# INTERNATIONAL JOURNAL OF RESEARCH IN COMMERCE, ECONOMICS & MANAGEMENT

IJRCM

A Monthly Double-Blind Peer Reviewed (Refereed/Juried) Open Access International e-Journal - Included in the International Serial Directories
*Indexed & Listed at:*
Ulrich's Periodicals Directory ©, ProQuest, U.S.A., EBSCO Publishing, U.S.A., Cabell's Directories of Publishing Opportunities, U.S.A., Google Scholar,
Open J-Gage, India [link of the same is duly available at Inflibnet of University Grants Commission (U.G.C.)],
The American Economic Association's electronic bibliography, EconLit, U.S.A.,
Index Copernicus Publishers Panel, Poland with IC Value of 5.09 & number of libraries all around the world.
Circulated all over the world & Google has verified that scholars of more than **5000 Cities** in **187 countries/territories** are visiting our journal on regular basis.
Ground Floor, Building No. 1041-C-1, Devi Bhawan Bazar, JAGADHRI – 135 003, Yamunanagar, Haryana, INDIA
http://ijrcm.org.in/

# CONTENTS

# CALL FOR MANUSCRIPTS

We invite unpublished novel, original, empirical and high quality research work pertaining to the recent developments & practices in the areas of Computer Science & Applications; Commerce; Business; Finance; Marketing; Human Resource Management; General Management; Banking; Economics; Tourism Administration & Management; Education; Law; Library & Information Science; Defence & Strategic Studies; Electronic Science; Corporate Governance; Industrial Relations; and emerging paradigms in allied subjects like Accounting; Accounting Information Systems; Accounting Theory & Practice; Auditing; Behavioral Accounting; Behavioral Economics; Corporate Finance; Cost Accounting; Econometrics; Economic Development; Economic History; Financial Institutions & Markets; Financial Services; Fiscal Policy; Government & Non Profit Accounting; Industrial Organization; International Economics & Trade; International Finance; Macro Economics; Micro Economics; Rural Economics; Co-operation; Demography: Development Planning; Development Studies; Applied Economics; Development Economics; Business Economics; Monetary Policy; Public Policy Economics; Real Estate; Regional Economics; Political Science; Continuing Education; Labour Welfare; Philosophy; Psychology; Sociology; Tax Accounting; Advertising & Promotion Management; Management Information Systems (MIS); Business Law; Public Responsibility & Ethics; Communication; Direct Marketing; E-Commerce; Global Business; Health Care Administration; Labour Relations & Human Resource Management; Marketing Research; Marketing Theory & Applications; Non-Profit Organizations; Office Administration/Management; Operations Research/Statistics; Organizational Behavior & Theory; Organizational Development; Production/Operations; International Relations; Human Rights & Duties; Public Administration; Population Studies; Purchasing/Materials Management; Retailing; Sales/Selling; Services; Small Business Entrepreneurship; Strategic Management Policy; Technology/Innovation; Tourism & Hospitality; Transportation Distribution; Algorithms; Artificial Intelligence; Compilers & Translation; Computer Aided Design (CAD); Computer Aided Manufacturing; Computer Graphics; Computer Organization & Architecture; Database Structures & Systems; Discrete Structures; Internet; Management Information Systems; Modeling & Simulation; Neural Systems/Neural Networks; Numerical Analysis/Scientific Computing; Object Oriented Programming; Operating Systems; Programming Languages; Robotics; Symbolic & Formal Logic; Web Design and emerging paradigms in allied subjects.

Anybody can submit the **soft copy** of unpublished novel; original; empirical and high quality **research work/manuscript** ***anytime*** in ***M.S. Word format*** after preparing the same as per our **GUIDELINES FOR SUBMISSION**; at our email address i.e. infoijrcm@gmail.com or online by clicking the link **online submission** as given on our website (***FOR ONLINE SUBMISSION, CLICK HERE***).

# GUIDELINES FOR SUBMISSION OF MANUSCRIPT

1. **COVERING LETTER FOR SUBMISSION**:

**DATED: _____________**

***THE EDITOR***

IJRCM

Subject: **SUBMISSION OF MANUSCRIPT IN THE AREA OF ______________________.**

**(e.g. Finance/Mkt./HRM/General Mgt./Engineering/Economics/Computer/IT/ Education/Psychology/Law/Math/other, please specify)**

**DEAR SIR/MADAM**

Please find my submission of manuscript titled '___________________________________________' for likely publication in one of your journals.

I hereby affirm that the contents of this manuscript are original. Furthermore, it has neither been published anywhere in any language fully or partly, nor it is under review for publication elsewhere.

I affirm that all the co-authors of this manuscript have seen the submitted version of the manuscript and have agreed to inclusion of their names as co-authors.

Also, if my/our manuscript is accepted, I agree to comply with the formalities as given on the website of the journal. The Journal has discretion to publish our contribution in any of its journals.

| | |
|---|---|
| **NAME OF CORRESPONDING AUTHOR** | : |
| Designation/Post* | : |
| Institution/College/University with full address & Pin Code | : |
| Residential address with Pin Code | : |
| Mobile Number (s) with country ISD code | : |
| Is WhatsApp or Viber active on your above noted Mobile Number (Yes/No) | : |
| Landline Number (s) with country ISD code | : |
| E-mail Address | : |
| Alternate E-mail Address | : |
| Nationality | : |

* i.e. Alumnus (Male Alumni), Alumna (Female Alumni), Student, Research Scholar (M. Phil), Research Scholar (Ph. D.), JRF, Research Assistant, Assistant Lecturer, Lecturer, Senior Lecturer, Junior Assistant Professor, Assistant Professor, Senior Assistant Professor, Co-ordinator, Reader, Associate Professor, Professor, Head, Vice-Principal, Dy. Director, Principal, Director, Dean, President, Vice Chancellor, Industry Designation **etc**. ***The qualification of author is not acceptable for the purpose***.

