IIM(A) 'CHAOS 2010' Carbon Footprint Control Project

'Realise' Project Report

FINAL

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Prepared by:
Vivek Gilani
Environmental Engineer (E.I.T)

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1 Acknowledgments

This report represents a final Carbon Footprint Assessment Report for CHAOS 2010 which was based on, and greatly assisted by, initial Footprint analyses conducted by Rajesh Sadhwani of IIM(A) under the guidance of Prof. Amit Garg of the Public Systems Group of IIM(A). Mr. Sadhwani and Anubhooti Kabra of IIM(A) were instrumental in refining the data quality and augmenting its accuracy for the final analysis presented herein.

2 Executive Summary

Eliminate Carbon Emissions Pvt. Ltd was contracted by IIM(A)'s CHAOS 2010 Organizing Committee to conduct a Carbon Footprint Calculation of the annual cultural festival (i.e. an inventory of the total Greenhouse Gas Emissions (GHGs) that contribute to Climate Change, resulting from direct and indirect resource consumption through event activities).

Boundaries for the Carbon Footprint Calculation process were defined in consultation with CHAOS 2010 Management. Defining boundaries involved two key-decision making areas: activities to be included (i.e. defining a comprehensive yet manageable set of resources who's consumption was to be inventoried) and stakeholders to be considered as part of the organization's footprint (i.e. defining which sets of peoples/groups/functions are to be included within the footprint boundary).

Since Carbon Footprint Reporting for events in India is not mandated by the Indian Government , nor by the United Nations Framework Convention for Climate Change (UNFCCC), and CHAOS 2010's initiative to address it's Climate Change Impacts are purely voluntary, no set of pre-established guidelines were required to be followed for boundary definition. In the absence of explicit guidelines for GHG Emission Reporting Indian Businesses, the globally accepted methodologies for National GHG Emissions Reporting (adopted by India as part of the Kyoto Protocol) laid down by the IPCC (Inter-Governmental Panel on Climate Change) as part of the 2006 Guidelines were used for guidance wherever appropriate. However, given the unique nature of this event, the overall methodology reflected a confluence of standard protocols and event-appropriate approaches which would provide an accurate estimate of the Climate Change impact of a unique cultural and live-entertainment event which CHAOS represents.

The CHAOS 2010 Carbon Footprint Boundary was defined as comprising the following activities:

1) Contributing Directly to Carbon Footprint: Cooking Fuel Consumption, Vehicular Fuel Consumption
2) Contributing Indirectly to Carbon Footprint (Primary Importance): Electricity Consumption, Water Consumption

3) Contributing Indirectly to Carbon Footprint (Secondary Importance): Transportation (Rail, Road, and Air Travel), Food & Beverage Consumption, Waste Generation, Plastic, Paper and Other Consumables.

The Stakeholders Boundary was defined as comprising the following sets of peoples/groups/function:

1) CHAOS 2010 Organization
2) Event Performers
3) Event Participants

The Carbon Footprint for CHAOS 2010, in the context of above mentioned footprint boundaries is estimated to be ***29.7 Tons of Carbon Dioxide Equivalents (Tons of CO_2e).*** The most significant contributor to the event's Carbon Footprint is Autorickshaw Travel by event participants (29%), followed by (in progressively lesser proportions), Air Travel for Performers (21%), Electricity (15%), Waste Generation (7%), Long Distance Bus Travel (7%), Bottled Water/Drinks Consumption (7%), Long Distance Rail Travel (6%), Cooking Fuel (5%), and Paper (3%). Dissecting the Carbon Footprint in terms of contributions from various Stakeholders reveals that the largest contributors are activities by Participants (50%), followed by (in progressively lesser proportions), Event organization (29%), and Performers (21%).

Based on an approximate participant 'footfall' base of 15,000 persons, the per-participant Carbon Footprint is estimated to be approximately ***2 kg CO_2e.***

3 Introduction

Eliminate Carbon Emissions (ECE) Pvt. Ltd was contracted by CHAOS 2010 Organizing Committee to calculate their annual event's Carbon Footprint (i.e. an inventory of the total Greenhouse Gas Emissions (GHGs) that contribute to Climate Change, resulting from direct and indirect resource consumption through event activities) to diagnose the key activities and practices that contribute to it so that they may be mitigated by altered methods of event organization during future editions of the event.

4 Project Goals

The goals of the 'Realise' phase of the project were to determine, with the greatest possible degree of accuracy, the following for CHAOS 2010:

1. Total Resource Consumption Inventory
2. Total Carbon Footprint
3. Resource consumption activity-differentiated Carbon Footprint
4. Stakeholder-differentiated Carbon Footprint
5. Per-participant Average Carbon Footprint

Results of the above research-based analysis were then synthesized to arrive at a rational roadmap for Carbon Footprint and Resource consumption minimization without hindering the fundamental pre-requisites of the Event operations.

5 Project Scope

Boundaries for the Carbon Footprint Calculation process were defined in consultation with CHAOS 2010 Management. Defining boundaries involved two key-decision making areas: activities to be included (i.e. defining a comprehensive yet manageable set of resources who's consumption was to be inventoried) and stakeholders to be considered as part of the organization's footprint (i.e. defining which sets of peoples/groups/functions are to be included within the footprint boundary).

