ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 8, Issue, 12, pp.43312-43319, December, 2016

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

PLANNING AND DEVELOPING THE RESOURCES BY CARBON FOOTPRINT ASSESSMENT

***Dr. Manoj Kumar**

Manager (M), Forest Déptt., CCL, Ranchi-29

ARTICLE INFO

Article History:
Received 03rd September, 2016
Received in revised form
19th October, 2016
Accepted 10th November, 2016
Published online 30th December, 2016

Key words:

GHG,
Footprint,
Pathways,
Emission.

ABSTRACT

Climate change related policies, action plans and GHG Protocol's Lifecycle Accounting and Reporting Standard were used to develop a model for assessment of carbon foot print of a large opencast coal mine in India. 28 numbers of mining activities grouped into Scope-1, Scope-2 & Scope-3 as per GHG protocol corporate standard. These activities either direct or indirect emitters are main contributors of GHG emissions during coal mining process. 20 nos. of empirical mathematical relations were used with assumptions. The paper also describes the Green House Gas (GHG) reduction measures in an opencast coal mine.27 pathways of GHG reduction along with 14 general pathways have been identified from different sources. The paper will certainly help the mine managers to reduce their carbon foot print & help the India's INDC commitment for reducing 2% of carbon emission as per Paris 2015 submits. Rural settlement sets on transforming to urban settlement on development of mines in a locality. Thus knowledge of carbon footprint beforehand will also help planners in planning and developing urban settlement in and around an open cast mine As per study although overall GHG emission has increased the GHG emission per unit of coal production has shown a decreasing trend. The majority of GHG emissions apart from fugitive emission are from diesel consumption. The study can be replicated in other similar units of India also. The results have been illustrated through graphs, tables and figures.

Citation: Manoj Kumar, 2016. "Planning and developing the resources by carbon footprint assessment", *International Journal of Current Research,* 8, (12), 43312-43319.

INTRODUCTION

Coal mining has encouraged urbanization. The cities developed in and around the coal mines stem from the combination of industrialization and urbanization. The rural settlement has been transformed to urban settlement. Globally, economic and population growth in coal mining areas continue to be the most important drivers of increases in CO_2 emissions from fossil fuel combustion. The mining industry is a major global energy user, but is not a significant GHG producer. Whole world is looking for clean energy. Coal being the prime source of energy needs to be cleaner and cleaner. A clean coal will result in less GHG emission. Carbon management for the urban population so developed near the coal mines will probably be the single most important challenge in the context of the enhanced greenhouse effect due to the various activities related to coal mining. Emission of CO_2, the principal greenhouse gas (GHG), is strongly related to use of fossil fuels, especially coal, for energy production. Increasing population and consequent increasing energy demand warrants development of strategies to assess greenhouse gas emission level with minimum uncertainty and also to ensure stabilized emission to a desired level. So it is essential to carryout research to find out engineering solutions.Carbon footprint measurement is one such solution. Once the size of carbon footprint is known, a strategy can be devised to reduce it, which will help conserve the resources in a sustainable manner. Greenhouse gases (GHG) as per Kyoto Protocol includes Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Hydroflourocarbons (HFCs), Perfluorocarbons (PFCs), Sulphur Hexafluoride (SF_6). As per International Panel of Climate Change – 1997 -CO_2 contributes about 77%, CH_4 – 14%, N_2O – 8%, F-gases – 1% of the global GHGs. As per IPCC – 2015: CO_2 emissions from fossil fuel combustion and industrial processes contributed about 78% to the total GHG emission.

Aim

As the world is looking for clean energy, the cleaner coal may be one of the solutions. The clean coal will result in less GHG emission. This requires an approach for producing clean and cleaner coal. Keeping this in mind a study was made to develop a model for carbon foot print assessment of an opencast coal mine and deduce the Green House Gas (GHG) reduction measures which helps the initial rural habitat and

Corresponding author: Dr. Manoj Kumar,
Manager (M), Forest Déptt., CCL, Ranchi-29

then urban habitat developed due to the establishment of coal mines and its ancillary activities.

Scope of study

These study were in accordance with GHG Protocol's Lifecycle - Accounting and Reporting Standard (Kumar, Manoj 2015). The assessment will further help the coal company to conserve the resources under their control. This model houses 20 empirical mathematical relations. The study area is the leasehold area of one of the opencast project of North Karnpura Coalfield of Jharkhand state. The study starts with selecting physical boundary and operational boundary. The various activities in operational boundaries of a mine are as under: disturbed area where tree cutting, felling and removal of top soil is in progress, area where overburden (OB) is being removed, OB dump site, current mining faces, de-coaled area where extraction of coal has been completed but no reclamation is done, de-coaled area where extraction completed and concurrent reclamation done, backfilled area where afforestation activity has been undertaken and the area has been restored, workshop, washery, coal stock yard etc. Emissions from oxidation of waste coal, spoil dump and fugitive emission is not being accounted because there is no accounting of quantity and huge uncertainty associated with it. Fig. 1.0 shows the conceptual coal Life Cycle Assessment (LCA) system covering typical view of physical (organizational) and operational boundary of study area. The study has been concentrated on this model.