**NOTES**:

a) The whole manuscript has to be in ***ONE MS WORD FILE*** only, which will start from the covering letter, inside the manuscript. ***pdf. version* is liable to be rejected without any consideration**.

b) The sender is required to mention the following in the **SUBJECT COLUMN of the mail**:

**New Manuscript for Review in the area of** (e.g. Finance/Marketing/HRM/General Mgt./Engineering/Economics/Computer/IT/ Education/Psychology/Law/Math/other, please specify)

c) There is no need to give any text in the body of the mail, except the cases where the author wishes to give any **specific message** w.r.t. to the manuscript.

d) The total size of the file containing the manuscript is expected to be below **1000 KB**.

e) Only the **Abstract will not be considered for review** and the author is required to submit the **complete manuscript** in the first instance.

f) ***The journal gives acknowledgement w.r.t. the receipt of every email within twenty-four hours*** and in case of non-receipt of acknowledgment from the journal, w.r.t. the submission of the manuscript, within two days of its submission, the corresponding author is required to demand for the same by sending a separate mail to the journal.

g) The author (s) name or details should not appear anywhere on the body of the manuscript, except on the covering letter and the cover page of the manuscript, in the manner as mentioned in the guidelines.

2. **MANUSCRIPT TITLE:** The title of the paper should be typed in **bold letters**, **centered** and **fully capitalised**.
3. **AUTHOR NAME (S) & AFFILIATIONS:** Author (s) **name**, **designation**, **affiliation** (s), **address**, **mobile/landline number** (s), and **email/alternate email address** should be given underneath the title.
4. **ACKNOWLEDGMENTS:** Acknowledgements can be given to reviewers, guides, funding institutions, etc., if any.
5. **ABSTRACT:** Abstract should be in **fully Italic printing**, ranging between **150** to **300 words**. The abstract must be informative and elucidating the background, aims, methods, results & conclusion in a **SINGLE PARA**. ***Abbreviations must be mentioned in full***.
6. **KEYWORDS:** Abstract must be followed by a list of keywords, subject to the maximum of **five**. These should be arranged in alphabetic order separated by commas and full stop at the end. All words of the keywords, including the first one should be in small letters, except special words e.g. name of the Countries, abbreviations etc.
7. **JEL CODE:** Provide the appropriate Journal of Economic Literature Classification System code (s). JEL codes are available at www.aeaweb.org/econlit/jelCodes.php. However, mentioning of JEL Code is not mandatory.
8. **MANUSCRIPT:** Manuscript must be in ***BRITISH ENGLISH*** prepared on a standard A4 size ***PORTRAIT SETTING PAPER***. *It should be free from any errors i.e.* ***grammatical, spelling*** *or* ***punctuation.*** *It must be thoroughly edited at your end*.
9. **HEADINGS:** All the headings must be bold-faced, aligned left and fully capitalised. Leave a blank line before each heading.
10. **SUB-HEADINGS:** All the sub-headings must be bold-faced, aligned left and fully capitalised.
11. **MAIN TEXT:**

***THE MAIN TEXT SHOULD FOLLOW THE FOLLOWING SEQUENCE***:

**INTRODUCTION**
**REVIEW OF LITERATURE**
**NEED/IMPORTANCE OF THE STUDY**
**STATEMENT OF THE PROBLEM**
**OBJECTIVES**
**HYPOTHESIS (ES)**
**RESEARCH METHODOLOGY**
**RESULTS & DISCUSSION**
**FINDINGS**
**RECOMMENDATIONS/SUGGESTIONS**
**CONCLUSIONS**
**LIMITATIONS**
**SCOPE FOR FURTHER RESEARCH**
**REFERENCES**
**APPENDIX/ANNEXURE**

The manuscript should preferably be in ***2000 to 5000 WORDS***, But the limits can vary depending on the nature of the manuscript.

12. **FIGURES & TABLES:** These should be simple, crystal **CLEAR**, **centered**, **separately numbered** & self-explained, and the **titles must be above the table/figure**. **Sources of data should be mentioned below the table/figure**. *It should be ensured that the tables/figures are referred to from the main text*.

13. **EQUATIONS/FORMULAE:** These should be consecutively numbered in parenthesis, left aligned with equation/formulae number placed at the right. The equation editor provided with standard versions of Microsoft Word may be utilised. If any other equation editor is utilised, author must confirm that these equations may be viewed and edited in versions of Microsoft Office that does not have the editor.

14. **ACRONYMS:** These should not be used in the abstract. The use of acronyms is elsewhere is acceptable. Acronyms should be defined on its first use in each section e.g. Reserve Bank of India (RBI). Acronyms should be redefined on first use in subsequent sections.

15. **REFERENCES:** The list of all references should be alphabetically arranged. ***The author (s) should mention only the actually utilised references in the preparation of manuscript*** and they may follow Harvard Style of Referencing. **Also check to ensure that everything that you are including in the reference section is duly cited in the paper**. The author (s) are supposed to follow the references as per the following:

- All works cited in the text (including sources for tables and figures) should be listed alphabetically.
- Use (**ed.**) for one editor, and (**ed.s)** for multiple editors.
- When listing two or more works by one author, use --- (20xx), such as after Kohl (1997), use --- (2001), etc., in chronologically ascending order.
- Indicate (opening and closing) page numbers for articles in journals and for chapters in books.
- The title of books and journals should be in italic printing. Double quotation marks are used for titles of journal articles, book chapters, dissertations, reports, working papers, unpublished material, etc.
- For titles in a language other than English, provide an English translation in parenthesis.
- ***Headers, footers, endnotes** and **footnotes** should **not be used** in the document.* However, **you can mention short notes to elucidate some specific point**, which may be placed in number orders before the references.

**PLEASE USE THE FOLLOWING FOR STYLE AND PUNCTUATION IN REFERENCES:**

**BOOKS**

- Bowersox, Donald J., Closs, David J., (1996), "Logistical Management." Tata McGraw, Hill, New Delhi.
- Hunker, H.L. and A.J. Wright (1963), "Factors of Industrial Location in Ohio" Ohio State University, Nigeria.

