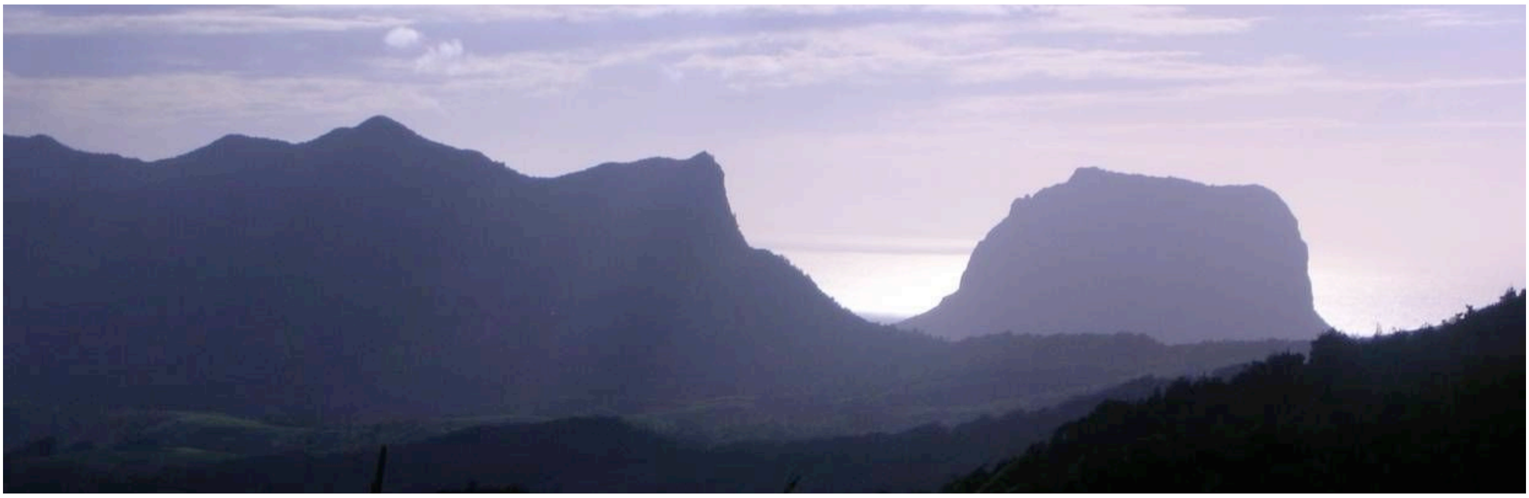

The School Footprinting Initiative

Student Introduction Pack

Version 1.0

May 2007

A Message from our Principal Sponsor

Shell Mauritius Limited

Shell was the first international oil company to set up business in Mauritius in 1905.

Shell accounts for nearly half of the imported energy demand of the island and is present in all sectors of this business activity. Shell Mauritius Limited is a leader in the provision of both automotive fuels and lubricants to the Mauritian downstream market through its extensive network of service stations, business-to-business commercial clients and aviation fuel at SSR International airport.

Among Shell Mauritius Limited pioneering services and products: the 'Shell Card' for purchasing petroleum products plus non-fuels goods, 'Autogas' for vehicles running on Liquefied Petroleum Gas (LPG), an into-plane service at SSR International airport, bunkering facilities from pipelines and through barges at Port Louis Harbour. Shell Mauritius Limited is the country's largest supplier of Liquefied Petroleum Gas (LPG), which is used for both domestic cooking purposes and commercial uses. Shell distributes over 2 million barrels of oil in Mauritius yearly and has effected substantial investment in storage capacity at Roche Bois through its associate, Energy Storage Company Limited (ESCOL). The latest development has brought Shell to distribute the first differentiated Diesel in Mauritius, Shell Diesel Extra, a new generation of fuel.

As a responsible company, Shell Mauritius Limited is fully engaged in social and corporate involvement projects such as the 'Shell LiveWIRE' which helps young entrepreneurs since 2000 and the 'Project Better World', a programme supporting projects aimed at sustainable development and the cause of children as well as numerous social, educational and environmental projects.

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Project Partners

University of Technology, Mauritius

Mauritius Institute of Education

Mauritius Research Council

In Collaboration with

Ministry of Education and Human Resources

British Council

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Table of Contents

About the Student Introduction Pack

Welcome to the Student Introduction Pack for the School Footprinting Initiative (SFI)! We hope that this pack will tell you most of the things you need to know to get started with the program. We've divided the pack into two sections: A. Introducing the School Footprinting Initiative, and B. Knowledge Starting Points. Section A aims to give you a picture of what you will be doing in the SFI, why you are doing it and what your learning aims should be. It begins with the driving problem we are asking you to solve. Then in Section B, we explain some of the key concepts and learning points that will help you to get the most out of the SFI.

Who are you?

You are probably a student at one of these schools:

1. Pailles SSS, 2. Terre Rouge SSS, 3. D.A.V College, 4. Manilal Dr. SSS, 5. Quartier Militaire SSS, 6. St. Andrew's School, 7. France Boyer de la Giroday SSS, 8. Emmanuel Anquetil SSS, 9. Loreto Convent Mahebourg, 10. Swami Sivananda SSS, 11. Bambous SSS, 12. College du St. Esprit.

Another guess is that you have volunteered, or been selected, to be a part of the SFI program. However, we do not expect you to know anything about Ecological Footprinting (yet!) nor do we expect you to be a student taking the sciences. All we ask is for you to give to this project-based experiential learning program all of your creative energy. We sincerely hope that you will find the project exciting and rewarding.

Who are we?

The SFI team consists of Drs Sanjeev Bokhoree, Ravhee Bholah and Sanju Deenapanray, in collaboration with Mr Christopher Cleaver (initiator of the project). We will take you through the basics of Ecological Footprinting (EF).

Section A

Introducing the School Footprinting Initiative

Chapter 1: Your Challenge

Below is the statement that will form the basis of the School Footprinting Initiative (SFI) program. This is a key starting point, so read it carefully. Importantly, ensure that you understand what it implies by discussing with your peers and teachers. This pack is intended to answer your questions. Please let us (or your teacher) know about any outstanding issues not duly covered in this pack!

> "You are one out of six and a half billion people living and using our planet. As a Mauritian, you personally take up an average of 3.25 hectares of fertile land just to sustain all the activities which make up your lifestyle, including the consumption of resources (e.g. eating food, using transport, consuming products like clothes, electrical goods, cosmetics, using services like banking, insurance, and telecommunications and renovating and maintaining your home) and the generation of waste. The trouble is that there is on average only 1.7-1.8 hectares of productive land available for each human being living on Earth, an area decreasing with increasing global population and the loss of productive land due to human-related activities (e.g. deforestation, loss of top soil due to erosion, desertification, changing rain precipitation patterns due to global warming). Hence, the average Mauritian is living beyond the ecological means of the planet; there is not enough productive land left on the planet to soak up our waste and provide us with resources we use. This situation is said to be "*unsustainable*". This means that the limited resources of the planet cannot sustain our current lifestyles indefinitely into the future.
>
> The change towards a sustainable future will involve changes to our lifestyle; to do this effectively we need to find out which activities have the biggest impact and then work out ways to reduce this impact. The *School Footprinting Initiative* (SFI) is for students who want to do this in their school, using a tool known as Ecological Footprint Analysis.
>
> To get you started, the *Footprinting for the Future* team has helped out a bit. Firstly you'll be part of a team; you can come up with more creative ideas, make better decisions and cover a lot more ground. We also have some money for you to spend on your ideas; once you are ready to spend it wisely! In order to achieve your objectives, we have split up SFI into five phases:
>
> 1. Organizing your team,
> 2. Designing an investigation
> 3. Carrying out the investigation
> 4. Reducing and reporting
> 5. Reflecting and Presenting
>
> Ultimately it is your school, and the challenge is yours to make it more sustainable!"

That may have been pretty dense, so we are going to summarise the key aims of the project.

The **main objectives** in SFI are to:

- **Measure** and **reduce** your school's Ecological Footprint.

Some Frequently Asked Questions?

We expected you might have some questions related to this, so here are some quick answers to some common questions to keep you going. Most of this will be covered in greater depth later in the pack.

Why did we set up the SFI?
The SFI was set up to give you the opportunity to understand the impacts that you have on the natural environment through your school activities using 'hands-on' or experiential learning. We hope that SFI will bring about a rejuvenation of civic culture and also equip you with the means to understand and deal with local and global sustainability issues. SFI will provide you with valuable life-skills that you will be able to directly apply in various contexts including your household and community (village, town, country or planet).

What is an Ecological Footprint?
The answer is deceptively simple: the Ecological Footprint (EF) is an estimate for the total area of land a community needs to maintain all its activities (i.e. consumption of resources + generation of waste).

What makes up the EF of my school community?
Ecological Footprint Analysis (EFA) is a complex process, but there are ways to simplify it! You start by thinking about all the resources (products and services, including building premises) that the school utilises, as well as all its waste streams.
One simple example is the area occupied by the school built infrastructures. Similarly, land is required to grow the food you eat, or to grow trees to produce the paper that you use, or to absorb the CO_2 released when you use energy. This can be done for all categories of resources and wastes that you would have identified. Fortunately, we will provide you with a methodology to convert all the resources and wastes into an equivalent of land area (i.e. m^2)!

But how do we measure the EF?
You will have to quantify the amount of resources and wastes that you have identified in the previous step. However, there will be categories of resources and wastes that would be difficult and tedious to measure. Hence, a guiding principle for selecting variables to

measures is the *practicability* (both in terms of ease and time required) their measurements. For example, variables that you *could* measure include bread used (in kg), or consumption of electricity (in kWh), or mass of waste paper (in kg). Fortunately, we will provide you with a software tool that can convert these measurements into an equivalent land area – i.e. the Ecological Footprint of your school.