MATERIALS AND METHODS

These studies were in accordance with GHG Protocol. Measurement of GHG emissions and includes (Kumar and Sangeeta, 2015): Identification of emission sources, Calculation approach, Collecting data, Applying suitable emission factors, Deriving total carbon footprint. Calculations were based on different activities in life cycle of coal production (Kumar and Sangeeta, 2015) (Fig 2.0) which is broadly divided into Overburden removal, Extraction of coal (i.e. breaking and Removal), Monitoring & maintenance, Coal Stocking, Coal Cleaning & Recycling, Afforestation. These activities (i) were further subdivided into sub-activities (j) and sub-activities into activities level (k).

Calculation of Carbon footprint in this model are based on empirical formula (IPCC, 2015; United States Department of Energy (USDOE) 1999; www.unfccc.int/resource/docs/cop2/15a01.pdf**)**

$$TE = \sum_i \sum_j \sum_k ES$$

Where,

TE = Total emission in kg CO_{2e}
ES = Emission due to various activity level
$ES = activity\ level * emission\ factor$

The other empirical relation used in the model are summarized in Table 1.

Fig.1. Conceptual LCA system of Opencast Coal Mine

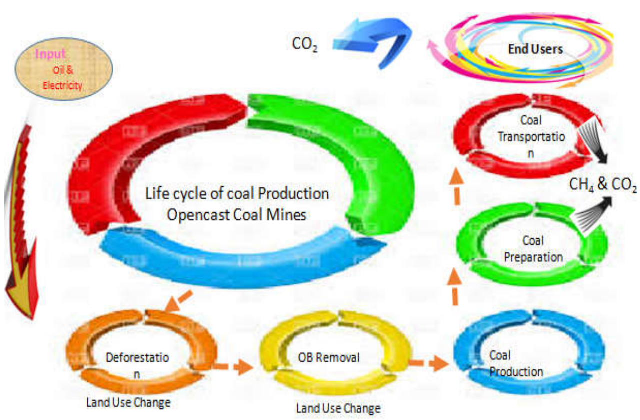


Fig.2. Life cycle of coal Production

Table 1. Empirical Relation for the model

(i)	$TE = \sum_i \sum_j \sum_k ES$
(ii)	$ES = activitylevel * emmissioncoefficient$
(iii)	$ES_a = CS_{perha} \times D_{ha/yr} \times M_R$
(iv)	$ES_b = CS_{perha} \times D_{ha} \times M_R$
(v)	$ES_c = SCS_{perha} \times D_{ha} \times \frac{1}{T} \times M_R$
(vi)	$ES_d = SCS_{perha} \times Dr_{ha} \times M_R$
(vii)	$ES_e = \sum (FC_{lt} \times EF_{kggas/lt})$
(viii)	$ES_f = EC_{kwh} \times EF_{grid}$
(ix)	$ES_g = EC_{kwh} \times EF_{grid} \times {}^{1}/_{CF}$
(x)	$ES_h = EB_t \times EF_{Ex}$
(xi)	$ES_i = LC_{lt} \times CCL_{lub} \times ODU_{Lub} \times M_R$
(xii)	$ES_j = P_{tes} \times EF_{CH4} \times GWP_{CH4}$
(xiii)	$ES_k = Aff_{ha} \times EF_{aff}$
(xiv)	$ES_{li} = D_{km} \times EF_{ECi} \times 1/1000$
(xv)	$ES_m = C_{kg} \times L_{annual} \times GWP$
(xvi)	$ES_n = E_{\$} \times EF_{Cons}$
(xvii)	$ES_o = P_{cc} \times R_a \times EF_{CB} \times SF$
(xviii)	$ES_p = W_{ct} \times EF_{TW}$
(xix)	$ES_p = W_{cnt} \times EF_{NTW}$
(xx)	$ES_q = W_{ctcu} \times EF_{TW}$
(xxi)	$ES_r = W_{cntcu} \times EF_{TW}$