**CONTRIBUTIONS TO BOOKS**

- Sharma T., Kwatra, G. (2008) Effectiveness of Social Advertising: A Study of Selected Campaigns, Corporate Social Responsibility, Edited by David Crowther & Nicholas Capaldi, Ashgate Research Companion to Corporate Social Responsibility, Chapter 15, pp 287-303.

**JOURNAL AND OTHER ARTICLES**

- Schemenner, R.W., Huber, J.C. and Cook, R.L. (1987), "Geographic Differences and the Location of New Manufacturing Facilities," Journal of Urban Economics, Vol. 21, No. 1, pp. 83-104.

**CONFERENCE PAPERS**

- Garg, Sambhav (2011): "Business Ethics" Paper presented at the Annual International Conference for the All India Management Association, New Delhi, India, 19–23

**UNPUBLISHED DISSERTATIONS**

- Kumar S. (2011): "Customer Value: A Comparative Study of Rural and Urban Customers," Thesis, Kurukshetra University, Kurukshetra.

**ONLINE RESOURCES**

- Always indicate the date that the source was accessed, as online resources are frequently updated or removed.

**WEBSITES**

- Garg, Bhavet (2011): Towards a New Gas Policy, Political Weekly, Viewed on January 01, 2012 http://epw.in/user/viewabstract.jsp

# INDIA: AGRICULTURE'S CONTRIBUTION TOWARDS CLIMATE CHANGE

*SATRAJIT DUTTA*
*ASST. PROFESSOR OF ECONOMICS*
*GORUBATHAN GOVERNMENT COLLEGE*
*GORUBATHAN, DT. DARJEELING, WEST BENGAL*

**ABSTRACT**

*Climate change is mainly caused by anthropogenic Green House Gases sourced from several factors including agriculture practices. This article is to find out the main agricultural sources of emissions responsible for climate change in India and the effects on agriculture and compatible solutions. The article is based on available evidences and avoids use of statistics/econometrics methods. Methane through enteric fermentation is the mostly released gas in Indian agriculture sector. High consumption of nitrogeneous fertilisers causes Nitrous Oxide emissions. Burning of biomass after harvesting of crops is another source of Green House Gases. Though emission of Carbon Dioxide has some positive effects on agricultural production but this will be outweighed by the negative effects of anthropogenic climate change. Adaptation and Mitigation solution in agriculture are in some cases found to be contradictory with other policies to contain the overall negative effects of climate change. Agro-forestry, organic agriculture, soil carbon sequestration are some of the measures which avoid these trade-offs.*

**KEYWORDS**
climate change, agriculture, environment, greenhouse gases.

**JEL CLASSIFICATION**
Q54, Q15, Q56, O13

## 1. INTRODUCTION

Climate change is defined by United Nations Framework Convention on Climate Change (UNFCCC) as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time period.

Increased concentration of greenhouse gases (GHGs) - Carbon dioxide ($CO_2$), Methane ($CH_4$) and Nitrous oxide ($N_2O$) in the atmosphere, trap the outgoing infrared radiation from the earth's surface. According to Inter-Governmental Panel on Climate Change (IPCC 2007), the temperature is projected to increase between 1.1 and 6.4°C by the end of the 21st century.

$CO_2$, $CH_4$, $N_2O$ are important GHGs contributing 60 per cent, 15 per cent and 5 per cent, respectively. Agriculture sector contributes 14 per cent of global GHGs emissions.

## 2. REVIEW OF LITERATURE

Before going into the details of the main research article, I would like to present reviews done on some existing literatures on the relationship between agriculture and climate change.

Francesco Tubiello, et.al. in 'Climate Change Response Strategies for Agriculture: Challenges and Opportunities for the 21st Century', pointed out the climate change challenges like elevated $CO_2$ concentration, precipitation changes, increased weeds and pests, the agriculture sector is going to face. The paper gives mention about the synergies between mitigation and adaptation measures.

Louis Bockel and Barry Smit in 'Climate Change and Agriculture Policies' pointed out that need for integrating climate change adaptation into agricultural development due to resilience and/or performance of the agriculture sector, and thus these are to be included in the national agricultural policies. Some policies with adaptation potentiality are – encouraging adapted crop development and farming practises, policies to promote soil conservation and land management, irrigation and water resource management policies and disaster risk management policies. The paper also mentions about the mitigation-oriented policy options like policies to promote conservation agriculture, options to reduce Methane emissions from rice fields, watershed management policies, livestock management policies.

'Potentials for greenhouse gas mitigation in agriculture' published by GIZ, points out the vulnerabilities of the developing countries and mentions about three GHGs – $CO_2$, $CH_4$, $N_2O$, relevant for agriculture, and land use change. It mentioned about the sources like nitrogen fertilisation, irrigated rice production, livestock husbandry, processing, cooling, storage, transporting and cooking of agriculture produce. It also mentioned three major mitigation measures like increase in $CO_2$ storage in soils and biomass, emissions reduction in agricultural production, reduction in required volume of agriculture production.

In 'Integrating mitigation and adaptation into climate and development policy: three research questions', Richard J.T. Klein, et.al., have stated that the international climate policy has become an amalgamation of policies directed at various sectors – energy, water, agriculture, forestry and nature conservation. Developing countries in particular, have more immediate challenges than climate change like food and water security, sanitation, education, health care, environmental degradation and natural hazards. In view of growing realisation of close links between climate policy and development policy, it becomes more necessary to establish links between adaptation and development policy and between mitigation and development policy, as well as to identify some desirable level and mix of climate policies and development policies.

In 'Climate Change in Context of Indian Agricultural Sector', Anupam Khajuria, et. al., mentioned about the major ecological and economical challenges Indian agriculture is facing –geographical limits to agriculture, changes in crop yields and impacts on agricultural system. The article gives the projected scenario of a 2.5°C to 4.9°C temperature rise, rice yields will drop by 32 - 40 per cent and wheat yields by 41 - 52 per cent, which would cause GDP to fall by 1.8 per cent-3.4 per cent. The basic mechanisms for GHGs mitigation in agriculture are reduction in Methane and Nitrous Oxide emissions from agricultural production, production of different forms of biomass for energy use in substitution of fossil energy sources, etc.