Since you will most probably not measure all identifiable variables (or measurable parameters), and also not able to accurately quantify measurable variables, the EF that you will obtain will only be a lower bound – i.e. the real EF of your school will be higher than what you would have estimated.

Do we include the EF of when we are at home?

In order to keep the exercise relatively simple, we have decided to keep your consumption of resources and generation of waste related to home activities out of the SFI. The SFI just concentrates on the EF the school community has as a result of school related activities. Hence, we are concerned here with only those resources and wastes that cross the school boundary. In this respect, the lunch that you bring from home adds to your school EF.

Nevertheless, your household SFI is just as important, and we would like you to think about it in parallel. In fact, you will be able to estimate the EF of your household once you have completed SFI. We encourage you to take this up as a challenge in parallel or after completion of SFI!

Chapter 2: What you'll be Doing

In this chapter we give you a feel for what you will be doing during the School Footprinting Initiative (SFI). Do not worry if you are wondering what exactly you will be doing as the SFI is like learning how to swim, or ride a bicycle; something best done in practice, not by reading about it, and hence the notion of experiential learning or learning by doing. All we ask of you is your enthusiasm, motivation and creativity! And yes ….. doing SFI should be FUN!

Working Arrangements

You will be working on the project as a group of around 16-20 students, and we would like you to split into about 4 smaller teams, of between 4-5 students. The project will last for about 14 weeks, from late April (although you would have been actively involved with SFI in early May) until mid-August. During this time, we expect you to meet regularly (at least once a week) as one group with your teacher(s). Your teacher(s) has(have) received prior training on EFA, and will be your main guide(s) throughout the project. These meetings will be a chance for you to organise and coordinate the whole project. You will be in charge of making almost all of the key decisions, and your guide(s) will only be next to you help to facilitate this process.

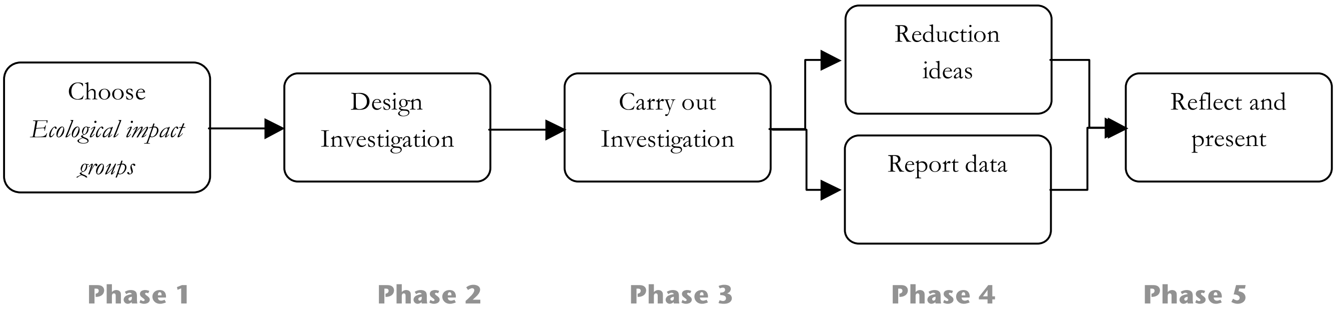
SFI uses a learning strategy called Project-Based Learning (PBL). See Chapter 9 for more details.

In order to be more productive during this relatively short lifespan of SFI, tasks are better allocated to smaller sub-teams. You will have to agree on a set of milestones (i.e. definition of main tasks and setting a deadline for their completion) during the group meetings. Then each sub-group will have to organise itself in terms of its resources (mostly time) to complete the allocated activities. You are in the best position to organise your own times for meetings and research work (e.g. lunch breaks, after school, weekends, etc …).

Splitting work into manageable chunks will be a common theme. For example, your sub-team can break down its tasks into sub-tasks that will have to be completed by pre-determined deadlines. See Chapter 9 for an example.

The Project Phases

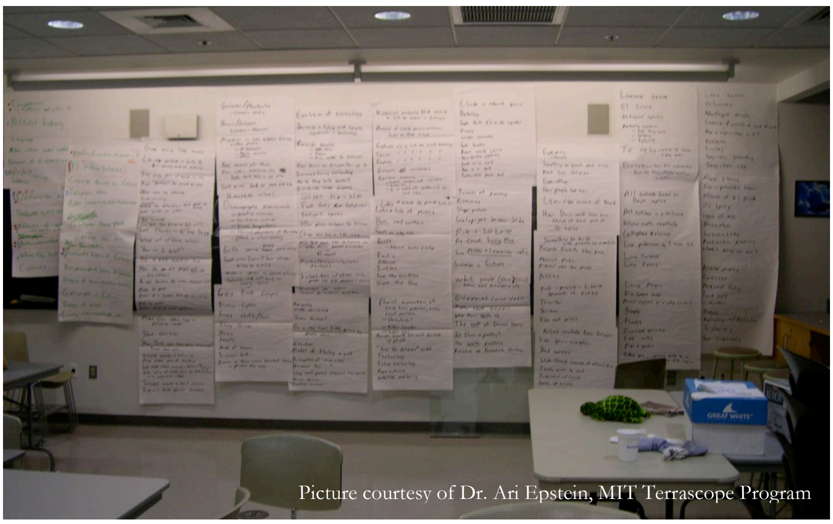
We have broken the project down into five phases, as shown in the flowchart below. The reason for this is two-fold: (1) make the project more manageable, and (2) give you the feeling that you are making progress. It also gives you a means to monitor the project and to provide feedback regarding its progress. We estimate that each phase will last between two to four weeks, but your teacher will explain the timeline to you in more detail along the way.



A Simplified Project Flowchart for SFI

Phase I: Organising Team and Project

During phase I you will organise your group into teams, within which you will be working for most of the project. After meeting all of your group members, everyone will be brainstorming their ideas about the school's ecological impact. **The choices you make in the first few meetings will influence the project's future direction.** We sincerely hope that everyone understands that her/his personal input is extremely important, and is able to make her/his voice heard – remember that SFI is *your project*.



Picture courtesy of Dr. Ari Epstein, MIT Terrascope Program

Group Brainstorming

One outcome of the brainstorming session is to identify & choose a small number (3 or 4) of *Ecological Impact Groups* (EIGs) that you would most like to investigate. Each EIG will have a sub-team formed around it, and you will get a chance to pick the EIG you want to work with. Of course, not each one of you may be assigned to the EIG you would most want to be working in. As a team you will be drawing up a list of *Measurable Parameters* (MPs) – also called *variables* - which you can go on to quantify in the next phases of the project. Each EIG will set its milestones in relation to the broader deadlines that have been set to complete SFI. It is advisable that you should elect a leader, and discuss some ground rules about the roles and responsibilities of each team member.

It is important that everyone in your team is happy with his or her role. For more advice about team formation see Chapter 9.

Phase II: Designing Investigation

Your sub-team will now work independently to design a way to collect data for each MP you have chosen. We want you to record this design process on an *Investigation Design Form*, which will be reviewed with the teacher at the end of the phase. Meanwhile, during group meetings your sub-team will update the other sub-teams on its progress against milestones.

What is an EIG?
An Ecological Impact Group (EIG) is a name given to a collection of ecologically burdening activities grouped along a certain common theme, examples might be 'Food', 'Transport', 'Energy ' or 'Everyday', 'Weekly', etc ….

What is a MP?
A Measurable Parameter (MP) or variable is a sub-set of an EIG that can be quantified. You will need to make critical decisions about how to aggregate consumption into MPs. For example, a 'Food and Drink' EIG might choose MPs such as 'Fruit Juices', 'Bread Products', and 'Meat'.

How will we measure MPs?
This is where you will need to be creative, and demonstrate some critical thinking. One method could be through a survey, or sometimes the school might record the information you need anyway – you will just need to arrange to access it. If the population of your target group is too large, you may need to use sampling techniques. For example, it will be too tedious to ask each and every student about his/her mode of transportation and distance to travel to school, especially when the number of students becomes larger. In this case, you may wish to conduct a survey on a limited sample set, and to extrapolate results to the entire school population.

Phase III: Carrying out Investigation

In Phase III of the SFI, you will carry out the investigation that you have just designed. Phase III can be carried out in parallel with Phase II since there are MPs for which measurements will be straightforward (e.g. area of school infrastructure), whereas the design phase may still be in process for other MPs that would require more elaborate measurement methodologies (e.g. use of paper in its various forms such as notebooks, text books, and library books).

In addition, you will be trained on how to use the software, that you will use to calculate the school's EF. The phase ends with a group data entry session, where each sub-team logs its data into the EF software.

Phase IV: Reducing and Reporting

Now there is a change in emphasis away from collecting and analysing data and towards making use of this information to drive a positive change. You will use a second brainstorming session to generate creative ideas for reducing your school's EF, and how you might deliver your message to the school. Each sub-team will research one of these ideas and write a proposal describing the idea. The written work of each sub-team will then be consolidated into a master proposal that will also include all of your prior research and measurements. A judging committee will review your proposal, following which awards will be made to the most innovative and realistic proposals to be implemented.

How do we think of ideas?
Although this is another area where we are asking you to be creative, you will be able to find a lot of ideas through researching, particularly on the internet. You could try starting with this website: http://www.teachernet.gov.uk/sustainableschools. Aim to have thought a bit about this before the brainstorm. Further, nothing prevents you from bouncing ideas off your schoolmates not necessarily participating directly in SFI. This may be a great way to involve the entire school in the project!