Where	
TE	Total emission in kg CO_{2e}
CF	T&D loss correction factor
$CS_{per\ ha}$	Carbon stock per ha of forest area
CCL_{Lub}	Carbon content of Lubricant in Kg / Litres
C_{kg}	Estimated charge volume of refrigerant gas
D_{km}	Employee commuting or distance covered in km
$D_{ha/yr}$	Area of deforestation of forest land per year in ha.
D_{ha}	Area of deforestation of forest land in ha
Dr_{ha}	Soil drainage area in ha
EB_t	Amount of explosive blasted in tons
EC_{kwh}	Electricity consumption in kwh
EF_{Ex}	Emission factor of an explosive.
ES	Emission due to various activity level
$E_{\$}$	Expenses on consumables in $
FC_{lt}	Fuel consumption in litre.
GWP	Global warming potential of refrigerant
GWP_{CH4}	Global warming potential $CO_2$to CH_4 (1:21)
LC_{lt}	Lubricant consumption in litres
L_{annual}	Leakage of refrigerant gas annually
M_R	mass ratio of CO_2 to C = 44/12
ODU_{Lub}	ODU (oxidized use) factor (default =0.2)
Pcc	Production of Clean coal in Tes
P_{tes}	Amount of Coal Produced in tes
R_a	Reduction in Ash %
$SCS_{per\ ha}$	Carbon stock of soil per ha of forest area
SF	Saving Factor (= 0.75% for 1000 km of Rail Transportation)
T	Transition period of loss of soil organic matter
W_{ct}	Water Consumption in cum
W_{cnt}	Water usages in cum
W_{ctcu}	Water consumption of treated water not used by self (community use) in cum
W_{cntcu}	Water consumption of without treated water not used by self (community use) in cum
	GHG emission due to
ES_a	Forest bio mass in kg CO_{2e}
ES_b	Forest carbon stock changein kg CO_{2e}
ES_c	Minieral Soil carbon loss in kg CO_{2e}
ES_d	Soil disturbance and degradation in kg CO_{2e}
ES_e	Fuel combustion in kg CO_{2e}
ES_f	Purchased electricity in kg CO_{2e}
ES_g	Electricity AT &C losses in kg CO_{2e}
ES_h	Explosiveblasted in kg CO_{2e}
ES_i	Cumbustion of Lubricant in kg CO_{2e}
ES_j	Emission of a given GHG by coalmining (kg GHG)
ES_{li}	Employee commuting in kg CO_{2e}
(i=1,2,,7)	Car, Air, Rail, Bus, Auto rickshaw, Motorbike, bicycle / foot for i=1,2,3,4,5,6,7 respectively. (emission in for car gCO_{2e}/km & others in gCO_{2e}/p/km)
ES_m	Fugitive emission ie leakage of refrigerant gas in kg CO_{2e}
ES_n	Consumption of consumable (paper, cartridgesetc.) in kg CO_{2e}
ES_p	Usage of water without treatment in kg CO_{2e}
ES_p	Usages of treated water in kg CO_{2e}