In his article, 'Agriculture and Farmers Well Being: Present Scenario', J. P. Mishra has mentioned that agriculture sector has remained important in terms of its contribution towards GDP and employment. This sector is increasingly confronting climate change-induced weather aberrations which require attention for the farmers' well being and necessity of adequate and growing food grains. He mentioned Pradhan Mantri Krishi SY, among different programmes of the Govt. for agricultural improvement, for efficient water use in this sector.

Prabha Shastri Ranade in his article, 'Impact of climate change on agriculture', focused on the Indian scenario, i.e. on climate change impacts on Indian agriculture. Approximately 20 to 30 per cent of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5 to 2.5°C. In view of this global phenomena, the author has forwarded measures for adaptation and mitigation in agriculture sector in India as agricultural research to develop new crop varieties, improved training and general education of populations dependent on agriculture, food programmes and other social security programs to provide insurance against supply changes. Removal of subsidies is important because they overshadow the climate change signal in the market place.

K Lenin Babu and K V Raju have mentioned in the article 'Green house gases emissions and potential carbon sequestration: A case study of semi-arid area in south India' the possible impacts of climate change as water stress, food security, natural ecosystem, coastal agriculture and settlements. The authors chose Kolar district of Karnataka state of India which is in semi-arid regions. It has been found that GHGs emission from agriculture sector is the highest after the energy sector in that district and the rate of carbon sequestration is low. High rates of emission are primarily due to inefficient use of biomass used for energy purposes. The article mentioned about the other sources of GHGs emission – industry, waste management, sinks, etc. The main sources for the GHGs in the agriculture sector are enteric fermentation, manure management, rice irrigation which all cause $CH_4$ emissions. $N_2O$ from the agriculture sector originates from manure management and agriculture sector.

All the above reviews of research articles and reports indicate the importance of agriculture in climate change process and the need of integration of both adaptation and mitigation strategies for agriculture with the strategies in other sectors of the economy.

## 3. IMPORTANCE OF THE STUDY

Economic liberalisation strategy without explicit mandate for liberalisation and global integration of Indian agriculture sector caused deceleration of Agri-GDP growth rate in the Post-Economic Reform (1992–93 to 2012–13) period to 2.92 per cent from 3.09 per cent (1980-81 to 1991-92). 32.7 per cent of Indian population is below the international poverty line of US$1.25 per day (PPP) and incidence of poverty is mostly in the agricultural labourers. Agriculture still contributes nearly 14 per cent of national GDP and retains the major share of employment of 47.1 per cent (as in 2011-12). Substantial year-to-year variability in the agricultural productivity trend is noted, mainly due to variability of weather and climate. Climate change is caused by several factors including agriculture and this change has profound negative effects on agriculture productivity. Thus studying this sector as a source of climate change process assumes importance in view of its above-mentioned economic importance in our country.

## 4. STATEMENT OF THE PROBLEM

Negative effects of climate change on agriculture, and associated food security implications are well-recognised. But there is another aspect which has not attracted much attention. Agriculture is also one of the significant contributors to the GHGs and which, in turn, cause negative impact on the climate. This negative climate change effect again accelerates the unsustainable change in environment and cast a negative effect on the agriculture itself, in the process.

## 5. OBJECTIVES

The purpose of the present research paper is to find out the causes of India's agriculture sector's contribution to climate change, and its effects and possible solutions. Though land and land use change and forestry are all important in analysing the research topic, I tried to focus basically on the agriculture practice only.

## 6. RESEARCH QUESTIONS

i) How Indian agriculture sector generates GHGs and its potential effects?

ii) How adaptation and mitigation measures can be incorporated in the Indian agriculture sector to reduce its potentiality of GHGs emission?

## 7. RESEARCH METHODOLOGY

In order to find out the satisfactory answers to the proposed research questions, secondary data, policies, facts and figures from various Government publications, independent research articles have been consulted and examined and used, although without any statistical or econometric method.

## 8. RESULTS AND DISCUSSION

### 8.1 CLIMATE CHANGE POTENTIALITY OF AGRICULTURE SECTOR

The direct contribution of agriculture to climate change causing total global GHGs emissions is about 10–15 per cent (Table -1) and with indirect emissions from land use change (viz., deforestation and cultivation of peat lands) and input production as well, this share rises to more than 30 per cent. Agriculture is also the largest producer of both Methane and Nitrous Oxide, together making up about 22 per cent of global emissions.

**TABLE-1: GLOBAL GREENHOUSE GAS EMISSIONS BY SECTORS**

| Power | Waste and wastewater | Land use change and forestry | Agriculture | Industry | Residential & commercial buildings | Transportation |
|---|---|---|---|---|---|---|
| 26per cent | 3per cent | 17per cent | 14per cent | 19per cent | 8per cent | 26per cent |

**Source:** 'Potentials for Greenhouse gas mitigation in agriculture', GIZ

Below (Table-2) is the share of different sub-sectors of direct contribution towards GHGs emissions in agriculture sector –

**TABLE- 2: DIRECT GHGs EMISSION FROM AGRICULTURE (15 PER CENT OF TOTAL GHGs EMISSIONS)**

| A: Sub-Sectors | Contribution (in per cent) | B: Share of Gas (per cent) |
|---|---|---|
| **Soils ($N_2O$)** | 40 | $N_2O$ – 46 per cent |
| **Enteric Fermentation ($CH_4$)** | 27 | $CH_4$ – 45 per cent |
| **Rice ($CH_4$)** | 10 | $CO_2$ – 9 per cent |
| **Energy-related $CO_2$** | 9 | |
| **Manure Management($CH_4$)** | 7 | |
| **Other ($N_2O$)** | 6 | |

