,043914	1,312094	0,9850836	1,136529

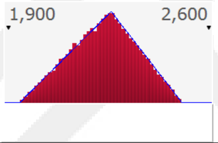
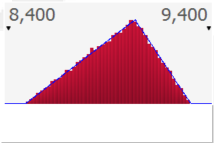
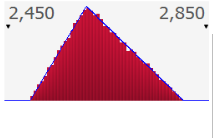
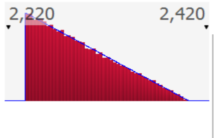
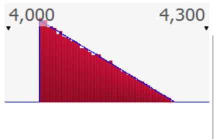
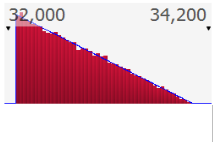
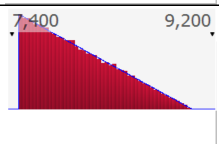
Name	Cell	Graph	Min	Mean	Max	5%	95%
Slope / Crop maize (kg dry matter/ha)	O36		0,876698	0,9999275	1,116626	0,9505705	1,0493
Slope / Crop rye (kg dry matter/ha)	O50		-0,9479282	1,089992	3,095394	0,2667258	1,914908
Slope / Crop oat (kg dry matter/ha)	O64		0,9100004	0,9498705	1,118138	0,9132773	1,007621
Slope / Crop sorghum (kg dry matter/ha)	O78		0,8800058	0,9833139	1,441115	0,8877322	1,134176
Slope / Crop patato (kg dry matter/ha)	O92		0,1000051	0,6479247	3,217304	0,1446738	1,441029
Slope / Crop t (kg dry matter/ha)	O106		0,9500046	1,102716	1,836235	0,9618867	1,32572
TAM / Uncertain Inputs	Z5		391,0357	391,9986	393,063	391,5854	392,4109

Name	Cell	Graph	Min	Mean	Max	5%	95%
TAM / Next (kg N/yr)	Z14		550,0323	550,9994	551,9908	550,5904	551,4089
TAM / Next (kg N/yr)	Z22		30,01129	30,99813	32,05705	30,58581	31,40795
TAM / Next (kg N/yr)	Z30		28,00002	28,20045	29,1413	28,01601	28,49106
TAM / Next (kg N/yr)	Z38		1,000004	1,199286	2,011498	1,015912	1,488284
TAM / Next (kg N/yr)	Z46		50	50,19808	51,05253	50,01584	50,48551
TAM / Next (kg N/yr)	Z54		130	130,1989	130,9926	130,0157	130,4901
TAM / Next (kg N/yr)	Z62		215,942	217,0004	218,0377	216,5866	217,4127

Name	Cell	Graph	Min	Mean	Max	5%	95%
TAM / Next (kg N/yr)	Z70		238	238,1986	239,0783	238,0155	238,4866
TAM / Uncertain Inputs	AK5		391,0623	392,0002	392,9758	391,5888	392,41
TAM / Next (kg N/yr)	AK11		550,0323	551,0001	551,9265	550,587	551,4086
TAM / Next (kg N/yr)	AK17		30,05193	31,00075	32,19993	30,59184	31,41063
TAM / Next (kg N/yr)	AK23		28,00001	28,19948	29,04458	28,01582	28,48783
TAM / Next (kg N/yr)	AK29		1,000009	1,199961	2,299313	1,015837	1,48985
TAM / Next (kg N/yr)	AK35		50	50,20002	51,14369	50,0155	50,49062