Continue……………..

	GHG emission reduction due to
ES_k	Removal GHG emission in kg CO2e
ES_o	Reduction due to Ash Reduction
ES_q	reduction due to usage of water used by community other than employee with treatment in kg CO_{2e}
ES_r	reduction due to usage of water by community other than employee without treatment in kg CO_{2e}
	Emission Factor of
EF_{aff}	afforestation
EF_{CB}	Emission factor of Coal Beneficiation
EF_{CH4}	given GHGby type of fuel in kg CH_4/ton)
EF_{cons}	Consumables
EF_{ECi}	Employee commuting through ith mode of travel
$EF_{kg\ gas/lt}$	Given GHG by type of fuel
EF_{grid}	grid of region
EF_{TW}	Water usage with treatment
EF_{NTW}	Water usage without treatment

Fig. 3 : Trend of CHG Emission [Scope wise

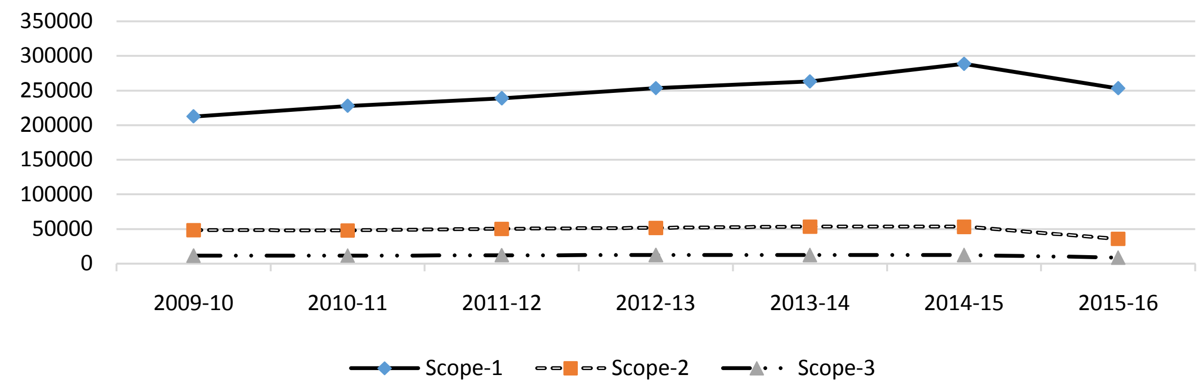


Fig 4 : CHG Emission Scope-wise & Yearwise

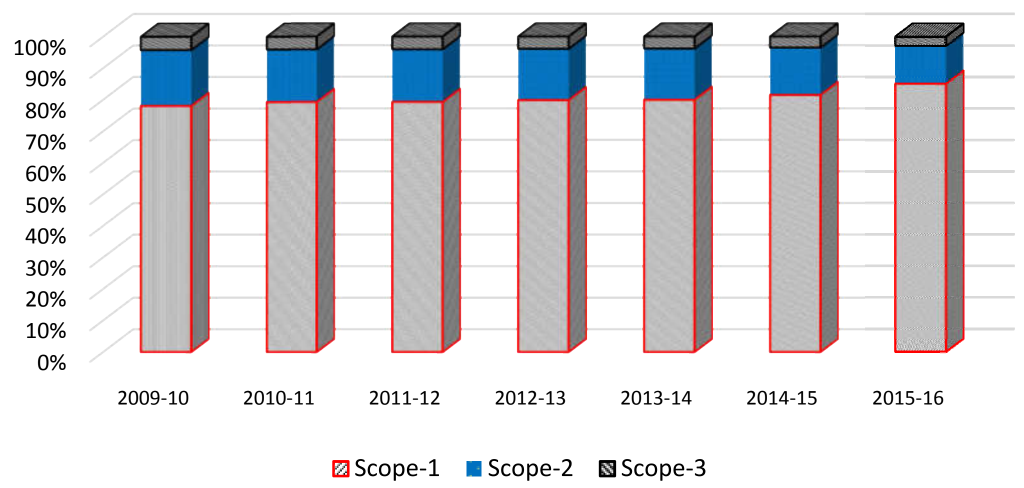


Fig 5 : SCOPE WISE GHG EMISSION SINCE 2009-10

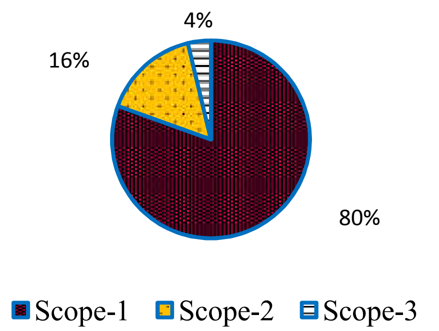


Fig 6 : GHG Load since 2009-10

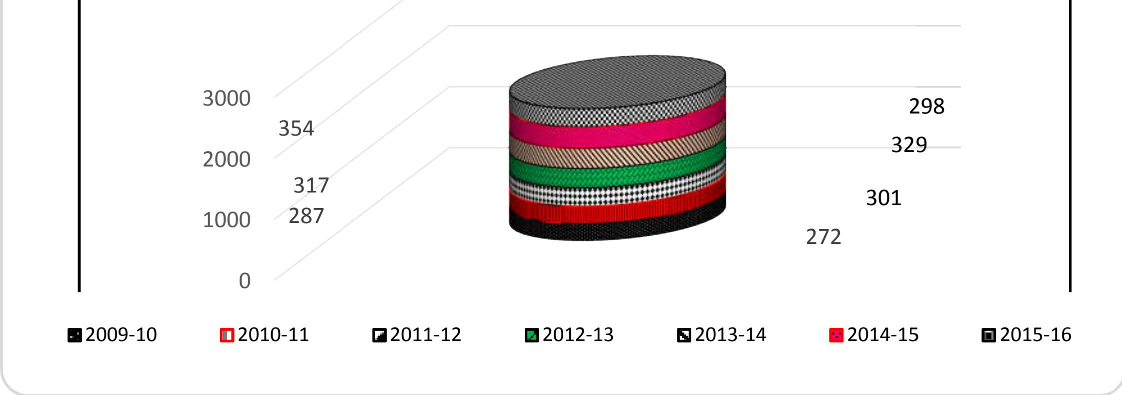


Fig 7 : CHG Emission per te vis a vis Coal production

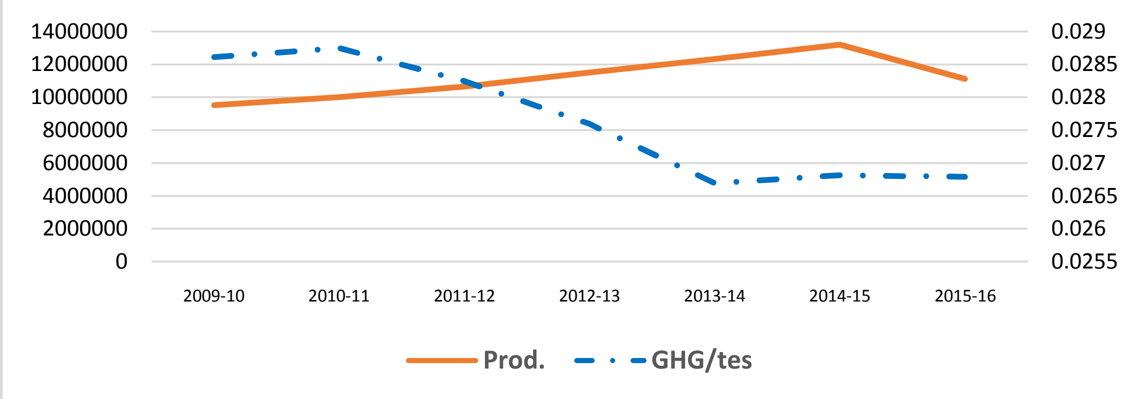


Fig 8: Hot Spot of Activities

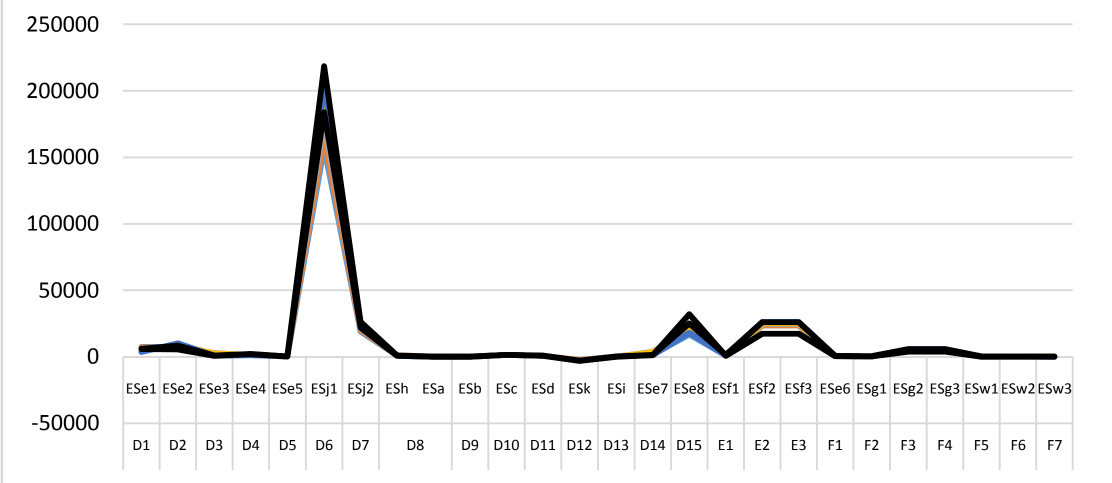
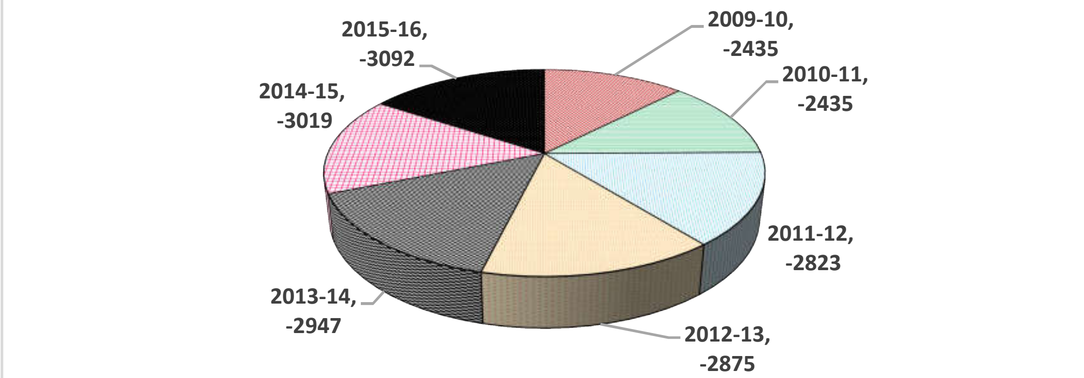