Will we get help with writing our proposal?
Yes. The British Council will be hosting Proposal Writing workshops for students to give you some general guidance about report writing. Also, your teacher will support you if you need help.

Phase V: Reflecting and Presenting

In the closing phase of the School Footprinting Initiative, you will be ask to reflect on the project as a group, and to share your experience with other schools. You will get a chance to deliver this presentation to a panel of judges. Pupils and parents from all twelve schools will be invited to the closing ceremony, when the implementation grants and prizes will be awarded.

Reflection is a key part of experiential learning, and instrumental to consolidating lessons learnt during the program.

What happens after the SFI finishes?
Firstly, we want you to help us evaluate the program by telling us what you enjoyed and how you think it could be improved. Then, we would be really excited to see you put your ideas into practice. Finally we would like you to transfer what you have learnt into positive contributions towards environmental sustainability!

Student Learning Journal

We would like you to fill in a journal throughout the program. The idea of the journal is to capture your learning points and give you a chance to articulate problems and concerns you may face during the implementation of SFI to your teacher. The journal will be a pre-printed booklet with directed headings for you to fill in.

We would like you to fill in your journal every week. In this way, your teacher can quickly respond to your problems, and it will help you to get used to thinking more about what you have learnt and directing your own learning. The journal may also make it easier for you and your teammates to eventually report on your experiences of the project.

Who else will see my Journal?
Your journal will not be shown to other team or group members. The journals may be made available to the SFI team for the purposes of supporting your teacher to help you, and also for evaluating the program.

Chapter 3: Your Learning Goals

Here is an outline of what you are going to learn and the skills you will develop as you go through the School Footprinting Initiative (SFI). Previous studies suggest that you will find it pretty useful to know about the benefits of experiential or project-based learning even prior to starting the project. They are:

Empowerment

You will feel more empowered to make a positive difference to your school environmental and its social practices.

You will feel more empowered to make a significant difference in the environmental practices of the wider community and the world. Remember that your school does not exist in isolation!

More importantly, you will gain an understanding of your interconnectedness with nature, and all other beings who are also dependent on ecosystem services for their wellbeing.

Environmental Understanding

You will be able to demonstrate the understanding that all human activities demand resources from the environment, while also generating waste that flows back to the environment.

You will be able to define the concept of systems thinking with respect to the environment, and provide specific examples in Mauritius.

You will be able to define environmental sustainability and provide specific examples in Mauritius.

Ecological Footprint

You will be able to define the terms 'ecological footprint' and 'sustainability indicator', and relate the two concepts.

You will able to identify the 6 Ecological Footprint (EF) land types, and for each, give an example human activity having that type of EF.

You will, in principle, know how to estimate the Ecological Footprint of any given community, and be able to outline the data you would need to collect.

Experiential or Project-Based Learning (PBL)

You will understand the concept of a driving question, as used in PBL, and will be able to give an example of another driving question you are interested in.

You will understand the concept of self-directed learning, and are able to give an example of how it was used in SFI.

You will feel able to contribute meaningfully to a group brainstorming exercise.

You will be able to demonstrate independent critical thinking, particularly when selecting Measurable Parameters, and designing an investigation.

Communication

You will be better equipped to write a formal proposal and deliver an oral presentation, following workshops provided by the British Council.

You will prepare and orally present and defend the results of your investigation, working towards SFI-developed assessment criteria.

You will be empowered to feel more comfortable communicating with adults, discussing ideas with team members, and explaining your own work.

Team Work

You will learn about criteria for determining team roles and responsibilities.

Given a challenge, you will be able to articulate the benefits of working in a team, the steps and importance of milestone setting.

You will learn, and how to resolve conflict and disputes (e.g. clash of ideas, lack of commitment) through dialogue.

For the purposes of evaluating the success of the program, we will distribute a questionnaire to all students, assessing whether you have met the learning goals we set out. The same questionnaire will be sent out both before and after the program, to monitor your progress throughout the SFI.

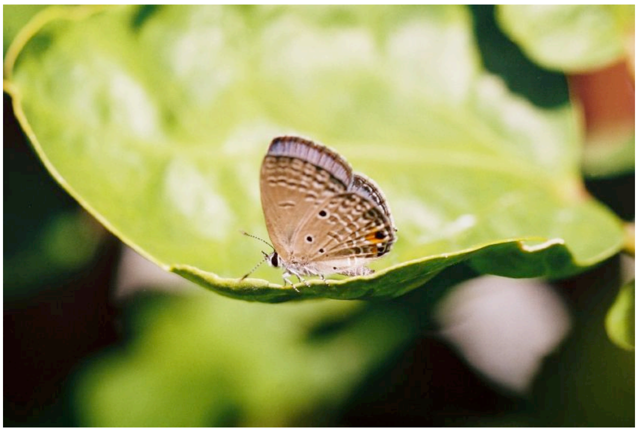
Section B

Knowledge Starting Points

Chapter 4: Systems Thinking about the Environment

Developing a new mindset

An environmental mindset would be second nature to someone whose day-to-day survival is dependent on gathering resources directly from the environment. Imagine crash-landing on a small, uninhabited island. You could perish within a few hours without shelter from extreme weather, after only a few days without water, or weeks without food. Therefore, your survival would be dependent on the environment providing these resources and absorb the waste products of your existence. The inclination to find out as much as you could about the environment's resources of water, food and shelter would be overriding!



Why does this type of environmental mindset not come naturally to people like us, living in a complex society? The answer could lie in complexity itself, often measured as the number of interactions between end products we consume, and the resources (or raw materials) drawn from the environment. This allows us, as consumers, to disregard how these numerous distant processes are using up the Earth's limited resources and causing lasting damage to ecosystems.

An example: Electricity generation from fossil fuels

Just take a pause and reflect on this example: In our modern era, we all take access to electricity for granted. Electricity is so ubiquitous to modern day living that our lives come to a standstill when there are power cuts for periods of times as short as one or two days! Yet the implications of using electricity, which is important for our wellbeing, are not straightforward and mostly unclear to most of us. So let us look at some of the impacts of using electricity.

To begin, you should understand that in Mauritius, and most of the world, electricity is generated from burning fossil fuels. If we consider the case of heavy oil or kerosene or diesel as a fossil fuel for generating electricity, we realise that stocks of this resource are reducing. The reason for this is simple: oil is being taken from the earth at a far higher rate than naturally occurring processes are replacing the oil, the resource is not 'renewable'. One immediate implication of this is that the rate of our consumption will have to peak within a few decades. Furthermore, the spatial distribution of these resources is not uniform; oil can only be obtained from certain areas of the world. We must be willing to think about the links between gaining access to these important, finite resources and forms of conflict that have (and will continue to) occurred, for example the breaching of the rights of indigenous persons and even war.

The processes by which you are provided with electricity do have damaging local environmental impacts. For example, occasional oil spills both on land and at sea can cause short-term habitat destruction. Or, burning oil (and other fuels) releases polluting gases, such as sulphur and nitrogen oxides that can dissolve in clouds, causing rainfall to become acidic and then damage local ecosystems. A global concern is the release of carbon dioxide when fossil fuels are burnt: CO_2 is a product of principal reaction which releases useful heat energy. Below we see how this is leading to the enhanced green house effect – i.e. global warming. In turn, global warming causes climate change and the increasing incidence of severe weather patterns, changes in precipitation patterns, sea level rise, loss of biodiversity, and propagation of tropical diseases to higher latitudes, among others.

An Oil Refinery

We hope that this simple example has shown you the number of complex interactions that arise from only one activity, namely using electricity generated from a fossil fuel. Very often, negative impacts take place geographically far from us. Whilst it is true that sustained effort, both political and technological can reduce these impacts, it is our responsibility as consumers not to be *numb* to them. Similarly, each one of your every day activities exhibits complexities that have local and global effects.

Understanding complex systems

Although this kind of complexity is hard to grasp, we need to be able to predict the ultimate consequences of our actions on the environment. This calls for cultivating a new skill called 'systems thinking' in order to picture how interconnected we are with our environment. **Our activities and consumption patterns impact on the environment, and this impact in turn affects our wellbeing**. In the past, there has been a tendency to compartmentalise knowledge gained from different disciplines (e.g. natural sciences, social sciences and the humanities) through a '*reductionist*' line of investigation – i.e. breaking something down into its smaller and simpler parts that are then studied and understood in isolation. A major problem with this approach is that the whole cannot be understood through the understanding of its parts. Let us take the example of the human being. Any individual human body is made up of discrete and distinct organs such as the brain, lungs, eyes, liver and heart. An understanding of the functioning of the individual organs, although quite important in itself, does not provide an accurate picture of the complexities of emotions, feelings and cognitive capacity of the whole being. Emotions, feelings and cognition emerge through the complex interactions between the organs of the body, and can be studied and understood only at the level of the whole being or system.

Similarly, understanding how the Earth works as a whole requires the 'systems approach', wherein knowledge gained from various disciplines are reconciled, and development of system models of how natural and human processes interact to result changes to the environment that sustains us.