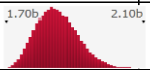
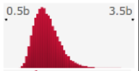
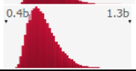
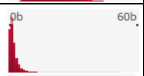
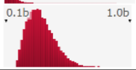
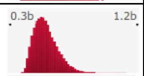
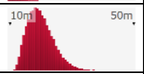
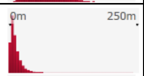
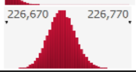
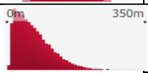
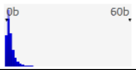
Name	Cell	Graph	Min	Mean	Max	5%	95%
TAM / Next (kg N/yr)	AK41		130	130,2	131,072	130,0154	130,4914
TAM / Next (kg N/yr)	AK47		215,9785	216,9988	218,0246	216,5856	217,4094
TAM / Next (kg N/yr)	AK53		238	238,2001	239,1054	238,0162	238,4933
TAM / Uncertain Inputs	BG5		391,004	391,9998	392,9727	391,5875	392,4084
TAM / Next (kg N/yr)	BG11		550,0225	550,9993	552,0554	550,5901	551,4095
TAM / Next (kg N/yr)	BG17		30,05783	31,00066	32,2882	30,58992	31,41117
TAM / Next (kg N/yr)	BG23		28	28,19904	29,01184	28,01574	28,49098

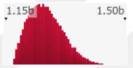
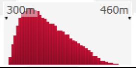
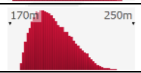
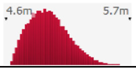
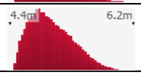
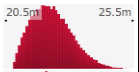
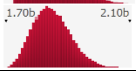
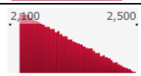
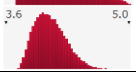
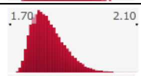
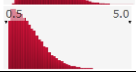
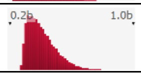
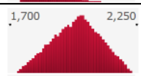
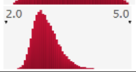
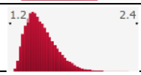
Name	Cell	Graph	Min	Mean	Max	5%	95%
TAM / Next (kg N/yr)	BG29		1,000005	1,199052	2,043459	1,015397	1,487998
TAM / Next (kg N/yr)	BG35		50	50,2	51,05877	50,01587	50,49252
TAM / Next (kg N/yr)	BG41		130	130,1985	131,107	130,015	130,4892
TAM / Next (kg N/yr)	BG47		216,0667	217,0004	218,1423	216,5902	217,4091
TAM / Next (kg N/yr)	BG53		238	238,2005	239,0535	238,016	238,492
ton/yr / Uncertain Inputs	BR10		126.485	126.485	126.486	126.485	126.485
Yield (kg/ha) / Uncertain Inputs	O5		2.400	2.533	2.800	2.410	2.709

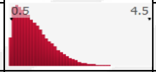
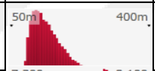
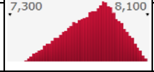
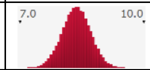
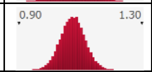
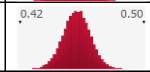
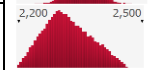
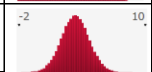
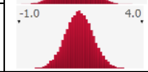
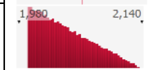
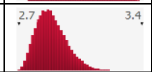
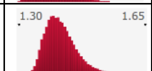
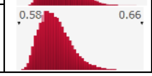
Name	Cell	Graph	Min	Mean	Max	5%	95%
Yield (kg/ha) / RAG (ration of above-ground residue for crop kg N/kg d.m.)	O19		1952,43	2235,877	2499,011	2042,393	2419,003
Yield (kg/ha) / RAG (ration of above-ground residue for crop kg N/kg d.m.)	O33		8500,785	8943,389	9299,046	8645,233	9197,458
Yield (kg/ha) / RAG (ration of above-ground residue for crop kg N/kg d.m.)	O47		2500,784	2636,966	2799,421	2540,829	2747,335
Yield (kg/ha) / RAG (ration of above-ground residue for crop kg N/kg d.m.)	O61		2240,001	2293,313	2399,263	2244,025	2364,928
Yield (kg/ha) / RAG (ration of above-ground residue for crop kg N/kg d.m.)	O75		4050	4116,576	4249,018	4054,868	4205,648
Yield (kg/ha) / RAG (ration of above-ground residue for crop kg N/kg d.m.)	O89		32120,04	32745,71	33990,33	32168,03	33573,39
Yield (kg/ha) / RAG (ration of above-ground residue for crop kg N/kg d.m.)	O103		7490,01	7993,096	8997,368	7528,238	8661,737