Since Carbon Footprint Reporting for events in India is not mandated by the Indian Government , nor by the United Nations Framework Convention for Climate Change (UNFCCC), and CHAOS 2010's initiative to address it's Climate Change Impacts are purely voluntary, no set of pre-established guidelines were required to be followed for boundary definition. In the absence of explicit guidelines for GHG Emission Reporting Indian Businesses, the globally accepted methodologies for National GHG Emissions Reporting (adopted by India as part of the Kyoto Protocol) laid down by the IPCC (Inter-Governmental Panel on Climate Change) as part of the 2006 Guidelines were used for guidance wherever appropriate. However, given the unique nature of this event, the overall methodology reflected a confluence of standard protocols and event-appropriate

approaches which would provide an accurate estimate of the Climate Change impact of a unique cultural and live-entertainment event which CHAOS represents.

5.1 Activity Boundaries

In order for Carbon Footprint calculation to be considered comprehensive it is essential to include all activities that impact it. However, since every activity involves some resource or energy consumption, each has a footprint. Clearly, this would render the entire exercise impossible to complete in a finite time-frame. The twin goals of comprehensiveness and manageability are achieved be defining activities known as 'Key Source Categories' and analyzing them comprehensively while paying lesser attention to those outside that framework. 'Key Source Categories' categories are defined as those who's collective contribution account for 95% of the total footprint (when added incrementally in the order of decreasing contribution). It is evident that technically 'Key Source Categories' can therefore only be determined following the completion of the Carbon Footprint calculation – thereby defeating its utility as a guiding principle for defining activity boundary. However, irrespective of the anthropogenic or business activity being analyzed, certain categories of activities can safely be presumed as being 'Key Source Categories'. Beyond these, others need to be identified based on rational considerations related to the specific nature of the business and following a detailed understanding of its operations. This process yielded the following activities as comprising the activity domain for CHAOS's Carbon Footprint calculation:

1) Contributing Directly to Carbon Footprint: Cooking Fuel Consumption, Vehicular Fuel Consumption (these are activities where an individual or business has direct control over the amount of activity and the emission coefficient through technological choices)
2) Contributing Indirectly to Carbon Footprint (Primary Importance): Electricity Consumption, Water Consumption (these are activities where an individual or business has direct control over the amount of activity but not the emission coefficient through technological choices)
3) Contributing Indirectly to Carbon Footprint (Secondary Importance): Transportation (Rail, Road, and Air Travel), Food & Beverage comprising of Meat, Seafood, Dairy, Rice, Alcoholic and Bottled Water/Soft Drink Beverage Consumption, Waste Generation, Plastic, Paper and Other Consumables (these are activities where an individual or business can be considered to not have direct control over the amount of activity nor the emission coefficient through technological choices)

It must be noted that all activity prior to actual event have been excluded from the Footprint Boundary. Hence resource consumption during pre-event planning is therefore absent from this analysis.

5.2 Stakeholder Boundaries

Stakeholders are defined as those groups of persons, service providers, beneficiaries, customers etc. that directly or indirectly participate in Carbon Footprint creation activities of a organization. As in the case of activity boundaries, this list too is technically nearly infinite since the 'indirect' contributors to an organization's footprint is an unbounded set of groups engaged in enterprise all across the globe. Since voluntary Carbon Footprint calculation and emission inventorying falls outside the domain of any internationally binding IPCC guidelines, 'Stakeholder Boundary' is determined through consultation with the 'Realiser' or client. While accountability for those entities directly part of its own operations is the cornerstone of the exercise, organizations are at liberty to select some operations outside its direct control but one's that are logically connected to or natural extensions of its direct operations. The outcome of these discussions with CHAOS 2010 was following Stakeholder Boundary definition comprising of:

1) CHAOS 2010 Organization
2) Event Performers
3) Event Participants

The prominent groups that are excluded from this boundary are Event Vendors; their processing, storage and logistics activities resulting in Carbon Footprint creation.

5.3 Life-cycle Boundaries

Carbon Footprint is essentially the product of multiplying activity data with GHG Emissions Factors (EFs). Emission Factors are indicative of the quantity of GHGs emitted per unit of activity. As an illustration, an EF of 1 kgCO2e per kWh of electricity indicates that generation/consumption of 1 unit of electricity (i.e. 1 kWh) causes the emissions of 1 kg of Carbon Dioxide Equivalents. It must be emphasized that these are 'indicative' since the true EF for any activity is technically unbounded; the reasoning for this is identical to the rationale provided in relation to the infinite nature of Activity and Stakeholder Impacts on Carbon Footprint. As an activity's EFs are investigated further-back into its life-cycle to include, beyond primary influences, secondary and tertiary impacts, the mathematical magnitude of the EF increases albeit to a gradually diminishing degree. Revisiting the example of electricity emission factors, the value of 1 kgCO2e/kWh would increase if analysis boundaries were expanded beyond the impacts of direct combustion of coal, diesel and other fossil fuels used for power generation to then include the energy expenditure to mine the fossil fuels. Its magnitude would further increase if the analysis boundary were radially extended to envelop the resource and energy consumption to create the capital goods (machinery, factories etc.) required to harness these natural resources. This expansion can be understood as 'penetrating deeper into the life-cycle of a product or service. Concisely stated, EF magnitudes are a dynamic function of the extent of life-cycle impacts selected for analysis in relation to the manufacturing process involved in creation of goods and services for human consumption.

Any Carbon Footprint analysis, so greatly dependent on the mathematical magnitude of EFs chosen, is therefore, by induction, a function of EF life-cycle analysis (LCA); selecting only primary aspects of LCA (such as direct emissions of fossil fuels) yields lower values of EFs while a more extensive LCA magnifies the impacts of the same activity and leads to a more conservative Carbon Footprint; a footprint that tends towards the 'true' Carbon Footprint of an activity. The following table presents the extent of LCA incorporated into the Emission Factors selected for the CHAOS Carbon Footprint calculation.