**Source:** 'Potentials for Greenhouse gas mitigation in agriculture', GIZ

**TABLE 3: ATMOSPHERIC CONCENTRATION, LIFETIME AND GLOBAL WARMING POTENTIAL (GWP) OF MAJOR GREENHOUSE GASES**

| Greenhouse gas | Atmospheric concentration | Lifetime (Years) | GWP (100 Years) |
|---|---|---|---|
| **Carbon dioxide** | 387 ppm | Variable | 1 |
| **Methane** | 1780 ppb | 12 | 25 |
| **Nitrous oxide** | 319 ppb | 114 | 298 |
| **CFC 11** | 250 ppt | 45 | 4600 |
| **CFC 12** | 533 ppt | 100 | 10600 |
| **HCFC 22** | 132 ppt | 11.9 | 1700 |
| **HFC 23** | 12 ppt | 260 | 12000 |

**Source:** 'Greenhouse Gas Emissions from Agriculture', H. Pathak, et. al., 'Climate Change Impact, Adaptation and Mitigation in Agriculture: Methodology for Assessment and Application', IARI, 2012

The atmospheric concentration of both Methane (1780 ppb) and Nitrous Oxide (319 ppb) (Table-3) has increased markedly world over predominantly due to agriculture and use of fossil fuel. Globally, 60 per cent of $N_2O$ and 50 per cent of $CH_4$ emissions come from agriculture. Moreover, during 1990 to 2005, agricultural Methane and Nitrous Oxide emissions increased by 17 per cent. Soil (38 per cent of $CH_4$ & $N_2O$), rice production (11 per cent of $CH_4$) and biomass burning (12 per cent of $CH_4$ & $N_2O$) are the three major sources of global Methane and Nitrous Oxide emissions from the agriculture sector.

In India, among other sources, agriculture sector contributes 28 per cent of the country's GHGs emissions as per the sources of Ministry of Environment and Forest (2008), thus it will be a big loser as a consequence of climate change.

**8.2 SOURCES IN INDIA**

As a GHG, **Nitrous Oxide ($N_2O$)** is 298 times more effective than $CO_2$, (Table-3):

– $N_2O$ from agricultural soils is released due to the microbial processes of nitrification and denitrification in the soil resulting in direct or indirect emissions. Direct soil $N_2O$ emissions is caused due to nitrogen input such as synthetic fertilisers, animal waste, through biological nitrogen fixation, from reutilised nitrogen from crop residues, and from sewage sludge application, and from organic soil due to enhanced mineralization; while, indirect $N_2O$ emissions take place after nitrogen is lost from the field as $NO_x$, $NH_3$ or after leaching or run-off.

**Methane ($CH_4$)** is about 25 times more effective as a GHG than $CO_2$ (Table-3):

– $CH_4$ is mainly produced as a by-product of the digestion of feed (like fibrous plants) in the rumen of the ruminant animals, under anaerobic condition and its emission is related to the composition of animal diet (grass, legume, grain and concentrates) and the proportion of different feeds (e.g., soluble residue, hemi-cellulose and cellulose content). Since, the digestion (enteric fermentation) is only 50-60 per cent efficient, some of the feed energy (i.e., 4-15 per cent) is lost in the form of Methane.

– Methane is also formed in soil through the metabolic activities of specific bacterial group - 'Methanogens' whose microbial activity increases in the sub-merged, anaerobic conditions in the wetland rice fields, which limit the transport of oxygen into the soil, and render the water-saturated soil devoid of oxygen. Decomposition of organic material in flooded rice fields produces $CH_4$, which escapes into the atmosphere primarily by vascular transport through the rice plants. India has vast areas of paddy fields.

**Animal agriculture –** In India, approximately, 50 per cent of all corn consumed used as animal feed mostly for poultry. Per capita egg consumption in India has more than doubled between 1980 and 2005, while meat consumption grew 38 per cent and milk consumption grew 69 per cent during the same period which puts pressure on agri-resources to feed these animals and contributes to deforestation. Moreover, compared to traditional farming system, the factory farms generate high amount of manures more than the absorbing capacity of the surrounding land and crops, causing pollution and contamination of the environment and generation of Methane.

**Biomass fires –** In India, large amount of crop residues of rice, wheat, cotton, maize, millet, sugarcane, jute, pulses, rapeseed-mustard and groundnut generated remain left in the fields during the use of mechanised combines and it is burnt to clear the remaining straw and stubble after the harvest to prepare the land for the next growing season. Gases produced by the biomass burning are $CO_2$, $N_2O$, $CH_4$, carbon monoxide, non-Methane hydrocarbons, nitric oxide, and atmospheric particulates.

**Fertiliser industry** – Especially, after the Green Revolution, fertiliser consumption has been increased in India, causing accumulation of heavy metals (Hg, Cd, As, Pb, Cu, Ni, and Cu; natural radionuclide like 238U, 232Th, and 210Po) in soil. Plants absorb the fertilisers which in turn enter the food chain, causing water, soil and air pollution. In India, per hectare consumption of nitrogeneous fertilisers is the highest – 166.58 lakh tones per hectare (2010-11) in comparison to Phosphatic and Potassic nutrients, causing $N_2O$ emissions. Moreover, the energy-intensive production of nitrogen fertiliser releases high amounts of $CO_2$ in the atmosphere (estimated at 1.2 per cent of total world GHGs emission).

**Soil** – Tilled soil in India emits more $CO_2$ than undisturbed soil (no till). Similarly, soil temperature has effect on $CO_2$ emission from soil by influencing the root and soil respiration. Soil temperature also affects $CH_4$ by affecting anaerobic carbon mineralisation and methanogenic activity.

After discussing direct GHGs emissions, now I come to Indirect GHGs emissions. It accounts for 16 per cent of the global agricultural GHGs emissions –

- Downstream GHGs emissions cases – considerable amount of fuels are used in transport and processing of the agricultural produce and also refrigeration of perishable foodstuffs (e.g., dairy sector), post-harvest losses due to pests and diseases.
- Upstream GHGs emissions cases – irrigation, transport of inputs to the farms, etc.

Table-4 shows GHGs originating from different sources within agriculture in India. Methane ($CH_4$) from enteric fermentation accounts for the major share. GHGs emissions from agriculture sector have reduced from 344.48 million tones $CO_2$-eq in 1994 to 334.41 million tones $CO_2$-eq in 2007.