Three Examples of Systems Thinking

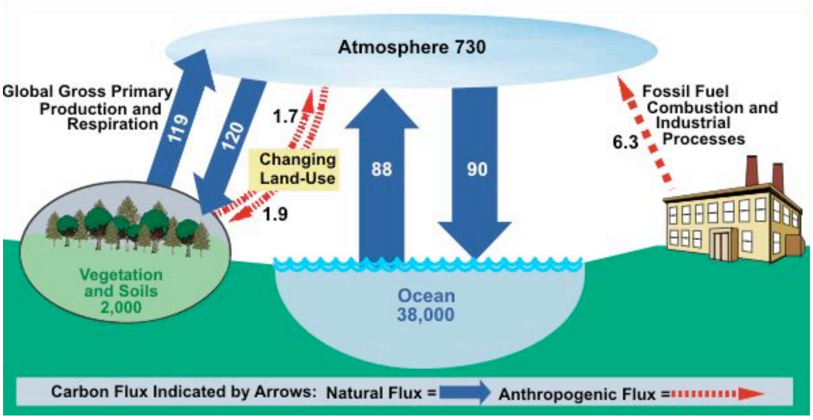
1. Systems view of the earth: Gaia Hypothesis

James Lovelock's 'Gaia' hypothesis that the Earth is a self-regulating entity is a great example of a systems thinking applied to the earth. He hypothesises that the Earth, which he labels Gaia, is a self-regulating entity, which acts towards the goal of maintaining conditions on earth hospitable to the Earth's current inhabitants. It had become apparent that conditions (e.g. temperature, composition of atmospheric gases) prevailing on Gaia are very different than they would be on a 'dead' planet, such as Mars. Lovelock hypothesised that these life-favourable conditions were being maintained by the combined action of many billions of plants and animals *themselves* over millions of years. Indeed, just like every human being is a living entity, the Gaia hypothesis presumes that the Earth taken as a whole is also a living entity. Processes that maintain life at our bodily human level are similar to those operating at the planetary level. These processes, such as maintaining an appropriate temperature or flux of nutrients to support life, are known collectively as *homeostatic functions*.

Gaia

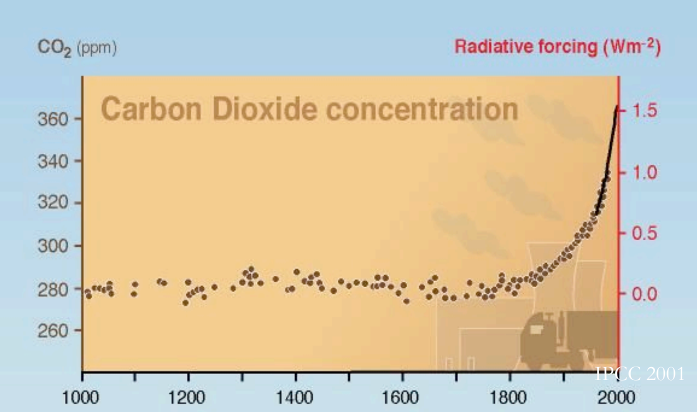
2. The Carbon Cycle, Fossil Fuels and Global Warming

The schematic diagram below shows the balance of carbon on our plant – i.e. the Carbon Cycle. It shows the yearly flows and total reserves of carbon, in billions of tons. The biological processes of photosynthesis and respiration control the level of atmospheric carbon dioxide (CO_2). During photosynthesis, plants convert CO_2 in the air into glucose and other forms of biomass (organic matter). The reverse of this process is respiration, when plants and animals use biomass as a fuel source to provide energy for growth, movement, reproduction and other functions. Through respiration, the carbon stored by photosynthesis is released to the atmosphere once again as CO_2, completing what we call the carbon cycle.



The Carbon Cycle

However, some of the 2,000 billion tonnes of carbon found in vegetation and soil reserves become buried underground. Over hundreds of millions of years and under the influence of heat and pressure this buried biomass can be converted into fossil fuel resources: coal, oil, natural gas, oil shales, and tar sands. Since the beginning of the industrial revolution (18^{th} Century), humankind has been combusting these fuels to produce electricity, heat its homes and industrial processes, and to provide energy for transportation. The combustion of fossil fuels releases billions of tonnes of CO_2 into the atmosphere. As shown below left, the concentration of atmospheric CO_2 has been increasing exponentially since the industrial revolution.



Atmospheric Carbon Dioxide Concentration

Through the greenhouse effect, atmospheric concentrations of CO_2 have a critical influence on global temperatures. Carbon dioxide is a principal greenhouse gas, and alongside methane, water vapour and nitrous oxide, it raises the temperature of the earth by trapping a fraction of the heat radiated back to space by the Earth. The markedly increased CO_2 levels since the early 19^{th} Century are strongly linked to global warming and climate change.

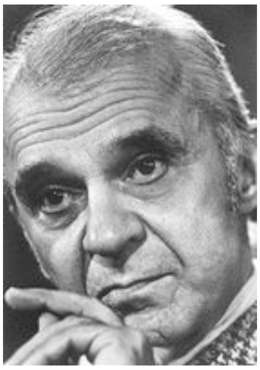
Global warming is expected to have serious consequences for all nations. In April 2007, the Intergovernmental Panel on Climate Change (IPCC) released a summary on climate change impacts, adaptations and vulnerabilities. Here is an excerpt of what they have to say about impact on small islands like Mauritius specifically:

> “Small islands, whether located in the tropics or higher latitudes, have characteristics which make them especially vulnerable to the effects of climate change, sea level rise and extreme events.
>
> Deterioration in coastal conditions, for example through erosion of beaches and coral bleaching, is expected to affect local resources like fisheries, and reduce the value of these destinations for tourism.
>
> Sea-level rise is expected to exacerbate inundation, storm surge, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities.
>
> Climate change is projected by the mid-century to reduce water resources in many small islands, e.g. in the Caribbean and Pacific, to the point where they become insufficient to meet demand during low rainfall periods.
>
> With higher temperatures, increased invasion by non-native species is expected to occur, particularly on middle and high-latitude islands.”

Who are the IPCC?
The Intergovernmental Panel on Climate Change (IPCC) is an independent organisation set up to assess and report information related to climate change. The IPPC was set up in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP). Its website can be found at http://www.ipcc.ch.

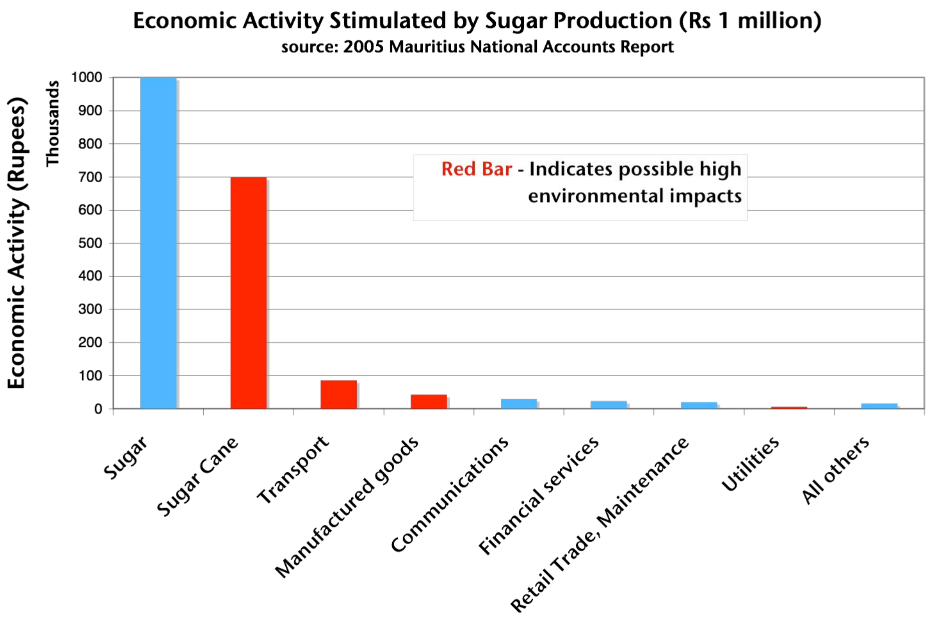
3. Systems view of the economy: The Input-Output Model

Another useful systems-related concept is the Input-Output (I-O) model of the economy. Invented by Wassily Leontief, the I-O model divides the economy into a number of sectors, and tracks how these sectors are interrelated. A given amount of output from one economic sector will require related inputs such as raw materials, product and services from other sectors. For example, see in the figure below how Rs 1 million of sugar industry output stimulates activity in other sectors, primarily (and predictably!) sugar cane agricultural production.



Wassiy Leontief

This I-O model allows us to assess the full environmental impact of choosing to buy sugar, since it involves activity in many different sectors you could otherwise have missed or neglected. Each sector has different types of impact: sugar cane production requires a large area of land and is water intensive through overhead irrigation, burning fossil fuels to power vehicles for harvesting and in the transport sector produces air pollutants and CO_2, and manufacturing of goods often involves the release of wastes, among others. Indeed, you should not be misled by the relative size of the bars, since the relative magnitude of environmental impacts in the various economic sectors could well be quite different!



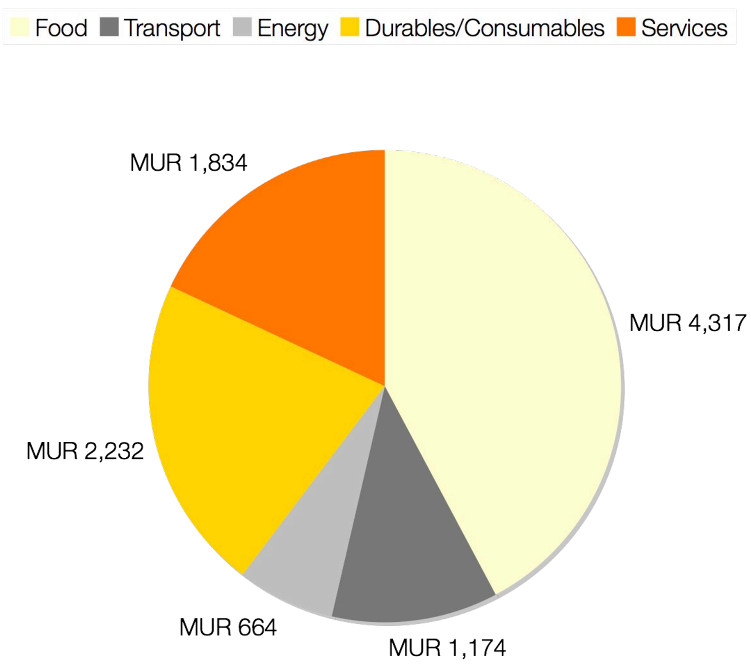
Data from Input-Output Model of Mauritius Economy

Chapter 5: The Environment and Us

Our environmental interactions

Having built up a systems approach to thinking about environmental interactions let us apply it now to some of the key ways in which we *all* interact with the environment. These interactions will not always be direct or linear, so we will need to get an understanding of the value chain that enables these activities, and next, the environmental impacts of these connected activities.