Fig 9 : CO2 sequestration



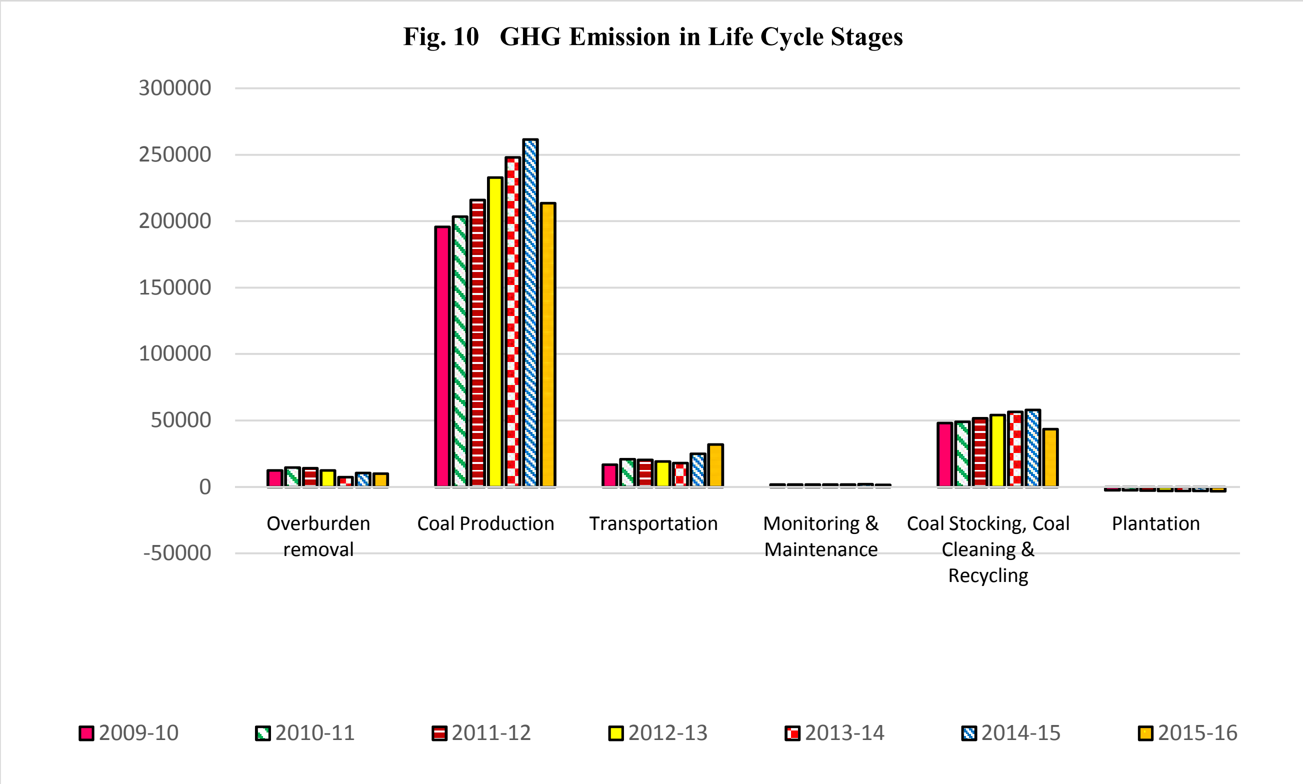


Table 2. GHG Reduction Measures

S.No.	Activity	09-10	10-11	11-12	12-13	13-14	14-15	15-16
1	Surface miner	83.160	160.830	158.396	166.278	157.066	296.985	148.628
2	Inpit crushing & Conveyor	2672.76	2412.38	2767.98	3099.81	3755.06	2602.86	895.784
3	Afforestation	2435.07	2435.07	2822.82	2874.52	2946.9	3019.28	3091.66
4	Compensatory Afforestation	4710.08	4710.08	5330.48	5775.1	5775.1	5775.1	5775.1
5	Existing Washery	6568	6504	7221	6561	6512	6560	4212
6	Timer in colony	nil	nil	nil	nil	nil	19630.07	13086.71
7	Supply of LPG cylinder	5777.20	5777.20	5777.20	5777.20	5777.20	5777.20	3851.47

Table 3. Scope for reduction in GHG emission

S.No.	Activity
1	Distribution of LED tube lights to employees
2	Replacement of existing fans with super energy fans in colony and offices
3	Replacement of existing tube lights / lamps in office with LED Tube lights
4	Switching off alternate street lights of colony after 11pm
5	Replacement of existing HPSV street light with LED street lights
6	Installation of meters for residential Quarters
7	Installation of floating pump house for dewatering
8	Implementation of Energy Saving measures for HEMMs to achieve benchmark diesel consumption
9	Deployment of Silo loading
10	Deployment of State of Art Belt Conveyor from mine to siding.
11	Solar Panel at various complexes (2 nos.)
12	Making separate arrangement of supply of water for (cooking + drinking) and (other rest)
13	Proposed Additional Washery (3.5 MTPA)

Table 4. GHG reduction by adopting further measures

Activity no.	GHG reduction in tes	Activity no.	GHG reduction in tes
1	859.56	2	182.54
3	49.64	4	44.04
5	280.86	6	Not quantified
7	3.02	8	4139.64
9	1966.18	10	12869.64
11	4960.91	12	44.757
13	804.03		

Case Study (DEFRA 2012; DEFRA 2013; Kumar, Manoj 2015)