**TABLE 4: GHGs EMISSIONS IN AGRICULTURE FROM DIFFERENT SOURCES FOR THE YEAR 2007 IN INDIA** (in thousand tonnes)

| **Agriculture** | **$CH_4$** | **$N_2O$** | **$CO_2$ Equivalent** |
|---|---|---|---|
| **Enteric fermentation** | 10099.80 | | 212095.80 |
| **Manure management** | 115.00 | 0.07 | 2436.70 |
| **Rice cultivation** | 3,327.00 | | 69,867.00 |
| **Agricultural soils** | | 140 | 43440.00 |
| **Field burning of agricultural residues** | 226.00 | 6.00 | 6606.00 |
| **Sub-total** | 13767.80 | 146.07 | 334405.50 |

**Source:** Compiled from 'India Green house Gas Emissions 2007', MoEF, GoI, 2010

**8.3 EFFECTS AND SOLUTIONS**

**8.3.1 EFFECTS**

Due to climate change process atmospheric $CO_2$ level rises having a fertilisation effect on crops with C3 photosynthetic pathway promoting agricultural growth and productivity.

On the other hand, increased temperature due to GHGs accumulation is likely to exacerbate drought conditions during sub-normal rainfall years, especially in large areas in Rajasthan, Andhra Pradesh, Gujarat, and Maharashtra and some areas of Karnataka, Orissa, Madhya Pradesh, Tamil Nadu, Bihar, West Bengal, and Uttar Pradesh. It will reduce crop duration, increase crop respiration rates, affect the survival and distribution of pest populations, hasten nutrient mineralisation in soils, decrease fertiliser-use efficiencies, and increase evapo-transpiration rate as direct effects. For each 10°C rise in mean temperature, wheat yield losses in India are likely to be around 7 million tonnes per year.

The negative effects would outweigh the positive effects and agriculture being a major source of GHGs, will intensify the negative effects, thereby, affecting food production which is required to keep increasing up to 300 mt by 2020 in order to feed its rising population likely to reach 1.30 billion by 2020.

**8.3.2 SOLUTIONS**

Of the two types of solution measures – Mitigation and Adaptation, the former addresses the causes of climate change (accumulation of GHGs in the atmosphere), while the latter addresses the climate change impacts. Both approaches are needed because even with strong mitigation measures, the climate would continue changing in the next decades and adaptation will not be able to eliminate all negative impacts and mitigation efforts are critical to limit changes in the climate system.

**8.3.2.1 ADAPTATION**

Adaptation is defined as adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

SOME IMPORTANT ADAPTATION MEASURES

Expansion of rainwater harvesting, Water storage and Conservation techniques, Water-use and Irrigation efficiency, Water reuse, Desalination, Adjustment of plantation time and Crop variety, Crop relocation, Improved land management, e.g., erosion control and soil protection through tree planting. Changes in land use to maximise yield under new conditions, application of new technologies, new land management techniques, and water-use efficiency techniques, Seasonal changes and changing sowing dates and different varieties or species, Forest fire management and/or other Natural disasters, etc. The adaptability of Indian farmers is severally restricted due to high reliance on natural factors and also lack of complementary inputs and institutional support systems.

**8.3.2.2 MITIGATION**

With respect to climate change, mitigation is defined as implementation of policies to reduce GHGs emissions and enhance sinks.

**SOME IMPORTANT MITIGATION MEASURES**

Improved crop and grazing land management to increase Soil Carbon Storage, Restoration of degraded lands, improved Rice cultivation, Improved water management practices, Efficient use of inorganic fertilisers, Livestock and Manure management by increasing feed use efficiency to reduce $CH_4$ emissions, improved nitrogen fertiliser application techniques to reduce $N_2O$ emissions, dedicated energy crops to replace fossil fuel use, improved energy efficiency, improvements of crop yields, etc.

**8.3.3 MEASURES ACT BOTH AS MITIGATION AND ADAPTATION FOR AGRICULTURE**

Agro-forestry in coffee plantations creates a multi-level canopy with coffee plants in the lower portion – it stores more carbon in comparison to conventional plantations and thus mitigates GHGs emissions. At the same time, shading of coffee in the lower canopy produces a microclimate that can reduce maximum leaf temperature by as much as $5^0$C and buffer the coffee plants against extreme expected temperature increases.

**8.3.4 MEASURES CONTRADICTORY TO EACH OTHER**

Use of bio-fuels as alternative to fossil fuels reduce GHGs emissions in the transport sector, will be countered by an increase of GHGs due to increase in energy requirement for water supply for production of bio-fuel crops and also its production causes pressure on marginal land and forested land and thereby, challenges food security.

**8.3.5 POLICY OPTIONS IN AGRICULTURE WITH MULTIPLE BENEFITS**

i) Reducing Methane ($CH_4$) emissions via integrated rice and livestock systems traditionally found in West Africa, India, Indonesia and Vietnam, is a mitigation strategy that also results in better irrigation water efficiency, improved performance of cultivated agro-ecosystems, and enhanced human well-being.

ii) Reduced nitrogen fertiliser applications improves water quality and also reduces $N_2O$ emissions.

## 9. CONCLUSIONS AND RECOMMENDATIONS

### 9.1 CONCLUSIONS

1. India's rice cultivation methods cause emissions of $CH_4$, a highly potent GHG.
2. Need to shift from very high to medium nitrogen fertilisation level for reduced $N_2O$ emissions.
3. Practice of agricultural residues burning can be done more scientifically to avoid GHGs emissions.
4. With changing food habits due to increasing income level, India faces pressure on agriculture production which needs to be addressed by appropriate animal feeds as changing the food habits is difficult.
5. The negative effects of climate change will outweigh the positive effects hence, agriculture's potential for generation of climate changing GHGs emissions should be reduced.
6. Adaptation and Mitigation measures are to be chosen keeping in view of synergies and trade-offs with other policies.

The first research question is answered in the 'SOURCES IN INDIA' subsection. After discussing the various intricacies of the Adaptation and Mitigation measures I am presenting the answer to the second research question in the RECOMMENDATIONS section.