A great place to start is to for you to get a feel for how we spend our money. Below is a breakdown of the average Mauritian household budget. You will see that food is the biggest category of expenditure (Rs 4,300 monthly), followed by spending on durable/ consumable products. You should remember that no category of consumption is exempted from environmental impacts!

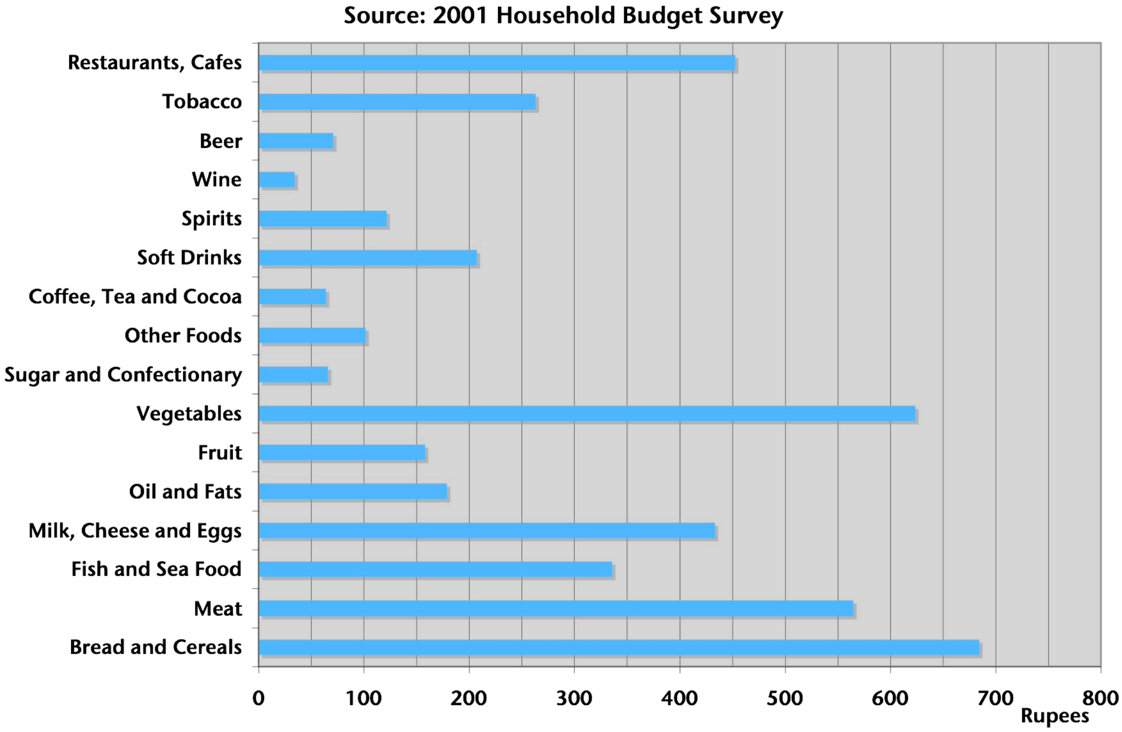


Monthly Household Spending: Average Mauritian 2001

Where did we get this information?
We used the 2001 Mauritius Household Budget Survey, available on-line at http://www.gov.mu/portal/site/cso/. You should definitely check it out sometime!

The food we eat

The interaction between foods we eat and the environment is, on one level, quite intuitive. In Mauritius, most money is spent on bread and cereals (including rice) and vegetables. Animal products including meat, fish and milk are also all consumed at a high level. Note that expenditure on 'restaurants and Cafes' is also quite substantial. This indicates the presence of affluence in Mauritius.



Monthly Household Spending on Food and Drink: Average Mauritian 2001

Supply Chain from the Environment

You should understand the distinction between primary and secondary products. For example, bread is a secondary product requiring cultivation of wheat as a primary crop. Processing of wheat produces flour as a primary product that is then used to bake secondary products like bread and cakes. Similarly, all the food that we consume can be traced to services rendered to us by natural ecosystems. Further, it is worth noting that water is an essential input to agriculture. For instance, it takes around 1000 litres of water to produce one kilogram of grains (e.g. wheat and rice). The water cycle is regulated by nature. Then there is also energy required to produce the food we consume!

What is important to note here is that all the base resources and primary products that are consumed in human societies are derived from the natural environment.

Irrigation

Environmental Impact – Deforestation

The load or pressure, L, that human beings have on the environment is a product of population size, P, and per capita consumption, A (or Affluence) – i.e. L = P x A. With increasing population growth (more mouths to feed) and a trend towards increasing per capita consumption, there is more need of land for agricultural purposes. Hence, the increasing demand for agricultural products and services translates directly into the clearing of forests or deforestation to make space for agriculture. However, it should be pointed out here that the major driver of deforestation is not necessarily agriculture for food production. Other dominant drivers of deforestation are (i) agriculture for energy production, namely biofuels, and (ii) production of timber and paper products.

Environmental Impact – Water Pollution and Eutrophication

Growing the food we eat is also chemically intensive; good crop growth is dependent on the use of chemical fertilizers. You should know that amongst nations in the world, Mauritius is one of the most intensive users of fertilizers. These fertilizers commonly contain nitrogen, phosphorous and phosphate compounds.

Although some of these chemicals are absorbed by crops (the intended use), others dissolve in water and reach underground aquifers, rivers and eventually the ocean. The result is two-fold: (i) pollution of underground water aquifers and rivers, and (ii) eutrophication. Accumulation of chemical nutrients in aquifers makes them unsuitable for human consumption as potable water, and, in rivers, they disrupt the habitat of fresh water organisms.

Eutrophication occurs in lagoons, seawater or rivers, when these chemical nutrients stimulate the growth of aquatic plants, especially algae (i.e. algal bloom). As the algae die, the population of bacteria that feed on dead algae by decomposing their cells increases rapidly, consuming more and more oxygen dissolved in water. The depletion of oxygen in water can lead to the death of aquatic animals (fish and crustaceans) by asphyxiation.

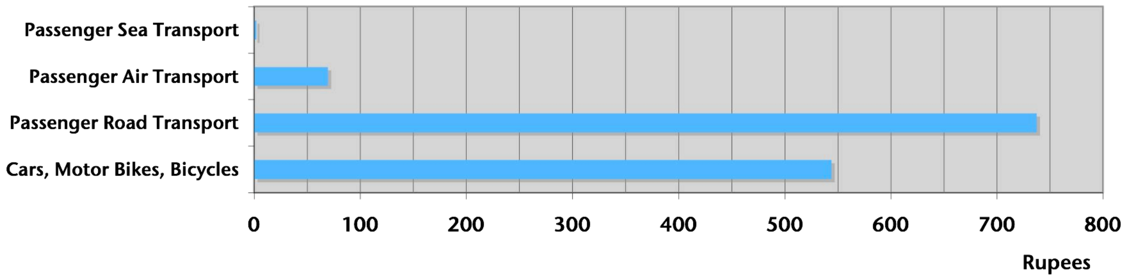
In these ways, the use of chemical fertilizers to help us grow better crops might therefore result in loss of biodiversity and ultimately deplete the range of food sources available for us to enjoy.

Rice Fields

How we get around: transport

The bar chart below shows the monthly household spending on transport in Mauritius in 2001. Road transport is a large chunk of our monthly expenditure. Although, mobility is important for carrying out our daily activities, such as commuting to work and travelling to school, the links between the transport sector and the natural environment is intricate. The following is a brief outline of the impacts of transport on the environment.

Source: 2001 Household Budget Survey



Monthly Household Spending on Transport: Average Mauritian 2001

Supply Chain from the Environment

The environmental impacts of transportation can be broken down into three parts: (i) manufacturing of vehicles (secondary products), (ii) use of vehicles (iii) final disposal of old vehicles.

Manufacturing of vehicles draws heavily on the environment. Most vehicles are fabricated using iron, steel and polymers. The raw materials from these primary products come from the mining (or chemical for polymers) industry. Mining and processing of metal ores has brought undoubtedly brought humankind many advantages, but we should remember that we do so both at the expense of topsoil and the intensive use of chemicals and energy. For example, when we produce aluminium from mined bauxite ore, through the purification process of electrolysis, 9.6 kg of CO_2 is released into the atmosphere for each kilogram of aluminium produced.

Traffic in New Delhi

However, the 'use' part of a vehicle's environmental impact (burning liquid fuels to make them move!) has been shown to be the most important. Some of these impacts are discussed below:

Environmental Impact – Traffic Fumes

The burning of liquid fuels (gasoline and diesel oil) to operate transport vehicles produces exhaust emissions or fumes. A typical analysis of exhaust emissions would show the presence of carbon dioxide, carbon monoxide, hydrocarbons (i.e. unburned fuel), nitrous oxides, sulphur dioxide, among others. In 2002, 92% of people surveyed declared that the emission of traffic fumes was a serious problem in Mauritius.[1] Although quantification has not been carried out for Mauritius, traffic fumes are known to cause respiratory problems.