This model was administered in one of the opencast coal mine using empirical equation at table 1 and covering 26 emission sources of which 16 emission sources were from Scope-1, three sources of Scope-2 and 7 sources of scope -3. The various activity Level includes: Forest bio-mass loss, Forest carbon stock change, Mineral Soil Carbon loss, Soil disturbance and degradation, Fuel use, Electricity (Purchased) use, Electrical AT & Losses, Explosive use, Lubricant use, Fugitive Emission, Carbon Stock Gain. This model have been administered over the period of 2009-10 to 2015-16. There was an increasing trend of GHG emission (Fig 3) ranging from 272 million tes CO_{2e} to 355 million tes CO_{2e} of which Scope-1 sources were the major contributors. Scope – 1 emission (Fig 4 & Fig 5) is the leading contributor amounting to about 80-81% followed by Scope-2 emissions with about 16-17 % and to Scope-3 emission ranging up to 4%. The emission load 21.58 Million tes of CO_{2e} (Fig. 6) has been contributed by the study area since 2009-10 with an average value of 27.6 kg CO_{2e} per ton of coal production. (Fig 7) The hot spots activity (Fig 8) point out for Source no. 6 i.e. contribution by fugitive emission is maximum. Other hot spot area is near source no. 16 to source no. 19. The mining operations are energy intensive and revolves around diesel consumption. Coal production process contributes maximum to life cycle stages of coal mining process (Fig. 10). The values ranges from 0.20 to 0.26 Million tes of CO_{2e} emission. Coal stocking, clearing and recycling process in LC stage are the next contributor ranging from 0.05 to 0.06 Million tes of CO_{2e} emission. The OB removal and the transportation process of LC stages have almost equal contribution i.e. 0.014 to 0.025 Million tes of CO_{2e} emission. There are some carbon stock gain enhances (Fig. 9) to the tune of 2435 to 3092 tes of CO_{2e} emission during afforestation done by the study area. This will increase in the times to come.

The total GHG Emissions revolves round the diesel consumption. The mining operations rely upon diesel powered machines. The GHG emission for diesel use i.e. the main fuel being used in the LC stage of coal production. The main contributor amongst them is coal evacuation process (ES_8) in scope-3 emission source contributing 38-39 %. The other contributor during coal production are ES_2 & ES_3 in Scope-1 emission source. (38-39% in combination) i.e. 76-78 % are contributed by ES_8, ES_2 & ES_3. In the years 2009-10, 2010-11, 2011-12, 2012-13 & 2013-14, 2014-15 & 2015-16 the GHG emission were 28.6, 28.7, 28.2, 27.6, 26.7, 26.8 & 26.8 kg CO_{2e} per ton of coal production respectively. The performance of GHG emissions per ton of coal production (Kumar and Sangeeta, 2015) in the study area though marginally increased from 2009-10 to 2010-11 seems to be improved from 2010-11 till 2013-14 and are flatten in last two years. There were continual improvement in performance of the order of 2%, 2%, 7% & 7% in subsequent year and a total of 7% from the 2010-11 level. The final analysis at the study area were found to be in order of fair GHG emission category. The GHG emission per unit of coal production has been a decreasing trend but the overall GHG emission has increased.

GHG reduction

The historic climate pact that was clinched in Paris puts India on board a global effort to achieve the global goal of "well below 2 degrees C" for temperature rise in order to tackle climate change. In the voluntary pledge — the Intended NDCs (INDCs) — submitted to the UNFCCC, India has submitted a goal of reducing emissions intensity of the GDP by 33-35 per cent over 2005 levels by 2030.The biggest loser in the Paris agreement could be the fossil fuel industry. Also it is scientifically estimated by the UN's IPCC that the world can emit only about 2900 billion tonne (gigatonne or Gt) of carbon dioxide from pre-industrialization level till 2100 to stay below 2^o Celsius global warming. But the world has already emitted 1,900 Gt of carbon dioxide till 2011, leaving only 1000 Gt of carbon space for the developing countries who still need to grow and thereby need to emit. Under this circumstances the coal companies may also contribute in combating the climate change by reducing the GHG emission. Though coal industry is not the major producers of the GHG, but can contribute a lot in providing cleaner fuel for further combating the climate change process. There is no single approach to achieve success of the GHG reduction commitment. It involves technical, managerial and human dimension and its unstained success depends on the right organizational climate. Many scientists agree that a doubling of atmospheric CO_2 concentrations could have a variety of serious environmental consequences (Barnett and Schlesinger, 1987; Lindzen, 1994; Santer *et al*., 1995; Adams *et al*., 1999). Technical ways to manage C include: (i) efficient use of energy (ii) increased usage of low-C or C-free fuels and renewable energy, and (iii) capturing and securely storing carbon emitted from the global energy system (C sequestration) (USDOE, 1999). This has also been advocated by Sri Subodh Varma in an interview with Times of India that there are three ways of combating climate change. The first way, which is the focus of traditional climate talks, involves reducing emissions of greenhouse gases. A second way involves planetary geoengineering, for example, by injecting sulfur into the stratosphere to cool earth's surface. Because of the high probability of unintended consequences, most scientists consider geoengineering extremely high risk - for example it may de-stabilise the south Asian monsoon. A third way of combating climate change is to draw enough CO_2 out of the atmosphere to make a difference to our climate future through biological & chemical approach. Biological approaches include initiatives such as reafforestation, the production of biochar, and wood chemistry technologies and Chemical pathways include the manufacture of carbon negative cements.