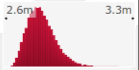
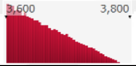
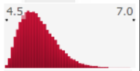
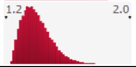
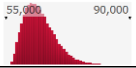
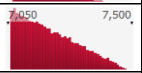
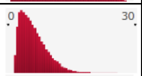
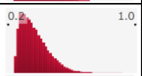
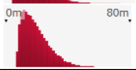
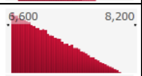
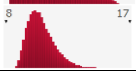
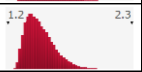
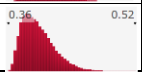
APPENDIX B: Output parameters for @RISK programme.

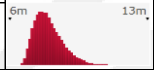
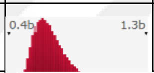
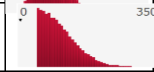
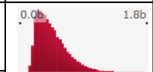
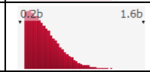
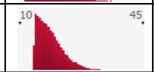
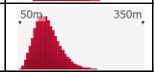
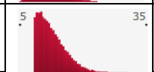
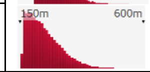
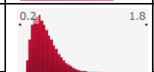
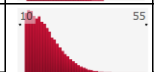
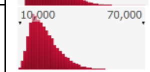
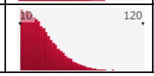
Table B.1 : Output parameters from @RISK programme.

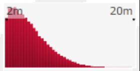
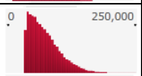
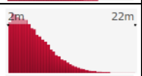
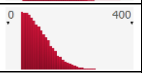
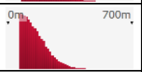
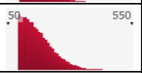
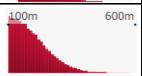
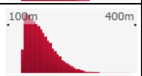
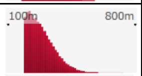
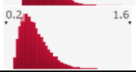
Status	Name	Cell	Graph	Min	Mean	Max	5%	95%	Errors
OK	Fsn	C122		1,702,860,000.00	1,850,373,000.00	2,093,842,000.00	1,763,094,000.00	1,950,643,000.00	0,00
OK	Fon	C123		560,019,000.00	991,275,333.00	2,133,972,000.00	731,114,000.00	1,327,464,666.00	0.00
OK	Fcr	C124		479,581,400.00	676,442,500.00	1,204,009,000.00	546,116,800.00	858,464,700.00	0.00
OK	TOTAL input	C127		4,669,083.00	85,390,700.00	1,723,147,000.00	20,805,953.00	216,486,266.00	0.00
OK	Fprp cpp	C128		92,056,150.00	181,397,000.00	471,106,800.00	114,311,950.00	269,900,500.00	0.00
OK	Fprp so	C129		262,260,400.00	374,055,866.67	747,438,000.00	300,449,200.00	473,325,000.00	0.00
OK	TOTAL prp	C132		13,454,360.00	291,914,900.00	6,419,668,000.00	64,525,970.00	762,993,500.00	0.00
OK	F manure (total) /	C133		11,688,820.00	20,339,320.00	45,357,230.00	14,560,390.00	27,881,870.00	0.00
OK	Total Manure management	C136		630,536.30	14,375,670.00	239,299,700.00	3,615,265.00	35,779,430.00	0.00
OK	Ag.burning /	C137		226,672.00	226,715.40	226,761.00	226,698.40	226,733.00	0.00
OK	Waste /	C138		742,953.90	7,289,514.00	33,712,790.00	2,008,784.00	15,747,800.00	0.00
OK	Overall /	C140		10.119.236,67	98.037.800,00	1.739.939.666,67	31.397.556,67	230.389.533,33	0,00