Table 1 Emission Factor LCA Status

No.	Footprint Head	EF LCA Status
1	Cooking Fuel	Direct Emissions
2	Generator Fuel	Direct Emissions
3	Vehicular Travel - 2 Wheeler	Direct Emissions
4	Vehicular Travel - 4 Wheeler	Direct Emissions
5	Electricity	Direct Emissions
6	Water	Direct Emissions
7	International Air Travel	Direct Emissions
8	Domestic Air Travel	Direct Emissions
9	Rail Travel - Local	Direct Emissions, Electricity
10	Rail Travel - Long Distance	Direct Emissions, Electricity
11	Bus Travel - Local	Direct Emissions
12	Bus Travel - Long Distance	Direct Emissions
13	Taxi Travel	Direct Emissions
14	Autorickshaw Travel	Direct Emissions
15	Meat	LCA
16	Seafood	LCA
17	Dairy	LCA
18	Alcoholic Beverages	LCA
19	Bottled Water / Drinks	Partial LCA
20	Waste Generation	Partial LCA
21	Paper	LCA
22	Plastic	LCA
23	Luxury Hotel	Direct Emissions, Electricity

6 Research Methodology

The research methodology followed for the project centered around the idea of dissecting the event operations and disaggregating consumption of resources to understand the consumption patterns 'ground-up'. While this approach was more time-consuming, as opposed to tracking all activities through a 'centralized' approach, it helped construct a detailed footprint-map that would be invaluable as an analysis tool to identify stakeholder contributions to overall footprint.

7 Analysis Methodology

The data collected through the research processes outlined earlier were refined and scrutinized for inaccuracies when data appeared to be erroneous.

7.1 Resource / Activity Tagging

Each resource/activity inventoried during research was tagged and collated under footprint-head groups. Table 2 presents the list of footprint-head groups used for data classification. The governing principle for the elaborate data classification was to provide intrinsic footprint head-wise analytic capability to gauge their relative impacts.

Table 2 Resource / Activity Footprint-Head Tagging

Footprint Head	***Item Type***	***Item Sub-Type***
Electricity Consumption		
Electricity	Electricity - Gross	Electricity
Water Consumption		
Water	Water	Water - Municipal
Water	Water	Water - Tanker
Fuel Consumption (Non-Travel)		
Fuel	Cooking Fuel	LPG - Commercial
Fuel	Cooking Fuel	PNG
Fuel	Cooking Fuel	Wood
Fuel	Cooking Fuel	Electricity
Fuel	Cooking Fuel	Charcoal
Fuel	Generator Fuel	Diesel
Travel		
Travel	Domestic Air Travel	Dom. Air - Short
Travel	Domestic Air Travel	Dom. Air - Medium
Travel	Domestic Air Travel	Dom. Air - Long
Travel	International Air Travel	Int. Air - Short
Travel	International Air Travel	Int. Air - Medium
Travel	International Air Travel	Int. Air - Long
Travel	Intercity Travel - Public	Long Dist. Rail
Travel	Intercity Travel - Public	Long Dist. Bus
Travel	City Travel - Public	Local Rail
Travel	City Travel - Public	Local Non AC Bus
Travel	City Travel - Public	Local AC Bus
Travel	City Travel - Private	Autorickshaw
Travel	City Travel - Private	Non AC Taxi
Travel	City Travel - Private	AC Taxi
Travel	City Travel - Private	2 Wheeler - 4ST Petrol
Travel	*City Travel - Private*	*Petrol 4-Door Car - City*
Travel	*Intercity Travel - Private*	*Petrol 4-Door Car - Highway*
Travel	*City Travel - Private*	*Diesel 4-Door Car - City*

Footprint Head	*Item Type*	*Item Sub-Type*
Travel	*Intercity Travel - Private*	*Diesel 4-Door Car - Highway*
Travel	*City Travel - Private*	*CNG 4-Door Car - City*
Travel	*Intercity Travel - Private*	*CNG 4-Door Car - Highway*
Travel	*City Travel - Private*	*LPG 4-Door Car - City*
Travel	*Intercity Travel - Private*	*LPG 4-Door Car - Highway*
Food, Beverage, Waste		
Food & Beverage	Meat	Beef
Food & Beverage	Meat	Mutton
Food & Beverage	Meat	Pork
Food & Beverage	Meat	Chicken
Food & Beverage	Seafood	Fish
Food & Beverage	Dairy	Milk
Food & Beverage	Dairy	Cheese
Food & Beverage	Dairy	Yogurt
Food & Beverage	Dairy	Butter
Food & Beverage	Dairy	Cream
Food & Beverage	Rice	Rice
Food & Beverage	Bottled Water / Drinks	Water - 20 Liter Jars
Food & Beverage	Bottled Water / Drinks	Water - 250 ml PET Bottles
Food & Beverage	Bottled Water / Drinks	Water - 500 ml PET Bottles
Food & Beverage	Bottled Water / Drinks	Water - 1 Liter PET Bottles
Food & Beverage	Bottled Water / Drinks	Water - 1.5 Liter PET Bottles
Food & Beverage	Bottled Water / Drinks	Water - 2.0 Liter PET Bottles
Food & Beverage	Bottled Water / Drinks	Soft Drink - 250 ml Can
Food & Beverage	Bottled Water / Drinks	Soft Drink - 330 ml Can
Food & Beverage	Bottled Water / Drinks	Soft Drink - 500 ml PET Bottle
Waste	Waste Generation	Waste (Landfilled)
Paper, Plastic & Consumables		
Paper, Plastic & Consum.	Paper	Food Serving Paper
Paper, Plastic & Consum.	Plastic	Miscellaneous Plastic

7.2 GHG Emission Factors

Activity data collated according to the framework described earlier was multiplied by the appropriate Greenhouse Gas (GHG) Emissions Factors specifically developed for India. These coefficients are presented in Appendix A. The product of the resource quantities and the GHG Emission Factors yielded the Carbon Footprint for the particular activity.