### 9.2 RECOMMENDATIONS

1. Practicing agro-forestry can promote soil carbon sequestration which improves agro-eco-system function and resilience to climate extremes by enriching soil fertility and soil water retention, recharging of ground water reservoirs for declining water tables.
2. Organic agriculture depends upon crop rotation, crop residues, animal manures, farm organic waste, mineral grade rock additives and biological system of nutrient management and pest and diseases control, low use of chemical fertilisers, pesticides, hormones, and has the potential to mitigate climate change. Under this, soil carbon sequestration rates on arable lands range from 200 kg to 2000 kg of carbon per hectare per year above conventional agriculture. It also reduces direct and indirect use of energy due to minimum/zero use of industrial fertilisers and pesticides; and lower $N_2O$ due to lower overall nitrogen input per hectare than in conventional agriculture. Though organic farms' average yield is lower than that of conventional farms by 10-15 per cent but the lower yields are balanced by lower input costs and higher margins.
3. Soil carbon stock in cropping systems can be increased to protect existing carbon in the system by slowing decomposition of organic matter and reducing erosion by reducing the frequency with which the soils are tilled (reduced tillage, or no tillage), by using perennials (which have larger root systems than annuals), applying biochar - often referred to as 'conservation agriculture'.
4. Altering water management practices, particularly mid-season aeration by short-term drainage as well as alternate wetting and drying can greatly reduce Methane emission from rice cultivation. Improving organic matter management by promoting aerobic degradation through composting or incorporating into soil during off-season drain-period is another promising technique.
5. Reducing emissions from enteric fermentation can be done by improvement in quality of feeds to improve digestibility – only 3 - 6 per cent of energy would be converted into Methane.
6. Food wastage reduction is a huge opportunity for reductions in costs and also in emissions along the entire supply chain.
7. Recycling of farm residues (e.g., straw, manure or food processing residues) instead of bio-fuel crops for production of bio-energy.
8. Avoiding of biomass and crop residues burning for maintaining maximum biomass in the field for mulching and incorporation.
9. Improved manure management as manure storage under cover, compost preparation.
10. For effective implementation of adaptation and mitigation measures in agriculture stakeholder engagement is necessary.

## 10. SCOPE FOR FURTHER RESEARCH

I wish to make a case study of a particular crop in a particular field area where the effects of agricultural practices on climate change can be assessed and based on it, a statistical model can be developed with predictions on agricultural productivity under different climate parameters.

## REFERENCES

1. Agricultural Greenhouse gases, California Environmental Associates, March, 2014
2. Babu, K. Lenin & Raju, K. V., (2009), 'Green house gases emissions and potential carbon sequestration: A case study of semi-arid area in south India', Working Paper - 211, Institute for Social and Economic Change
3. Bockel, Louis & Smit, Barry, (2009), 'Climate Change and Agriculture Policies - How to mainstream climate change adaptation and mitigation into agriculture policies? -Advanced Draft of Policy Guidelines', EASYPol
4. Bockel, Louis (2009), 'How to mainstream climate change adaptation and mitigation into agriculture policies?', EASYPol
5. Chand, Ramesh, et.al. (2015), 'Fertliser use and Imbalance in India: Analysis of States', Economic and Political Weekly, Vol-L, No.-44, Oct. 31
6. Chaturvedi, Vaibhav, (2015), 'The Costs of Climate Change Impacts for India', CEEW Working paper 2015/11, March
7. Climate Change 2014: Synthesis Report – Summary for Policymakers, IPCC
8. Climate Change Adaptation and Mitigation – Challenges and Opportunities in the food sector, Food and Agriculture Organisation, 2012
9. Climate change adaptation and mitigation in the food and agriculture sector, Food and Agriculture Organisation, March 5-7, 2008
10. Climate Change and Food Security: A Framework Document, Food and Agriculture Organisation of the United Nations, Rome, 2008
11. Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries, United Nations Framework Convention on Climate Change (UNFCCC), 2007
12. Dutta, Satrajit (2015), 'Climate Change and Indian Agriculture', Vol.-XXXVI, No.-10, World Focus, ISSN- 2230-8458, October, pp.131-137
13. Dutta, Satrajit (2015), "Indian Economy in the Light of 'Green Economy' Concept", Proceedings of the Fourth International Conference on Global Business, Economics, Finance and Social Sciences (GB15Kolkata Conference) ISBN: 978-1-63415-898-5, Kolkata-India. December 18-20, Paper ID - K558