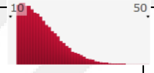
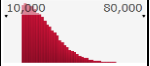
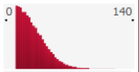
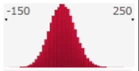
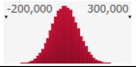
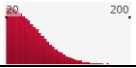
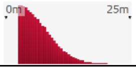
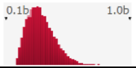
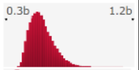
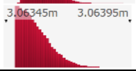
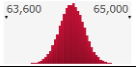
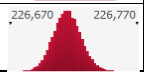
Status	Name	Cell	Graph	Min	Mean	Max	5%	95%	Errors
OK	FSn (wheat)	E5		1.177.381.000,00	1.270.385.000,00	1.451.506.000,00	1.199.918.000,00	1.356.968.000,00	0,00
OK	FSn (barley)	E8		305.655.200,00	354.083.800,00	453.712.300,00	315.599.600,00	406.461.200,00	0,00
OK	FSn (maize)	E11		177.491.400,00	198.544.800,00	241.546.400,00	182.121.000,00	219.962.800,00	0,00
OK	FSn (rye)	E14		4.655.747,00	4.988.951,00	5.601.886,00	4.739.514,00	5.293.551,00	0,00
OK	FSn (oat)	E17		4.480.850,00	5.014.317,00	6.075.643,00	4.596.635,00	5.555.146,00	0,00
OK	FSn (rice)	E20		20.862.460,00	22.345.280,00	25.250.590,00	21.219.020,00	23.718.210,00	0,00
OK	Fsn total (Kg N/yr)	E21		1.702.860.000,00	1.850.373.000,00	2.093.842.000,00	1.763.094.000,00	1.950.643.000,00	0,00
OK	Crop wheat	P7		2.136,01	2.254,38	2.491,71	2.144,99	2.411,40	0,00
OK	AGwheat	P10		3,75	4,11	4,98	3,87	4,42	0,00
OK	RAGwheat	P11		1,73	1,83	2,10	1,76	1,92	0,00
OK	RBGbarley	P15		0,66	1,40	4,71	0,73	2,46	0,00
OK	FCR (wheat)	P17		276.852.200,00	415.311.600,00	916.609.000,00	307.062.100,00	584.881.900,00	0,00
OK	Cropbarley	P21		1.737,66	1.989,93	2.224,12	1.817,73	2.152,91	0,00
OK	AGbarley	P24		2,32	3,00	4,51	2,59	3,52	0,00
OK	RAGbarley	P25		1,26	1,51	2,31	1,33	1,77	0,00

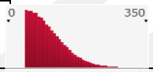
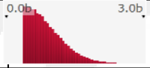
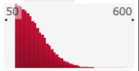
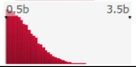
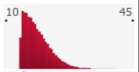
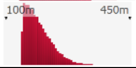
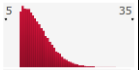
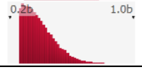
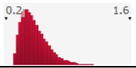
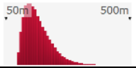
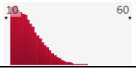
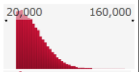
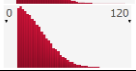
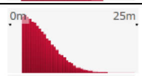
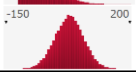
Status	Name	Cell		Min	Mean	Max	5%	95%	Errors
OK	RBGbarley	P29		0,51	1,21	4,38	0,60	2,18	0,00
OK	FCR (barley)	P31		80.516.370,00	147.745.000,00	382.602.100,00	98.933.540,00	223.315.300,00	0,00
OK	Crop maize	P35		7.395,68	7.780,75	8.090,17	7.521,35	8.001,79	0,00
OK	AGmaize	P38		7,05	8,38	9,75	7,82	8,93	0,00
OK	RAGmaize	P39		0,92	1,08	1,27	1,01	1,14	0,00
OK	Rbgmaize	P43		0,42	0,46	0,50	0,44	0,47	0,00
OK	FCR (maize)	P45		69.201.720,00	80.432.280,00	91.572.660,00	75.752.680,00	85.017.160,00	0,00
OK	Crop çavdar	P49		2.200,69	2.320,53	2.463,49	2.235,93	2.417,66	0,00
OK	AGçavdar	P52		-1,59	3,41	8,68	1,32	5,49	0,00
OK	RAG çavdar	P53		-0,67	1,47	3,73	0,57	2,36	0,00
0	Rbgçavdar	P57		0,00	0,00	0,00	0,00	0,00	0,00
OK	Crop yulaf	P63		1.993,60	2.041,05	2.135,34	1.997,18	2.104,79	0,00
OK	AGyulaf	P66		2,71	2,89	3,38	2,77	3,05	0,00
OK	RAGyulaf	P67		1,33	1,42	1,62	1,36	1,49	0,00
OK	Rbgyulaf	P71		0,58	0,60	0,66	0,59	0,62	0,00