GHG reduction (in tes) by some of the measures till now at Piparwar OCP is given at Table 2. It can be observed that 0.19 M tes CO_{2e} of GHG emission have already been saved at study area by adopting various GHG emission reduction measures. There are a lot of scope for further reduction in emission (Table 3). The details are tabulated at Table 3 and Fig. 11

By applying above measures further GHG reduction (in tes/yr) may also be taken at Piparwar OCP (Table 4).

The various other ways which may be think off are:

1. Using serpentine rocks as floor material, which sequester CO_2 from the atmosphere as they weather.
2. New initiatives are to be launched in areas such as cleaner thermal power generation
3. Promoting renewable energy
4. Reducing emissions from transport and waste
5. Creating climate resilient infrastructure.
6. Manufacture of plastics and carbon fibers from CO_2

7. Chilling the air to drop out CO_2 as snow and burying them under earth crust.
8. Fly ash bricks used
9. Monetary reward to employee for GHG reduction initiative.
10. Publicity and promotion are essential to create an environment for success of GHG Reduction strategy.
11. Regular articles on energy conservation should be included in company newsletter.
12. Posters and pamphlets may be exhibited at strategic locations.
13. Vehicles plying in the project areas may be painted with signs publicizing GHG Reduction.
14. Setting one day of the year as "GHG Reduction Day".

Conclusion

Under certain assumed conditions and with the help of derived equations carbon footprint of coal mine with available data can be assessed in ecofriendly manner and GHG emission can be derived and calculated. The pilot projects developed can be replicated to other similar units also.We strongly believe that this model will contribute to initiatives being taken to will not combat climate change but conserving the resources in better way. This will also help in planning and developing urban settlement in and around an open cast mine.

Acknowledgement

Authors is thankful to all for rendering their help both onsite and offsite. The views presented by authors are solely his interpretation.

REFERENCES

Adams, R.M., B.H. Hurd and J. Reilly. 1999. Agriculture and global climate change: AReview of Impacts to U.S. Agricultural Resources. The Pew Center on Global Climate Change, Arlington, VA

Barnett, T.P. and M.E. Schlesinger. 1987. Detecting changes in global climate induced by greenhouse gases. *J. Geophy. Res*., 92:14772-14780

DEFRA 2012: Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting; Version: 1.0; Updated: 28/05/2012, pp. 1-54.

DEFRA. 2013, "Government GHG Conversion Factors for Company Reporting: Methodology Paper for Emission Factors" (July 2013); Department for Environment, Food and Rural Affairs, London, pp 27-40 (www.gov.uk/defra).

IPCC, 1997. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual (3). Chapter 4: Agriculture. Intergovernmental Panel on Climate Change. Paris, France

IPCC, 2015, Climate Change 2014, Synthesis Report; pp. 1-167 (ISBN 978-92-9169-143-2); (http://www.ipcc.ch.)

Kumar M, Sangeeta, 'Carbon Footprint Assessment Model for Opencast Coal Mine (2015); IMEJ, Bhubaneshwar, Oct, 2015.

Kumar M, Sangeeta, Kumar A; 'Carbon Footprint Assessment –A tool to conserve resource', pp. 23-26, JSPCB, Ranchi, 5th June 2015.

Kumar M, Sangeeta, Kumar A; 'Carbon Footprint Measurement –At an Opencast Coal Mine', pp. 153, Kerala Environment Congress- 2015, 6th to 8th May, 2015, National Workshop on Climate Change and Sustainable Development, available at http://www.cedindia.org/wp-content/uploads/ 2013/08/KEC-2015-full-pages.pdf

Kumar, Manoj 2015. "Carbon Footprint Measurement at An Opencast Project – A Case Study, project work submitted to WWF-India and NLU, Delhi for the partial fulfillment for the award of the certificate of post graduate diploma in environmental law and policy, pp. 1-62.

Lindzen, R.S. 1994. On the scientific basis for global warming scenarios. Environ. Pollut.83:125-134

Padhi, BRK. and Mishra, R. "Energy Conservation & Sustainable development at Baphlimali Bauxite Mine of M/s Utkal Alumina International Ltd.: A journey towards Excellence; National Seminar on Energy Conservation in Mining & Mineral Industries for Sustainable Development; IMEJ: Sep 2015, pp. 14-17

Singh, Sanjay Kumar, "CO2 emission from passenger transport in India 1950-51 to 2020-21", table 6.

United States Department of Energy (USDOE). 1999. Carbon Sequestration: State of theScience, A working paper for road mapping future carbon sequestration R&D.USDOE, Washington, D.C.

www.unfccc.int/resource/docs/cop2/15a01.pdf (Framework Convention on Climate Change FCCC/CP/1996/15/Add.1, 29 October 1996, Report of the COP on its second session, held at Geneva from 8-19 July 1996)

****