14. Economic Surveys, 2014-15, 2013-14, 2012-13, 2011-12, Min. of Finance, Govt. of India
15. Estimating Greenhouse Gas, Emissions in Agriculture: A Manual to Address Data Requirements for Developing Countries, Food and Agriculture Organisation, UN, 2015
16. Garg, Amit, Shukla, P.R., Bhattacharya, Sumana & Dadhwal, V.K., 'Regional and Sectoral Assessment of Greenhouse Gas Emissions in India', Paper Published in Atmospheric Environment, Vol. 35/15, e2 Analytics, pp. 2679-2695
17. Gupta, Shreekant, Sen, Partha & Srinivasan, Suchita (2012), 'Impact of climate change on the Indian economy: Evidence from foodgrain yields', Working Paper No. 218, Centre for Development Economics, Delhi School of Economics, September
18. India: Greenhouse Gas Emissions 2007, MoEF, Govt. of India, May 2010
19. Kahjuria, Anupam, & Ravindranath, N.H., (2012), 'Climate Change in context of Indian Agricultural Sector', Earth science and Climatic Change, Vol.3, Issue1, pp.1-4
20. Keane, Jodie, Page, Sheila, Kergna, Alpha & Kennan, Jane (2009), 'Climate Change and Developing Country Agriculture: An Overview of Expected Impacts, Adaptation and Mitigation Challenges, and Funding Requirements, Issue Brief No.2, International Centre for Trade and Sustainable Development (ICTSD), December
21. Klein, Richard J.T., Schipper, E. Lisa F. & Dessai, Suraje, (2005), 'Integrating mitigation and adaptation into climate and development policy: three research questions', Environmental Science & Policy 8, pp. 579-588
22. Kumari, K. Anitha, Kumar, K.N.Raja & Rao, CH. Narasimha, (2014), 'Adverse effects of chemical fertilisers and pesticides on human health and environment', Journal of Chemical and Pharmaceutical Sciences, Oct., pp.150-151
23. Locatelli, Bruno (2011), 'Synergies between adaptation and mitigation in a nutshell', Center for International Forestry Research, August
24. Mishra, J. P. (2016), 'Agriculture and Farmers Well Being: Present Scenario', Yojana, Vol. 60, June, pp.11-14
25. Mitigating Greenhouse Gases in Agriculture - A challenge and opportunity for agricultural policies, Diakonisches Werk der EKD e.V., November 2011
26. Pardis & Devakumar, A S (2014), 'Green House Gas Emission of Major Agriculture Crops of Southern India', 2nd International Conference on Sustainable Environment and Agriculture, IPCBEE Vol. 76
27. Pathak, H, Aggarwal, P.K. & Singh, S.D., eds. (2012), 'Measures of Greenhouse gas emissions from crop, livestock, and aquaculture', NICRA Manual Series 2, IARI
28. Potentials for Greenhouse gas mitigation in agriculture, GIZ, March, 2014
29. Ranade, Prabha Shastri, Impact of climate change on agriculture, ISPRS Archives XXXVIII-8/W3 Workshop Proceedings, pp.183-185
30. Rodriguez, Elizabeth, Sultan, Ryan & Hilliker, Amy (2004): Negative Effects of Agriculture on Our Environment, The Traprock, Vol. 3, May, pp.28-32
31. Sathaye, Jayant & Najam, Adil, (2007), 'Sustainable Development and Mitigation', Chap.-12, Sustainable Development and Mitigation, In Climate Change 2007: Mitigation, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, pp.691-744
32. Savci, Serpil (2012), 'An Agricultural Pollutant: Chemical Fertilizer', International Journal of Environmental Science and Development, Vol. 3, No. 1, February
33. Sharma, A.R. & Behera, U.K. (2008), 'Modern concepts of Agriculture – Conservation Tillage'
34. Sharma, Subodh K., et.al. (2011): Greenhouse gas inventory estimates for India, Current Science, Vol. 101, No. 3, August 10, pp.405-415
35. Shetty, P. K., Ayyappan, S. & Swaminathan, M. S., eds., (2013), 'Climate Change and Sustainable Food Security', NIAS & ICAR
36. Singh, R.B. (2000), 'Environmental consequences of agricultural development: A case study from the Green Revolution state of Haryana, India', Agriculture, Ecosystems and Environment, 82, pp.97-103
37. Singh, S.D., Pathak, H. & Aggarwal, P.K. (2012), 'Climate Change Impact, Adaptation and Mitigation in Agriculture: Methodology for Assessment and Application', IARI, March
38. Smith, Pete, Martino, Daniel, et.al. (2007), Agriculture, Chapter-8, Agriculture, In Climate Change: Mitigation, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, pp. 497-540
39. Sridevi H., et. al., (2014), 'Comparative analysis of greenhouse gas emissions from major cities of India', International Journal of Renewable Energy and Environmental Engineering, ISSN 2348-0157, Vol. 02, No. 01, January
40. State of Indian Agriculture, 2012-13, Min. of Agriculture, Govt. of India
41. Strategies for mitigating climate change in agriculture, California Environmental Associates, April, 2014
42. The impact of animal agriculture on the environment and climate change in India: A focus on methane, HSI Fact sheet, Humane Society International, May, 2011
43. Tubiello, Francesco N., et. al. (2015), 'Estimating Greenhouse Gas Emissions In Agriculture - A Manual to Address Data Requirements for Developing Countries', Food and Agriculture Organisation
44. Tubiello, Francesco N., Schmidhuber, Josef, Howden, Mark, Neofotis, Peter G., Park, Sarah, Fernandes, Erick & Thapa, Dipti, (2008), 'Climate Change Response Strategies for Agriculture: Challenges and Opportunities for the 21st Century', Agriculture and Rural Development Discussion Paper 42, The International Bank for Reconstruction and Development/The World Bank
45. Twelfth Five Year Plan (2012-17) Vol-I, II & III, Govt. of India
46. Verchot, Louis V., Noordwijk, Meine Van, Kandji, Serigne, Tomich, Tom, Ong, Chin, Albrecht, Alain, Mackensen, Jens, Bantilan, Cynthia, Anupama, K. V. & Palm, Cheryl, (2007), 'Climate change: linking adaptation and mitigation through agroforestry', Mitig Adapt Strat Glob Change
47. Yedla, Sudhakar & Peddi, Sowjanya (2003): Roles of Agriculture (ROA) India Environment National Assessment, October.

# *REQUEST FOR FEEDBACK*

**Dear Readers**

At the very outset, International Journal of Research in Commerce, Economics & Management (IJRCM) acknowledges & appreciates your efforts in showing interest in our present issue under your kind perusal.

I would like to request you to supply your critical comments and suggestions about the material published in this issue as well as, on the journal as a whole, on our e-mail **infoijrcm@gmail.com** for further improvements in the interest of research.

If you have any queries, please feel free to contact us on our e-mail **infoijrcm@gmail.com**.

I am sure that your feedback and deliberations would make future issues better – a result of our joint effort.

Looking forward to an appropriate consideration.

With sincere regards

Thanking you profoundly

**Academically yours**

Sd/-
**Co-ordinator**

# DISCLAIMER

# ABOUT THE JOURNAL

In this age of Commerce, Economics, Computer, I.T. & Management and cut throat competition, a group of intellectuals felt the need to have some platform, where young and budding managers and academicians could express their views and discuss the problems among their peers. This journal was conceived with this noble intention in view. This journal has been introduced to give an opportunity for expressing refined and innovative ideas in this field. It is our humble endeavour to provide a springboard to the upcoming specialists and give a chance to know about the latest in the sphere of research and knowledge. We have taken a small step and we hope that with the active co-operation of like-minded scholars, we shall be able to serve the society with our humble efforts.

## Our Other Journals