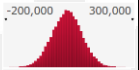
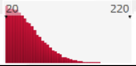
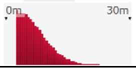
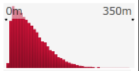
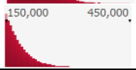
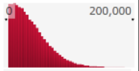
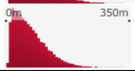
Status	Name	Cell	Graph	Min	Mean	Max	5%	95%	Errors
OK	FCR (oats)	P73		2.636.369,00	2.800.631,00	3.218.076,00	2.694.591,00	2.934.037,00	0,00
OK	Crop sorghum	P77		3.604,50	3.663,75	3.781,63	3.608,83	3.743,03	0,00
OK	AG sorghum	P80		4,52	5,15	6,90	4,69	5,77	0,00
OK	RAG sorghum	P81		1,24	1,41	1,90	1,28	1,57	0,00
0	Rbg sorghum	P85		0,00	0,00	0,00	0,00	0,00	0,00
OK	FCR (sorghum)	P87		56.870,77	64.867,59	86.984,44	59.132,50	72.655,26	0,00
OK	Crop patato	P91		7.066,41	7.204,06	7.477,87	7.076,97	7.386,15	0,00
OK	AG patato	P94		1,79	6,29	25,57	2,58	12,05	0,00
OK	RAG patato	P95		0,25	0,87	3,58	0,36	1,67	0,00
OK	Output patato	P99		0,25	0,37	0,92	0,27	0,53	0,00
OK	FCR (patato)	P101		7.538.149,00	20.126.420,00	73.922.800,00	9.773.129,00	36.223.290,00	0,00
OK	Crop Rice	P105		6.666,11	7.113,86	8.007,66	6.700,13	7.708,95	0,00
OK	AG Rice	P108		8,81	10,63	16,30	9,38	12,37	0,00
OK	RAG rice	P109		1,27	1,50	2,25	1,34	1,73	0,00
OK	Rbg rice	P113		0,36	0,40	0,52	0,37	0,44	0,00

Status	Name	Cell		Min	Mean	Max	5%	95%	Errors
OK	FCR (rice)	P115		6.662.905,00	8.036.837,00	12.325.980,00	7.091.215,00	9.350.917,00	0,00
OK	FCR (total)	P116		479.581.400,00	676.442.500,00	1.204.009.000,00	546.116.800,00	858.464.700,00	0,00
OK	Next (kg N/yr) / cow	AA7		47,18	104,47	346,98	51,47	187,35	0,00
OK	Fon cow	AA11		150.744.200,00	468.372.000,00	1.748.251.000,00	224.388.100,00	859.172.200,00	0,00
OK	Next (kg N/yr) / d.cow	AA16		96,40	176,79	512,77	102,87	293,64	0,00
OK	Fon d.cow	AA20		273.018.600,00	500.687.600,00	1.452.203.000,00	291.330.700,00	831.621.600,00	0,00
OK	Next (kg N/yr) / coat	AA24		14,15	18,99	41,06	14,83	25,61	0,00
OK	Fon goat	AA28		53.084.670,00	120.225.600,00	312.223.800,00	77.000.260,00	176.539.800,00	0,00
OK	Next (kg N/yr) / sheep	AA32		8,69	12,87	30,58	9,07	18,86	0,00
OK	Fon sheep	AA36		159.008.600,00	243.818.700,00	572.264.100,00	171.887.900,00	357.481.700,00	0,00
OK	Next (kg N/yr) poultry	AA40		0,30	0,54	1,68	0,35	0,83	0,00
OK	Fon poultry	AA44		78.557.620,00	141.920.800,00	440.393.700,00	92.531.980,00	218.193.500,00	0,00
OK	Next (kg N/yr) swine	AA48		12,42	19,72	54,26	13,03	30,25	0,00
OK	Fon swine	AA52		10.138,82	22.714,79	69.529,40	14.103,53	35.839,95	0,00
OK	Next (kg N/yr) ass+mule	AA56		12,35	31,25	110,87	13,80	59,05	0,00