Environmental Impact – Contribution to Global Warming

Whenever we drive our vehicles, CO_2 is released into the atmosphere. In Mauritius, the use of liquid fuels accounts for approximately 50% of final energy consumption, of which transportation is responsible for about 30%. Therefore, an increase in fuel use in the transport sector will result in a large increase in pollution, including emission of CO_2. As you are aware, CO_2 is a greenhouse gas that produces global warming and associated climatic changes discussed earlier. We expect that the demand for private (cars and aviation) transporation will continue to increase, and we know for sure that this would increase the levels CO_2 emissions in Mauritius.[2]

Environmental Impact – Noise Pollution

The Mauritian Social Attitudes Survey 2002 has shown that 81% of respondents revealed that traffic noise in towns was a serious problem.[3] The result was the same whether or not the respondents owned a vehicle themselves. Since the number of vehicles on our roads is increasing, while the length of roads is almost constant, there is also increasing incidence of traffic congestion both on highways and in towns. The increasing incidence of traffic congestion exacerbates all forms of pollution (exhaust fumes, noise and CO_2 emissions) from the transport sector.

Parked Cars

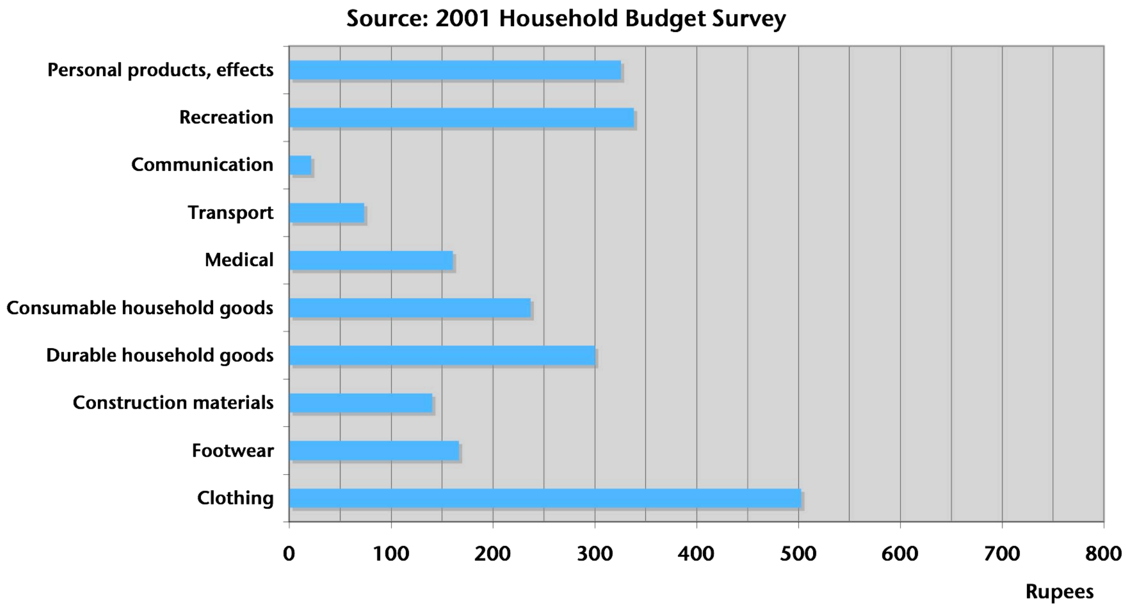
[1] Mauritian Social Attitudes Survey 2002 (Centre for Applied Social Research, University of Mauritius), pg. 117.

[2] Environment Statistics – 2004 (Issue 518 of Economic and Social Indicators, 18 August 2005).

[3] Mauritian Social Attitudes Survey 2002 (Centre for Applied Social research, University of Mauritius), pp.116-117.

The items that we buy

The bar chart below summarises our monthly expenditure on various consumer items. Items of clothing, personal products and recreation are those on which we choose to spend most of our money. The cumulative expenditure on the later items of consumption is comparable with expenditure on food items like vegetables or bread & cereal (see above). Such consumption patterns are, indeed, indicative of the level of affluence or materialist consumer attitude prevalent in Mauritius. They are exactly the reasons why the Ecological Footprint of Mauritius as a whole is unsustainable.



Monthly Household Spending on Durable/Consumable Goods: Average Mauritian 2001

Environmental Impact - Industrial pollution

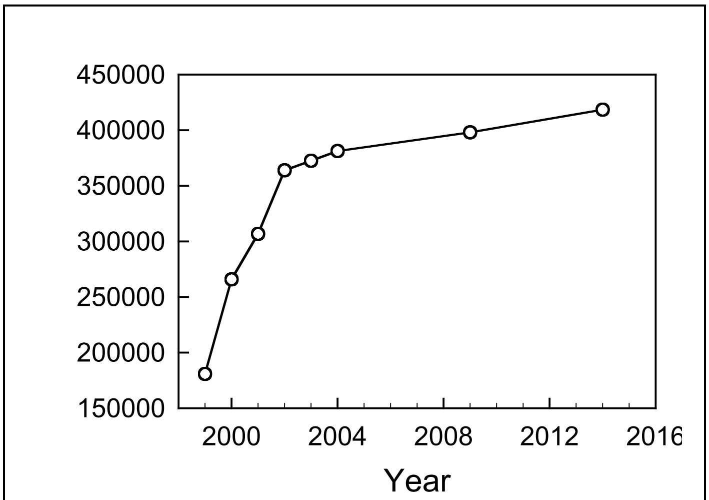
Since Mauritius is a net importer of many goods, much of the industrial pollution associated with their production is delocalised – i.e. the effect is not felt where consumption takes place geographically. With increasing globalisation, it is very easy for the consumer to become shielded from the environmental impacts of producing the goods and services that they consume. For instance, the manufacturing industry in Mauritius produces only 13-15% of the CO_2 emissions of Mauritius (i.e. approximately 360 thousand tonnes of CO_2). However, the sum total of CO_2 emission associated with the energy embodied with the products that we import is expected to be much more significant.

Molten Iron

Environmental Impact – Generation of Waste

A direct outcome of consumption is waste generation. Waste generation is also a product of population size and per capita consumption (for a given state of technology to deliver services and products). The graph below shows clearly the trend towards increasing waste generation in Mauritius, which is linked directly to our increasingly consumerist lifestyles. The generation of waste is also associated with littering (land pollution). In a 2002 study, 43% of Mauritians reported that rubbish as the biggest environmental problem (23% pollution from factories, 17% pollution from motor vehicles, 9 % chemicals and pesticides, 6% unplanned development, and 1% tourism).[4] Rubbish is a highly visible stain on the environment, and it also has a detrimental impact on human wellbeing.

Waste Disposal



Waste Produced in Mauritius: 1999-2014.

Historical and Predicted Trend of Waste Porduction, Mauritius

[4] Mauritian Social Attitudes Survey 2002 (Centre for Social Applied Research, University of Mauritius), pr. 111.

Chapter 6: Sustainable Development

You should by now have understood a bit more about the consequences of your own lifestyle, especially how this can have an environmental impact. These environmental impacts can in turn have detrimental impacts on our activities, thereby impairing our quality of life. We now pose a new question, how do we weigh the importance of these environmental impacts in relation to other aspects of our lifestyle and the nation's development?

Economic development through the exploitation of the environment has undoubtedly raised standards of living of Mauritians. However, if we continue along this path, we face a trade-off with damaging the environment that sustains us irreversibly as expressed by an analogy Lovelock makes:

> "It would make us like sailors who burnt the timbers and rigging of their ship to keep warm"

Gro Harlem Bruntland

The process we should use is *sustainable* development: improving quality of life or human wellbeing without degrading the environment to such an extent that further improvements in wellbeing are no longer possible. The message here is very simple. The 'systems thinking' has shown us that human wellbeing is intricately linked to the integrity of natural ecosystems. Hence, it is in our own benefits to maintain the integrity of these natural ecosystems. The Bruntland Commission coined the following definition in 1987: '

> "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs"

Although the above definition has been useful to promote a new form of economic development (i.e. sustainable development) that is compatible with natural processes, it is widely recognised today to have practical limitations. In this context, alternative definitions of sustainable development that are more operational have been articulated. One such alternative definition sees sustainable development as:

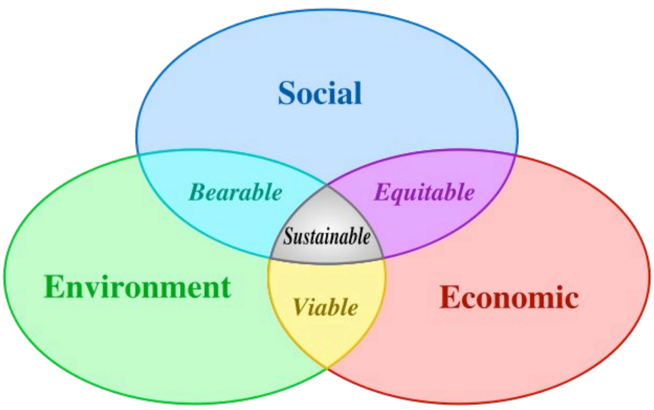
> "…a change process, in which the societies improve their quality of life, reaching dynamic equilibrium between economic and social aspects, while protecting, caring for and improving the natural environment. This integration and equilibrium among these three aspects must be taught and transferred from this generation to the next and next."