8 Results

8.1 Resource Consumption Inventory

The following table presents the aggregated consumption inventory for CHAOS 2010.

Table 3 CHAOS 2010 Resource Consumption Inventory - 2010

No.	*Footprint Head*	*Qty.*	*Measuring Unit*
1	***Scope 1***		
1.1	Fuel – Cooking Fuel - LPG	480	kgs
1.2	Fuel – Cooking Fuel - Wood	NA	kgs
1.3	Fuel – Cooking Fuel - Charcoal	NA	kgs
1.4	Fuel – Vehicular Travel	Not Known	
2	***Scope 2***		
2.1	Electricity	2,924	kWh
2.2	Water	Not Known	
3	***Scope 3***		
3.1	***Travel***		
3.1.1	Domestic Air Travel	50,082	pass-km
3.1.2	International Air Travel	0	pass-km
3.1.3	Intercity Travel - Public	202,671	pass-km
3.1.4	City Travel – Public	105,000	pass-km
3.2	***Food, Beverage, Waste***		
3.2.1	Meat	Not Known	
3.2.2	Seafood	Not Known	
3.2.3	Dairy (Milk, Cheese, Yogurt, Butter, Misc.)	Not Known	
3.2.4	Rice	Not Known	
3.2.5	Bottled Water / Drinks	7,500	liters
3.2.6	Solid Waste	3,750	kgs
3.3	***Paper, Plastic, Consumables***		
3.3.1	Paper	375	kgs
3.3.2	Plastic	Not Known	

It must be noted that all items identified as 'Not Known' represent data that was sought by ECE but not available for analysis due to constraints encountered by data gathering personnel. 'Underlined' quantities represent activities where consumption was estimated based on a assumed per-participant consumption quantity. It was endeavored to refine these estimates during and following the event; however, owing to constraints encountered by the organizing committee this data could not be refined through field measurements. These assumptions are explicitly listed in later sections of the report.

8.2 Total Carbon Footprint

The Total Carbon Footprint of CHAOS 2010, for the activities and stakeholders presented in Sections 4.1 and 4.2, is estimated to be 29.7 tons of CO2e.

8.2.1 Activity-Differentiated Carbon Footprint

Table 5 presents the contributions to Total Carbon Footprint differentiated across all footprint heads.

Table 4 CHAOS 2010 Activity-Differentiated Total Carbon Footprint

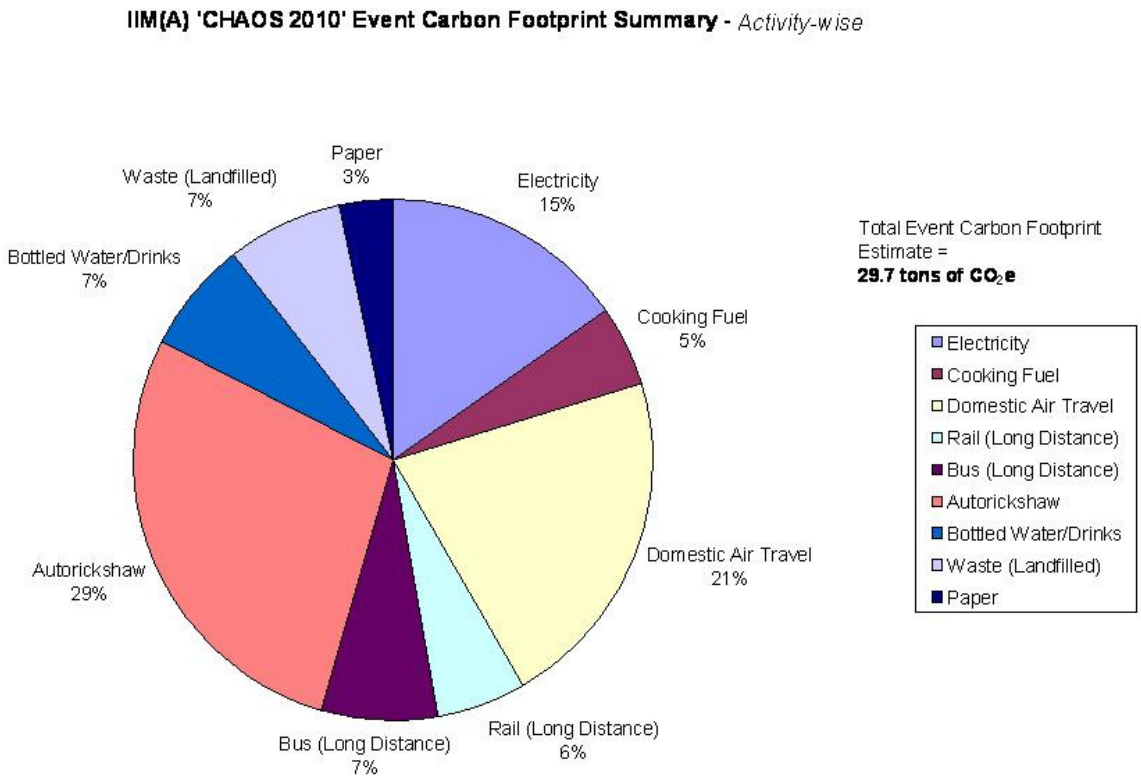
	Footprint Head	***Footprint (kg CO2e)***	***% Contribution***
1	***Scope 1***		
1.1	Fuel - Cooking Fuel	1,504	5%
1.2	Fuel - Vehicular Travel	Not Known	Not Known
	Sub-Total	***1,504***	***5%***
2	***Scope 2***		
2.1	Electricity	4,553	15%
2.2	Water	Not Known	Not Known
	Sub-Total	***4,553***	***15%***
3	***Scope 3***		
3.1	***Travel***		
3.1.1	Domestic Air Travel	6,302	21%
3.1.2	International Air Travel	0	0%
3.1.3	Intercity Travel - Public	3,858	13%
3.1.4	City Travel - Public	8,361	28%
	Sub-Total	***18,521***	***62%***
3.2	***Food, Beverage, Waste***		
3.2.1	Meat	Not Known	Not Known
3.2.2	Seafood	Not Known	Not Known
3.2.3	Dairy (Milk, Cheese, Yogurt, Butter etc.)	Not Known	Not Known
3.2.4	Rice	Not Known	Not Known
3.2.9	Bottled Water / Drinks	2,038	7%
3.2.10	Solid Waste	2,164	7%
	Sub-Total	***4,202***	***14%***
3.3	***Paper, Plastic, Consumables***		
3.3.1	Paper	967	3%
3.3.2	Plastic	Not Known	Not Known
	Sub-Total	***967***	***3%***
Totals	***(tons CO2e)***	***29.7***	***100%***