Status	Name	Cell	Graph	Min	Mean	Max	5%	95%	Errors
OK	Fon ass+mule	AA60		2.104.706,00	5.518.327,00	19.550.960,00	2.437.618,00	10.412.380,00	0,00
OK	Next (kg N/yr) camel	AA64		30,05	61,62	211,74	32,59	108,23	0,00
OK	Fon camel	AA68		34.897,51	74.099,92	249.430,50	39.180,13	130.108,40	0,00
OK	Next (kg N/yr) horse	AA72		22,60	57,25	200,22	25,22	107,98	0,00
OK	Fon horse	AA76		2.399.776,00	6.272.696,00	21.735.040,00	2.764.906,00	11.830.680,00	0,00
OK	Fon	AA77		840.028.500,00	1.486.913.000,00	3.200.958.000,00	1.096.671.000,00	1.991.197.000,00	0,00
OK	Next (kg N/yr) / cow	AL7		47,17	104,06	394,57	51,61	187,69	0,00
OK	Fprp,cpp cow	AL9		73.715.090,00	162.609.000,00	616.559.500,00	80.650.100,00	293.289.400,00	0,00
OK	Next (kg N/yr) / d.cow	AL13		96,48	176,71	509,12	102,73	293,70	0,00
OK	Fprp,cpp d.cow	AL15		109.290.600,00	200.184.900,00	576.747.100,00	116.370.500,00	332.709.300,00	0,00
OK	Next (kg N/yr) / coat	AL19		14,14	18,99	40,52	14,84	25,59	0,00
OK	Fprp,so goat	AL21		134.527.700,00	180.714.300,00	385.647.200,00	141.222.700,00	243.507.200,00	0,00
OK	Next (kg N/yr) / sheep	AL25		8,69	12,86	32,20	9,07	18,84	0,00
OK	Fprp,so sheep	AL27		197.560.800,00	292.360.400,00	732.083.000,00	206.241.400,00	428.352.400,00	0,00
OK	Next (kg N/yr) poultry	AL31		0,30	0,54	1,55	0,35	0,82	0,00

Status	Name	Cell	Graph	Min	Mean	Max	5%	95%	Errors
OK	Fprp,so poultry	AL33		42.311.760,00	74.917.530,00	215.946.800,00	49.018.140,00	114.498.000,00	0,00
OK	Next (kg N/yr) swine	AL37		12,41	19,74	49,79	13,02	30,46	0,00
OK	Fprp,so swine	AL39		18.792,39	29.889,78	75.375,16	19.718,19	46.117,22	0,00
OK	Next (kg N/yr) ass+mule	AL43		12,34	31,25	120,12	13,80	58,86	0,00
OK	Fprp,so ass+mule	AL45		2.406.069,00	6.092.727,00	23.417.960,00	2.690.916,00	11.474.800,00	0,00
OK	Next (kg N/yr) camel	AL49		-131,76	29,83	219,35	-35,56	95,44	0,00
OK	Fprp,so camel	AL51		-174.893,90	39.600,96	291.150,90	-47.209,81	126.695,50	0,00
OK	Next (kg N/yr) horse	AL55		22,59	57,29	199,60	25,37	107,57	0,00
OK	Fprp,so horse	AL57		2.732.820,00	6.929.475,00	24.144.530,00	3.069.374,00	13.011.460,00	0,00
OK	Fprp cpp	AL59		184.112.300,00	362.794.000,00	942.213.600,00	228.623.900,00	539.801.000,00	0,00
OK	Fprp so	AL60		393.390.600,00	561.083.800,00	1.121.157.000,00	450.673.800,00	709.987.500,00	0,00
OK	Fag.burning (wheat)	AW4		3.063.493,00	3.063.573,00	3.063.929,00	3.063.499,00	3.063.688,00	0,00
0	Fag.burning (maize)	AW7		110.869,10	110.869,10	110.869,10	110.869,10	110.869,10	0,00
OK	Fag.burning (rice)	AW10		63.792,18	64.349,52	64.964,29	64.124,37	64.575,54	0,00
OK	Fag. Burning total (kg)	AW12		226.672,00	226.715,40	226.761,00	226.698,40	226.733,00	0,00