Weak and Strong Sustainability

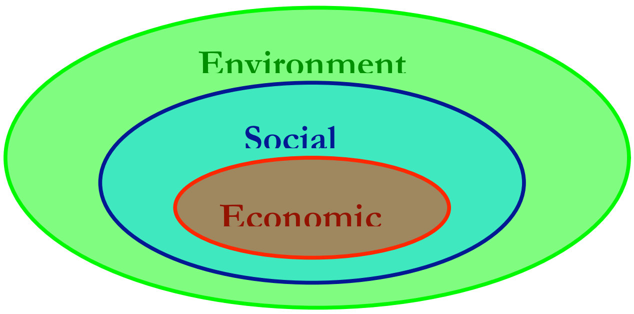
Two models of the interaction between 'Social', 'Environment' and 'Economic' factors, used to describe sustainability are shown below.

The widely used model to the left characterizes what can be called '*weak sustainability*'. Sustainability is achieved when economic, social and environmental conditions are all met. The separation of the three regions embodies an assumption that economic, social and environmental factors can be isolated from one another. In fact, we know very well that this is not the case; the economy is reliant on the environment. For example, there are no human-made capital artefacts that can regulate the global temperature or the production of oxygen and the sequestration of carbon dioxide which make economic activities possible.

Hence, another model – '*strong sustainability*' - has been conceptualised as shown below. It shows a clear hierarchy between 'Environment', 'Social' and 'Economic'. It shows that the economy is a social structure, both of which are embedded within the natural environment. It is the life-support services provided by nature that allows societies to flourish and for economies to be formed for addressing human needs.



Weak Sustainability



Strong Sustainability

Easter Island: A case study in unsustainable development

We don't have to search too hard to find examples of how a society has brought about its own collapse through pursuing unsustainable practices. A good example is the case of the Polynesian society on Easter Island, in the mid-pacific ocean, as explained in Jared Diamond's book 'Collapse'.[5]

Signs of a Complex Society

When Jacob Roggeveen discovered the island on April 5 (Easter), 1772, it appeared to him as a wasteland: "its wasted appearance could give no other impression than of a singular poverty and barrenness". By this time the indigenous population numbered just 2,000, with limited seafaring capacity and reliant on a limited number of food sources.

Carved Statue: Easter Island

And yet there is evidence that a complex society once flourished on the island, since their arrival in AD 400. For example, the island is home to over 200 giant carved stone statues, as pictured left. More than 700 further statues were left half-completed at different quarry sites.

Roggeveen was astonished by these statues, "we could not comprehend how it was possible that these people, who are devoid of heavy thick timber for making any machines, as well as strong ropes, nevertheless had been able to erect such images". A complex society must have existed to feed and support the specialist craftsmen needed to produce such statues, but what became of it?

The Likely Cause: Deforestation

The archaeological record suggests that the island was once covered by a sub-tropical forest, abundant Easter Island Palm, hauhau and tomorino trees. Through pollen analysis of cores of built-up sediment, John Flenley and Sarah King were able date the gradual depletion of these forest resources between 800 until 1400AD. Further evidence of diet and remaining artefacts suggest that the islanders were reliant on these trees for food, shelter and fuel, as well as statue-building enterprises. The enlarging population's demand for wood must have exceeded the regenerative capacity of the island's forests and the society collapsed, a direct result of unsustainable exploitation of its environment.

What should we learn from this?

It is all too easy for a society to be oblivious to the environmental destruction it is causing. In this case, Diamond argues that deforestation was such a gradual process that the society did not react to it accordingly: "any islander who tried to warn about the

[5] Jared Diamond, Collapse – How Societies Choose to Fail or Survive (Allen Lane, Victoria, 2005).

dangers of progressive deforestation would have been overridden by vested interests of carvers, bureaucrats, and chiefs, whose jobs depended on continued deforestation". To avoid this in our society, an approach we might take is to develop a sustainability indicator that we *do* respond to with corrective action. In fact, Diamond also provides clear examples from past and contemporary societies that decisive and timely action by communities can remedy their negative impacts on their natural environment. Any positive steps required to enhance the integrity of our natural ecosystems first requires the cultivation of a new ecological awareness of the complex interactions between social and natural systems.

Chapter 7: About Ecological Footprinting

The Ecological Footprint was developed by William Rees and Mathis Wackernagel from University of British Columbia in the 1980s. It provides a numeric assessment of the human demand on the biosphere at a given point in time. Developing indicators such as this is very important since it allows us to track the load or pressure that we place on the natural environment as a function of time. It also allows us to determine the impacts that our interventions and changes in lifestyles may have on the demands we place on the planet.

The Ecological Footprint indicator uses the units of 'global hectares', of biologically productive land use. You might find it useful to remember and understand the following definition:

> The Ecological Footprint (EF) of an activity is the total area of biologically productive land that the activity appropriates through directly and indirectly consuming resources and generating wastes.

EF Land Types

The six types of biologically productive land usage are identified under the EF indicator, are presented below. Can you think of examples from your own life of how you might use land?

	Land Type	Examples
	Crop Land	Crops for human consumption: e.g. wheat, rice, sugar Crops for animal feed: e.g. Other crops: Cotton, ??
	Grazing Land	Rearing grazing animals: e.g. Cattle, sheep, goats, equine, camels

	Forest	Timber for construction, furniture Pulp for paper, cardboard products Fuel wood
	Built-up	Housing Transportation Industry Hydroelectric power
	Sea	Fishing grounds
	CO_2	Electricity generation Transportation Home fuel usage Industrial fuel usage

What is CO_2 land?
CO_2 land represents the total area of land required to absorb the waste produced by burning fossil fuels, namely carbon dioxide. The EF method assumes that a certain amount growing forest area could, in principle, be devoted to absorbing this CO_2 and storing it in the form of organic biomass.

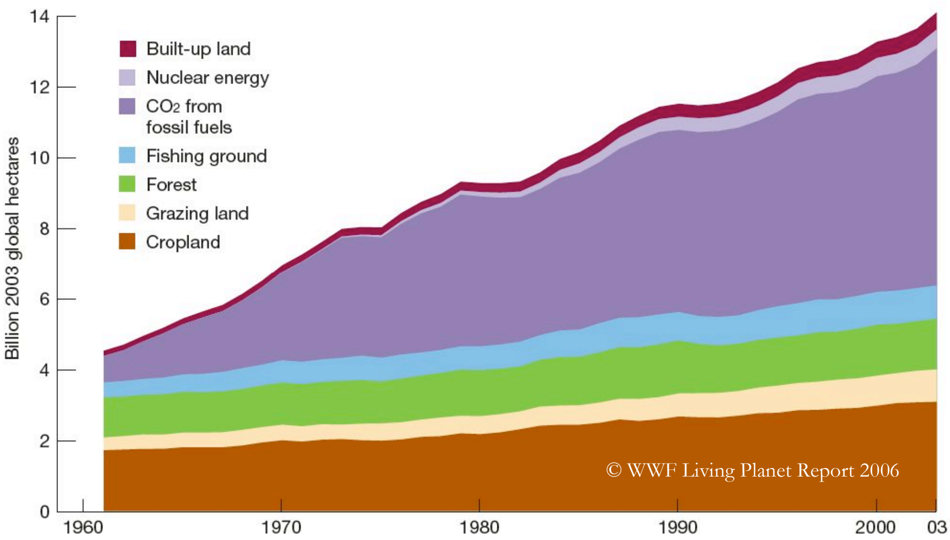
Does this land really exist?
Yes and no! By burning fossil fuels, we are unlocking the energy stored by forestland from millions of years ago. However, at present vast areas of land are not deliberately set aside for absorption of CO_2 (and hence atmospheric levels are rising). For practical purposes, it is a methodology used to quantify our energy intensity on the planet.

Biocapacity

A feature of the EF is that it can be compared the actual productive capacity of the bioshpere, biocapacity, at that point in time. Below you see that in 2006 this came to 1.7 hectares per person, about the size of two and a half football pitches.

Global EF vs. Bio-capacity

Look at the graph below, reproduced from the WWF Living Planet Report 2006 that tracks global EF between 1960 and 2003. One of the first points you should notice is that our ecological footprint is growing! This is linked to the product of increasing population and per capita consumption.



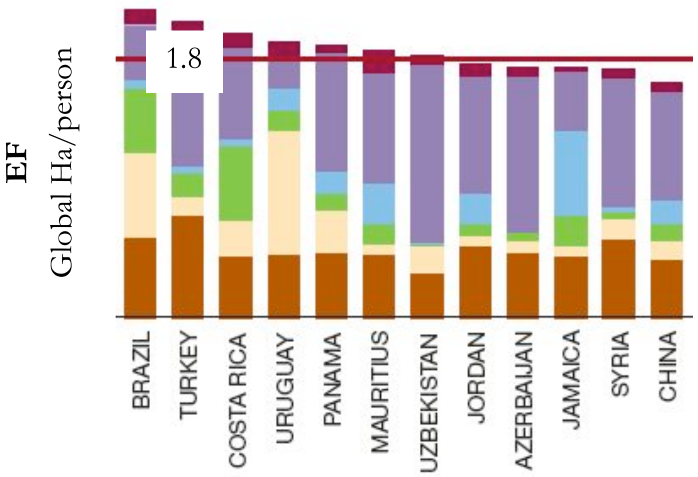
Humanity's Global Ecological Footprint, Historic Trend 1960-2003

The biggest single EF land type has been CO_2 land. This reflects what you saw earlier; our lifestyle exerts a large demand for energy at home, in our cars and in our industries. The combination of Cropland, forests and grazing land roughly match the CO_2 land. Built-up land has only a relatively small contribution to the total EF.

But recall that the biocapacity of the earth was only 11.2 billion global hectares. Therefore, you can see that since the 1980s, humankind's demand on the biosphere has overshot what the earth could provide! Clearly, there is a call for nations to reduce their ecological footprint.