It must be noted that all items identified as 'Not Known' represent data that was sought by ECE but not available for analysis due to constraints encountered by data gathering personnel. 'Underlined' quantities represent activities where consumption was estimated

based on a assumed per-participant consumption quantity. These assumptions are explicitly listed in later sections of the report.

Figure 7 presents the collective contributions of the footprint-heads grouped into their parent categories.

Figure 1 Percent (%) Contributions to Total Carbon Footprint (Activity-wise)



8.2.2 Stakeholder Differentiated Carbon Footprint

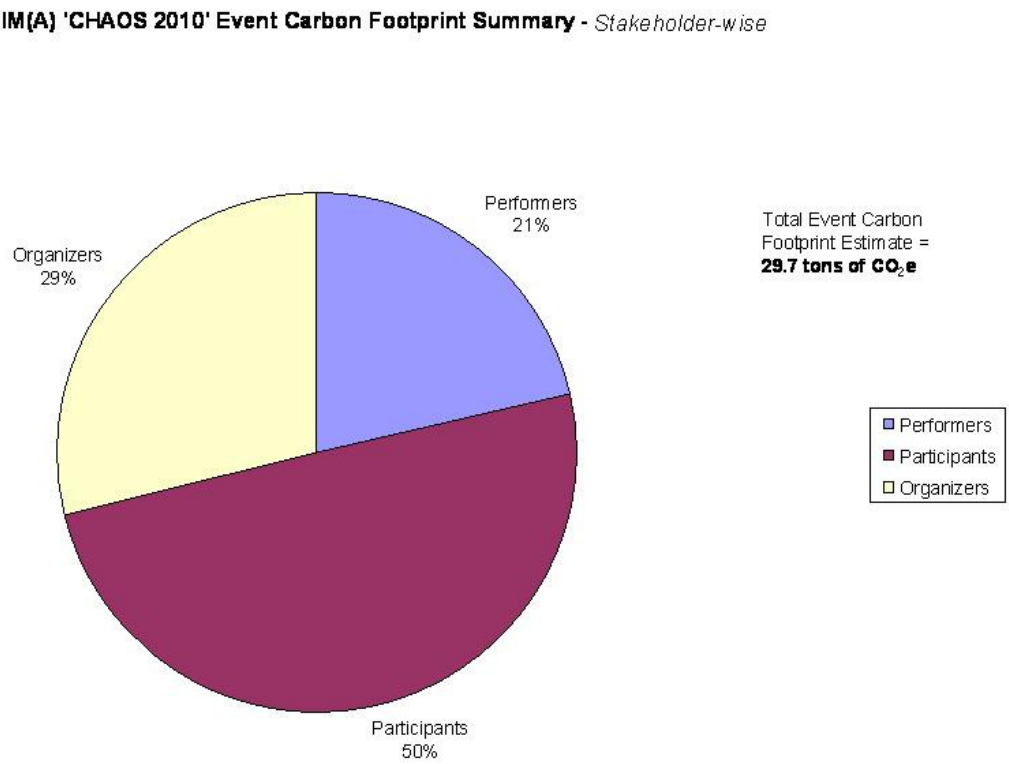
The Total Carbon Footprint of CHAOS 2010, allocated to the stakeholders identified earlier is presented in Table 5 and Figure 2.

Table 5 CHAOS 2010 Stakeholder-Differentiated Total Carbon Footprint

	Stakeholder	***Footprint (kg CO2e)***	***% Contribution***
1	Performers	6,349	21%
2	Participants	14,779	50%
3	Organizers	8,619	29%
Totals	***(tons CO2e)***	***29.7***	***100%***

As noted in the earlier sections of the report, the prominent groups that are excluded from this are CHAOS 2010 Vendor's processing, storage and logistics activities. Inclusion of these stakeholders in the project boundary could increase the Total Carbon Footprint notably.

Figure 2 Percent (%) Contributions to Total Carbon Footprint (Stakeholder-wise)



9 Context of Carbon Footprint

The Total Carbon Footprint estimate of 29.7 tons CO2e is created by CHAOS 2010's activities to serve an participant base of approximately 15,000 persons. Based on this, the per-particpant Carbon Footprint is estimated to be approximately 2.0 kg CO2e.