Status	Name	Cell		Min	Mean	Max	5%	95%	Errors
OK	Next (kg N/yr) / cow	BH7		47,17	104,34	340,00	51,66	187,55	0,00
OK	Fmm cow	BH9		409.499.700,00	905.793.100,00	2.951.538.000,00	448.455.600,00	1.628.177.000,00	0,00
OK	Next (kg N/yr) / d.cow	BH13		96,48	177,13	563,18	102,66	295,74	0,00
OK	Fprp,cpp d.cow	BH15		546.501.500,00	1.003.278.000,00	3.189.923.000,00	581.487.400,00	1.675.136.000,00	0,00
OK	Next (kg N/yr) / coat	BH19		14,23	18,98	40,21	14,84	25,60	0,00
OK	Fmm goat	BH21		147.222.900,00	196.376.800,00	415.977.200,00	153.538.900,00	264.820.200,00	0,00
OK	Next (kg N/yr) / sheep	BH25		8,69	12,87	30,84	9,07	18,83	0,00
OK	Fmm sheep	BH27		270.693.500,00	400.848.000,00	960.411.800,00	282.367.700,00	586.254.300,00	0,00
OK	Next (kg N/yr) poultry	BH31		0,30	0,54	1,57	0,35	0,82	0,00
OK	Fmm poultry	BH33		96.216.980,00	170.268.600,00	496.328.400,00	111.472.200,00	260.551.600,00	0,00
OK	Next (kg N/yr) swine	BH37		12,41	19,82	56,51	13,04	30,40	0,00
OK	Fmm swine	BH39		32.972,02	52.633,80	150.099,30	34.622,86	80.731,45	0,00
OK	Next (kg N/yr) ass+mule	BH43		12,34	31,17	115,04	13,83	58,28	0,00
OK	Fmm ass+mule	BH45		2.614.526,00	6.605.755,00	24.376.670,00	2.931.137,00	12.349.830,00	0,00
OK	Next (kg N/yr) camel	BH49		-124,88	30,07	186,09	-35,03	95,07	0,00

Status	Name	Cell	Graph	Min	Mean	Max	5%	95%	Errors
OK	Fmm camel	BH51		-180.172,90	43.386,09	268.486,80	-50.554,12	137.182,90	0,00
OK	Next (kg N/yr) horse	BH55		22,59	57,31	208,17	25,37	107,93	0,00
OK	Fmm horse	BH57		2.970.776,00	7.534.588,00	27.369.820,00	3.335.353,00	14.190.950,00	0,00
OK	Fww	BS9		721.552,50	7.267.004,00	33.686.690,00	1.986.600,00	15.723.910,00	0,00
OK	Fcompost	BS12		15.178,42	18.346,05	40.099,79	15.363,73	24.000,90	0,00
OK	Fopenburningarea	BS18		660,94	4.163,29	18.532,95	936,61	9.284,25	0,00
OK	F total waste	BS19		742.953,90	7.289.514,00	33.712.790,00	2.008.784,00	15.747.800,00	0,00

CURRICULUM VITAE

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PROFESSIONAL EXPERIENCE AND REWARDS:

- (2018 – con.) Istanbul Sabiha Gökçen International Airport Investment Development and Operation Inc – Qality Assurance Specialist and Environmental Responsible
- (2017 – 2018) MWH Global Inc. – Intern