The EF of Mauritius

The same report breaks down the EF of each country, see left, the size of Mauritius' EF per person. Again, the biggest contributor is the burning of fossil fuels as an energy source. In the last two decades, Mauritius has experienced almost exponential economic growth. Whilst this has undoubtedly led to improved standards of living, the EF indicator shows how this has come at the cost of taking up a larger share of the bioproductive capacity of the biosphere.



The Ecological Footprint of Selected Nations, 2003

Who calculated this?

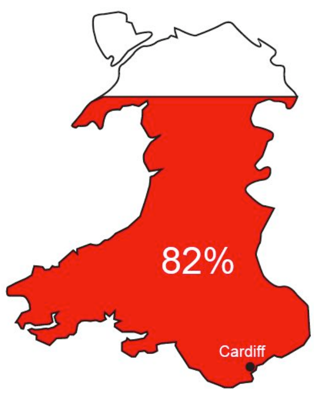
Published in the WWF Living Planet Report 2006, these EF results were calculated by Global Footprint Network, http://www.globalfootprintnetwork.org/

How are they calculated?

They use official government and international statistics about production, imports and exports, to calculate the overall consumption of certain resources. These are then converted into global hectares, using standardised conversion factors. In this project you will not have to go into the details of 'conversion factors', which can be quite tedious and complicated. Rather, we will provide you with a simplified Excel spreadsheet that will compute all the necessary conversions of your MPs into the equivalent land area.

The EF of a community: Cardiff City

EF studies can be made for any size of community, from global, nations to cities, towns and villages. Here you can see the results of a study that was made of the city of Cardiff, in Wales, United Kingdom.



Big ecological hitters	gha (global hectares) per capita	% of footprint
food and drink	1.33	24%
energy use	0.99	18%
passenger travel	0.99	18%
the city's infrastructure and housing	0.90	16%
consumables and durables	0.64	11%
others (including government, services, holiday activities see page 12)	0.77	14%
TOTAL	5.59	100%

Results of Cardiff City EF Study, Cardiff Council

At this level of study, it is possible to break the EF down into different categories of consumption. You can see that food and drink has the biggest individual footprint component, followed by energy use and passenger travel. It is interesting to compare the % EF in Cardiff, with the % *spending* on similar categories in Mauritius. How do you account for the differences, say in Energy use? Is it because Cardiff citizens are doing something different, or is it that some types of spending are more 'footprint intensive' than others?

Where can I find this study?
The study can be downloaded from Cardiff City Council's website: http://www.cardiff.gov.uk/

An example of EF Calculation from scratch: Eating Chicken

Here you will see how you might start to work out the ecological footprint of the average Mauritian's consumption of chicken. It is just to give you an idea of how it might be done – remember that you will not go into such details in the SFI! The EF of consuming chicken on average for one year is 607 m^2 per person.

Key data:
Average Mauritian Consumption = 26.2 kg / year
Feed yearly yield = 0.42 kg / m^2
Biomass conversion factor = 25%
Embodied energy, processing = 80 GJ / kg
Yearly carbon sequestration rate = 7.1 GJ / m^2

Crop Land

Crop land is needed to grow the chicken's feed. If 25% of all feed biomass is converted into chicken biomass, this means that we must grow 104 kg/year of feed. Given an average feed crop yield 0.42 kg/m^2, this will require:

Crop Land $= [26.2\ (kg/year) \div 25\%] \div 0.42\ (kg/m^2\text{-year})$
$= 275\ m^2$

CO_2 Land

Energy is needed during the rearing, processing and cooking of the chicken meat, and the growing, cultivation and transportation of the feed. This, so-called embodied energy, is estimated at 80 GJ/ kg of chicken. You have seen how whenever we use energy, carbon dioxide is emitted into the atmosphere. The CO_2 footprint is based on the rate at which growing trees can absorb this CO_2 (sequestration rate), which in our case is:

CO_2 Land $= [26.2\ (kg/year) * 80\ (GJ/kg)] \div 7.1\ (GJ/m^2\text{-year})$
$= 332\ m^2$

Where is this data from?

Yearly chicken consumption is from Digest of Agricultural Statistics 2005 published by the Central Statistics Office.

Conversion factors are from a 'Household EF Assessment v2.0' by Redefining Progress

Is there anything more to EF?

Yes! Each land type is not considered equal (for instance, crop land is more valuable than poorer quality pasture land), the following **equivalence factors** are used to convert from land area (hectares) to EF (global hectares):

	gha/ha
Primary cropland	2.21
Marginal cropland	1.79
Forest	1.34
Permanent pasture	0.49
Marine	0.36
Inland water	0.36
Built-up land	2.21

See footprint standards at www.footprintstandards.org for more information!

EF of your School

You will be conducting an Ecological Footprint investigation for your own school community. Here's a reminder of the plan we set out for how you'll do that:

1. Your group decides a list of 3 or 4 Ecological Impact Groups (EIGs), that you think are going to be most important.
2. Your sub-team working on one EIG gives us list of Measurable Quantities (MPs) that you can investigate.
3. We work out all of the conversion factors, and provide you with your school's customised EF Software
4. You measure each MP and plug your results into the EF Software
5. You will have an estimate of the school's EF!

Limitations of Ecological Footprint Accounting

The Ecological Footprint attempts to answer one question which is central to achieving sustainability: 'how much of the bioproductive capacity of the biosphere is used by human activities.' A necessary condition of sustainability is, therefore, that the world's ecological footprint does not exceed the world's biocapacity. However, a healthy EF is **not** also a *sufficient* condition for sustainability.

To measure overall progress towards environmental sustainability, the Ecological Footprint needs to be complemented by other measures such as those measuring the depletion of scarce resources, levels of deforestation and desertification, loss of biological diversity and local effects of pollution, and the use of synthetic materials produced by humans for which nature has no productive or assimilation capacity.

What other Sustainability Indicators exist?
A great book to read is 'The Wellbeing of Nations'. This provides a country-by-county index of the quality of life and the environment. It uses:
- 36 indicators of human wellbeing (e.g. health, population, wealth, education, communication, freedom, peace, crime, and equity)
- 51 indicators of ecosystem wellbeing (e.g. and health, protected areas, water quality, water supply, global atmosphere, air quality, species diversity, energy use, and resource pressures)!

Furthermore, there are difficulties with actually implementing the EF methodology for a community-level study such as yours:

- It is very difficult to quantify exactly all MPs;
- Some of the methodologies to quantify MPs, say energy use, are not exact and are constantly being revised through research and better insight of complexities involved when studying nature;

The combination of the above shortcomings means that the footprint that you will calculate for your school will necessarily be a lower bound estimate – i.e. the real footprint of your school will be higher than what you have measured.

Chapter 8: About Project-Based Learning

We've developed the SFI as a Project-Based Learning (PBL) program. PBL is a new teaching and learning strategy that gives you, the students, responsibility for your project and directing your learning. Here we give a quick definition, and then explore some useful concepts:

> "Project Based-Learning (PBL) is a way of learning knowledge and skills through an extended inquiry process structured around a complex, authentic problem and carefully designed final products and tasks"
>
> ADAPTED FROM BUCK INSTITUTE OF EDUCATION

Driving Problem

A key feature of PBL is a driving problem, requiring multiple activities and the synthesis of knowledge from different sources to solve. The Buck Institute for Education, a leader in the PBL field in the USA, recommends that driving problems:

- Are provocative
- Are open-ended
- Are challenging
- Arise from real-world dilemmas

Below we give some examples of beginning and refined problems to give you a feel for what makes up a great driving problem:

Beginning (OK) Problem	Refined (Excellent) Problem
What is global warming?	Should we be worried about global warming in our town?
What have been the most popular novels among teenagers in the last 30 years?	How has reading changed for teenagers over the last 30 years?
How has automation changed our society in the past century?	How might automation change our town and its businesses in the next century?

Who are the Buck Institute for Education?
The Buck Institute for Education (BIE) is a non-profit, research and development organization dedicated to improving the practice of teaching and the process of learning. Visit http://www.bie.org/ for more information!

Team Roles & Responsibilities

We really hope you enjoy working in a team. To get the most out of the experience it's really useful if you spend some time discussing team roles and responsibilities. One way of doing this is to draw up a simple contract of agreements. Here's an example of a contract:

All team members have agreed to:
- Turn up punctually to meetings
- Contribute to team discussions
- Respect and honestly critique others views
- Complete tasks to high quality standards, and as far as possible, on time.

The appointed secretary will:
- Take notes on discussion during meetings
- Record team milestones
- Recap notes from previous meeting

The team leader will:
- Lead discussion in meetings
- Report progress to the big group

Setting Milestones

A great way to manage the activities and work you'll be doing is to set sub-team milestones. A milestone marks a change of state for the team, for example the completion of a certain activity or acquisition of new knowledge. There are three key aspects to a milestone:

1) Description: key words that provide a short description of the milestone, that everyone can quickly understand
2) A due date, when can you realistically expect to finish?
3) Responsibility; it is often best to assign overall responsibility to an individual

Realistically, milestones can slip. Some people swear by a factor of 5 for both time and money!

Example

Milestone Description	Due date	Responsibility	Complete
Choose list of MPs	16th May	Fred	Y
Define boundaries, overlaps	23rd May	Alice	
Conduct research	23rd May	Bob	
Complete investigation design forms	6th June	Wendy	

Self-Directed Learning

Self directed learning is what you've been engaging in if you've managed to read this far! In a PBL program it's *you* who are in charge of working out what you need to know in order to progress with the project, like how to conduct a survey, or how the carbon cycle works, and then going away and finding it out under your own steam. Another aspect to self-directed learning is bringing together what you and your team members know from many different disciplines and experiences.