The quantity of Carbon Dioxide absorbed by a tree is a direct function of the growth stage (young, mature or old tree), the specific species of the tree, the quantity of foliage (leaves), size of tree etc., and hence it is incorrect to think of the Carbon Dioxide absorption capacity of a tree as being a simple static number that applies in all instances. However, for indicative purposes (to present some perspective on the relative Climate Change impacts of activities) it becomes necessary to arrive at some general consensus about the number of trees that would be required to 'offset' the Greenhouse Gas emissions from human activities. Research presented by the United Nations Environment Program (UNEP) as part of its 'Billion Tree Campaign' states that an average tree absorbs 12 kgs of CO2 per year. Assuming an average life-span of 20 years for a tree (accounting for tree-planting mortality rates etc.), this equates to 240 kgs or approximately 0.25 tons of CO2e as the Carbon Dioxide absorption capacity of a tree over its lifetime. Thus, a Carbon Footprint of 1 ton of CO2e can be thought of as requiring the planting of approximately 4 trees to 'neutralize' its impact. It must be emphasized that this shouldn't be misconstrued as an endorsement of tree planting for neutralizing carbon footprint.

Based on the above approximations, the Total Carbon Footprint of CHAOS 2010 can be thought of as requiring 119 trees to 'neutralize' its impact on Climate Change.

The average Annual Carbon Footprint of an Indian Citizen (based on 2004-2005 National GHG Inventory data) is estimated to be 1.6 tons of CO2e/year. A family of 4 in India thus emits approximately 6.4 tons of CO2e/year. CHAOS 2010's Total Carbon Footprint over 3 days thus equates to the Annual Carbon Footprint of approximately 5 average Indian families.

10 Discussion

10.1 Assumptions

The following are the key assumptions made during the project analysis:

1) Only services/products paid for or directly contracted by CHAOS 2010 or received in exchange of services are included in the resource consumption inventory.
2) Electricity consumption during event planning phase has been excluded

3) The following types of supplies were not considered for resource inventory calculation for CHAOS 2010: paper, plastic, and office supplies consumed by the organization team during pre-event planning and paper, plastic collaterals for event advertising, sponsor advertising during event.
4) Total participant 'footfalls' assumed to be 15,000 for the 3-day event.
5) Bottled Water/Soft Drink consumption estimated to be equal to one (1) 500 ml PET bottle per participant.
6) Paper consumption related to food & beverage consumption assumed to be equal to 25 grams per participant.
7) Paper content assumed to contain 0% post-consumer recycled content for Footprint calculation purposes.
8) Waste Generation Footprint is an estimate based on assuming a typical 'household' mix of the kind used in studies to estimate landfill GHG emissions.
9) All inter-city flight distances calculated using travelmath.com.
10) Participant travel profile assumed to be as follows:
    - 200 participants traveling 500 km roundtrip each via railway
    - 200 participants traveling 500 km roundtrip each via long distance AC bus
    - 10,000 participants traveling 10 km roundtrip each via autorickshaw.

10.2 Data Gaps

The existing resource consumption inventory and Total Carbon Footprint magnitude is influenced by a few clearly identified data-gaps (in the context of the finite Footprint calculation boundary). Their impact on Total Footprint and the resultant activity and stakeholder differentiations is expected to be significant. Primary amongst these data gaps are:

1) Water consumption data during festival.
2) Local vehicular travel data for Performers and Organizers sponsored by CHAOS 2010.
3) Travel distances and mode of transportation for CHAOS 2010 participants.
4) Food and beverage consumption details under categories of meat, seafood, dairy, rice, bottled water, and soft drinks.
5) Accurate waste generated weight and differentiation amongst organic and recyclable dry-waste.
6) Accurate measurement of paper and plastic consumables consumption amongst various stakeholder groups.

10.3 Uncertainties

10.3.1 Activity-Data Uncertainty

Scope 1 and Scope 2 data was calculated from vendor inputs and staff members of IIM(A)'s electrical services department and are reasonably accurate. Air travel data for

performers is also accurate as it was based on details provided directly by the Organizing Committee. Instances wherein activity data was obtained through estimates include:

1) Participant travel data
2) Waste generation – approximate estimate provided by Housekeeping Contractor.
3) Bottled Water/Soft Drink and paper consumption by participants..

10.3.2 Emission Factor Uncertainty

The following EF-related assumptions are known to add uncertainty to the Footprint calculations:

1) All paper related items were assumed to composed of paper with an Emission Factor equivalent to that of the commonly used A4-size computer printer paper in most offices (technically referred to as 'Uncoated Freesheet'). Ideally, unique EFs would be used for different paper products. However, unavailability of adequate research-based EFs prevented adoption of this approach.
2) Electricity EFs are based on 2004-2005 Electricity Generation Statistics reported by Central Electrical Authority (CEA). Fuel mix specific to India were used for estimating India-specific Electricity Emission Factors. The EF thus calculated was 0.996 kgCO2/kWh. The national T&D Loss Factor was calculated as being 35.9% (including unaccounted consumption) for 2004-2005. The effective EF was thus equal to 0.996/(1-0.359) = 1.55 kgCO2/kWh. While this EF value is notably higher than values used conventionally for CDM project calculations, the methodology adopted herein is rational and possibly more appropriate. The total Footprint value is greatly dependent on the Electricity EF and hence any uncertainty in this factor also greatly influences the overall uncertainty of final calculations.

The cumulative impact of the above mentioned uncertainty elements has not been quantified. Quantification of the uncertainty and estimates of accuracy and precision of the analysis will be pursued in the future editions of the event.

11 Limitations

The existing project analysis is limited in the following aspects.

11.1 Fixed Capital Manufacturing Footprint

The current state-of-art does not allow for Life Cycle Analysis for any of the fixed capital used by CHAOS 2010 for activities. For instance – replacement of lighting equipment, heating elements and even periodic replacement of Air Conditioning equipment (amortized over its life-span) all exert an equivalent Footprint 'embedded' in their manufacturing and disposal processes. However, since the life-span of these pieces of equipment would be significantly greater than their time-span of use during CHAOS, their contribution to Total Carbon Footprint would perhaps be marginal. The calculation of these Life-Cycle based footprints are not only beyond the scope of this project but also limited by the state-of-art in terms of the sophisticated software systems required to analyze them which are expensive to procure and require specialized training to operate.

11.2 Temporary Construction Impacts

This study has not taken into account the Footprint creation due to logistics of temporary constructions erected during the event. Wood, bamboo, steel and other construction material along with the quantities of electrical and fuel energy used are impacts that would have a some impact on the footprint of CHAOS 2010.

11.3 Life-Cycle Emission Factors

Besides Food and Beverage EFs, most other EFs used are based primarily on direct fuel or energy consumption. The ancillary infrastructure that is an inalienable part of these anthropogenic activities would have an augmented impact on the Footprint calculations for using those services. For instance, airport construction, operation and maintenance as well as aircraft manufacturing do impact air travel footprint but have not been studied adequately by research communities to yield usable Emission Factors. This partial-LCA Emission Factor defines the state-of-art but is nonetheless a recognizable limitation.

11.4 Water Footprint

Water is a scarce resource and warrants study as a distinct entity beyond the Carbon Footprint implications involved in its processing and public supply distribution systems as well as on-site pumping. This does study does not quantify the total quantity of water used and its associated Carbon Footprint nor does it provide an estimate of the other (and possibly more significant) ecological impacts associated with high quantities of water

usage). Moreover, the study does not include the 'embedded' Water Footprint implicit in the resources purchased and consumed themselves. Including this quantity would possibly increase the Water Footprint of CHAOS 2010. However, state-of-art prevents such an exhaustive assessment to be conducted at this point in time.

12 Conclusions and Recommendations

The Total Carbon Footprint of CHAOS 2010 , estimated to be 29.7 tons CO2e., is comprised of the following activity-related Footprints: Autorickshaw Travel by event participants (29%), Air Travel for Performers (21%), Electricity (15%), Waste Generation (7%), Long Distance Bus Travel (7%), Bottled Water/Drinks Consumption (7%), Long Distance Rail Travel (6%), Cooking Fuel (5%), and Paper (3%). Dissecting the Carbon Footprint in terms of contributions from various Stakeholders reveals that the largest contributors are activities by Participants (50%), followed by (in progressively lesser proportions), Event organization (29%), and Performers (21%).

The Footprint analysis leads to the following pertinent conclusions that can serve as a guiding and planning tool for future editions of CHAOS at IIM(A):

1) Participant travel footprint is the highest component of Total Carbon Footprint and also contains the greatest uncertainty in terms of raw data. Spectator travel distances and modes must therefore be studied to a greater extent in future events through professionally designed market-research surveys of a pre-determined sample size.
2) Food and Beverage consumption must be studied exhaustively in future events under categories of meat, seafood, dairy, rice, bottled water, and soft drinks.
3) Water consumption during future festival must be studied through water audits.
4) Local vehicular travel data for Performers and Organizers sponsored by CHAOS must be tracked.
5) Waste generation and differentiation amongst organic and recyclable dry-waste must be undertaken in future events.
6) Paper and plastic consumables consumption amongst various stakeholder groups must be tracked during future events.
7) Logistic activities of event vendors must be studied in detail during future editions of the event.

Preemptively, Participant Travel and Waste Generation Footprints must be mitigated in future events through:

1) provision of mass-transit based systems such as fuel-efficient or alternative fuel (CNG) busses to transport participants from pre-determined nodal locations in the surrounding areas of IIM(A) to the event.
2) Waste Management principles centered around waste segregation, organic waste composting, and waste recycling must be adopted in conjunction with the rigorous participant awareness effort to ensure minimal waste is sent to landfills as an outcome of CHAOS.

Finally, based on the above analysis presented earlier, it is recommended that IIM(A) offset a significant percentage of the footprint of CHAOS 2010 (29.7 tons of CO2e) through ‘domestic’ action. The entire footprint can be offset by conserving a total of 19,192 units (kWh) of electricity. It is recommended that IIM(A) review its monthly electricity consumption and set a achievable ‘percentage-reduction’ target for the first-

quarter during the new Academic Year beginning in mid-2010 to 'offset' at least 50% of the 19,192 units (i.e. 10,000 units). This target must be met through collective and participative efforts towards energy conservation of all stakeholder groups at IIM(A) – students, faculty and administration staff.

APPENDIX A

GHG Emission Factors

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Footprint Head	EF Type	Weight EF	Units	Qty. EF	Units	Distance EF	Units
Electricity	Electricity			1.55	kg CO2/kWh		
Fuel	Charcoal	1.89	kg CO2e/kg				
Fuel	Diesel	3.19	kg CO2e/kg	2.66	kg CO2e/liter		
Fuel	LPG - Commercial	3.13	kg CO2e/kg				
Fuel	LPG - Domestic	3.13	kg CO2e/kg				
Fuel	PNG			0.00	kg CO2e/liter		
Fuel	Wood	1.89	kg CO2e/kg				
Water	Water - Municipal			0.00	kg CO2e/liter		
Water	Water - Tanker			0.00	kg CO2e/liter		
Travel	2 Wheeler - 4 ST Petrol	3.17	kg CO2e/kg	2.37	kg CO2e/liter	0.04	kg CO2e/v-km
Travel	Autorickshaw					0.08	kg CO2e/v-km
Travel	CNG 4-Door Car - City	2.48	kg CO2e/kg			0.15	kg CO2e/v-km
Travel	CNG 4-Door Car - Highway	2.48	kg CO2e/kg			0.11	kg CO2e/v-km
Travel	Diesel 4-Door Car - City	3.19	kg CO2e/kg	2.66	kg CO2e/liter	0.21	kg CO2e/v-km
Travel	Diesel 4-Door Car - Highway	3.19	kg CO2e/kg	2.66	kg CO2e/liter	0.16	kg CO2e/v-km
Travel	Dom. Air - Long - COEFF A						kg CO2e/pass/km
Travel	Dom. Air - Long - COEFF B					0.07	kg CO2e/pass/km
Travel	Dom. Air - Long - COEFF C					27.97	kg CO2e/pass/km
Travel	Dom. Air - Medium - COEFF A						kg CO2e/pass/km
Travel	Dom. Air - Medium - COEFF B					0.07	kg CO2e/pass/km
Travel	Dom. Air - Medium - COEFF C					27.97	kg CO2e/pass/km
Travel	Dom. Air - Short - COEFF A						kg CO2e/pass/km
Travel	Dom. Air - Short - COEFF B					0.07	kg CO2e/pass/km
Travel	Dom. Air - Short - COEFF C					27.97	kg CO2e/pass/km
Travel	Int. Air - Long - COEFF A					0.00	kg CO2e/pass/km
Travel	Int. Air - Long - COEFF B					0.04	kg CO2e/pass/km
Travel	Int. Air - Long - COEFF C					109.09	kg CO2e/pass/km
Travel	Int. Air - Medium - COEFF A					0.00	kg CO2e/pass/km
Travel	Int. Air - Medium - COEFF B					0.04	kg CO2e/pass/km
Travel	Int. Air - Medium - COEFF C					109.09	kg CO2e/pass/km

Footprint Head	EF Type	Weight EF	Units	Qty. EF	Units	Distance EF	Units
Travel	Int. Air - Short - COEFF A					0.00	kg CO2e/pass/km
Travel	Int. Air - Short - COEFF B					0.04	kg CO2e/pass/km
Travel	Int. Air - Short - COEFF C					109.09	kg CO2e/pass/km
Travel	Local AC Bus					0.03	kg CO2e/pass/km
Travel	Local Non AC Bus					0.02	kg CO2e/pass/km
Travel	Local Rail					0.02	kg CO2e/pass/km
Travel	Long Dist. Bus					0.01	kg CO2e/pass/km
Travel	Long Dist. Rail					0.02	kg CO2e/pass/km
Travel	LPG 4-Door Car - City			1.50	kg CO2e/liter		
Travel	LPG 4-Door Car - Highway			1.50	kg CO2e/liter		
Travel	Non AC Taxi					0.18	kg CO2e/v-km
Travel	Petrol 4-Door Car - City	3.17	kg CO2e/kg	2.37	kg CO2e/liter	0.23	kg CO2e/v-km
Travel	Petrol 4-Door Car - Highway	3.17	kg CO2e/kg	2.37	kg CO2e/liter	0.17	kg CO2e/v-km
F&B	Beef	8.61	kg CO2e/kg				
F&B	Butter	23.76	kg CO2e/kg				
F&B	Cheese	8.48	kg CO2e/kg				
F&B	Chicken	4.48	kg CO2e/kg				
F&B	Fish	3.76	kg CO2e/kg				
F&B	Fresh Cream	7.60	kg CO2e/kg				
F&B	Milk - Avg.	0.89	kg CO2e/kg	0.92	kg CO2e/liter		
F&B	MSW - Landfilled	0.57	kg CO2e/kg				
F&B	Mutton	12.69	kg CO2e/kg				
F&B	Pork	5.53	kg CO2e/kg				
F&B	Rice	0.92	kg CO2e/kg				
F&B	Soft Drink - 500 ml PET Bottle			0.15	kg CO2e/bottle		
F&B	Water - 1 Liter PET Bottles			0.27	kg CO2e/bottle		
F&B	Water - 1.5 Liter PET Bottles			0.41	kg CO2e/bottle		
F&B	Water - 2.0 Liter PET Bottles			0.55	kg CO2e/bottle		
F&B	Water - 20 Liter Jars			0.45	kg CO2e/bottle		
F&B	Water - 250 ml PET Bottles			0.07	kg CO2e/bottle		

Footprint Head	EF Type	Weight EF	Units	Qty. EF	Units	Distance EF	Units
F&B	Water - 500 ml PET Bottles			0.14	kg CO2e/bottle		
F&B	Yogurt	1.92	kg CO2e/kg				
Consumables	Uncoated Freesheet (Copy Paper)-COEFF B	-0.95	kg CO2e/kg				
Consumables	Uncoated Freesheet (Copy Paper)-COEFF C	2.58	kg CO2e/kg	0.01	kg CO2e/sheet		
Consumables	Uncoated Groundwood (Newsprint)-COEFF B	-1.61	kg CO2e/kg				
Consumables	Uncoated Groundwood (Newsprint)-COEFF C	3.16	kg CO2e/kg	0.35	kg CO2e/newspaper		