الجامعات المستدامة
Sustainable Campus

Basmat Al Shabab Al Beeiya

Youth Handprint for the Environment

A Guiding Manual for Campus Audits

Basmat Al Shabab Al Beeiya

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"The true wealth of a nation lies in its youth...one that is equipped with education and knowledge and which provides the means for building the nation and strengthening its principles to achieve progress on all levels."

H.H. Sheikh Mohammed Bin Zayed Al Nahyan
Crown Prince of Abu Dhabi.

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Contents

Foreword

At the Environment Agency - Abu Dhabi, we strongly believe that promoting environment education and encouraging a shared sense of responsibility will greatly assist us in our journey towards a sustainable environment. We also believe that youth engaged with sustainability concerns can be great enablers in helping secure the wellbeing of our environment, and in providing a safe future for our country.

Our aforementioned beliefs have compelled us to launch the Sustainable Campus Initiative, a programme through which we can reach out to youth in colleges and universities. Through this initiative, we aspire to strengthen the skills and leadership capacity among youth, to address issues of environmental sustainability. The programme strives to provide a platform and a mechanism for youth in colleges to network and collaborate for environmental protection and conservation. Youth placed at the higher portals of learning are strategically positioned to promote innovation and research. They will definitely be a major player in helping implement our nation's blueprint for green growth and enabling a sustainable future.

Basmat Al Shabab Al Beeiya (Handprint of youth on the environment) is essentially a guiding manual for youth to undertake audits within their own campuses. It is designed to assist youth in assessing and evaluating the impact on climate change, water use, energy use, management of waste and land use, at the individual, institutional and the community levels. Additionally, it will help them address their impact in a concrete and concise manner, thus increasing their "handprints", which are positive actions towards sustainability.

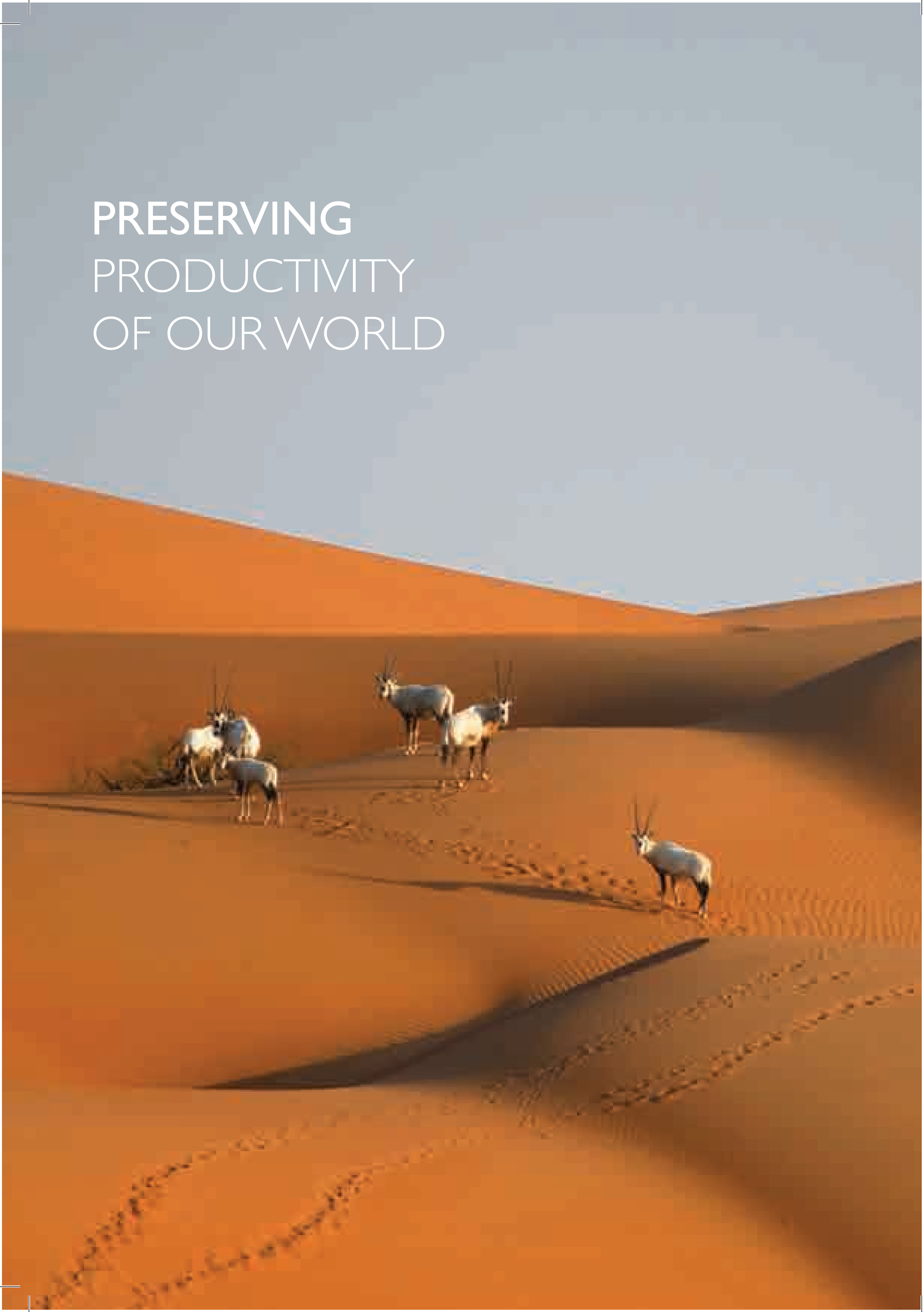
It is often stated that what cannot be measured cannot be managed, and this holds true for environment as well. The campus audit is the starting point. It will help students in contextualising issues of sustainability within their own campus or the community, and view it holistically from global, regional and local perspectives. By 'learning while doing', it will help youth comprehend the complexity of working for sustainability in a simple, but effective manner, and thus pave the way for a brighter tomorrow.

The tasks laid out in each of the audits are generic, but at the same time gives the local specific context and a frame of reference for the youth to take concrete action in their campus.

We wish you all the best to you for increasing your *Basmat al Beeyia* (handprint on the environment).

H.E. Razan Khalifa Al Mubarak
Secretary General, EAD

PRESERVING PRODUCTIVITY OF OUR WORLD



"The great challenge of the twenty-first century is to raise people everywhere to a decent standard of living while preserving as much of the rest of life as possible." - Edward O. Wilson

'SUSTAINABILITY' WHAT?

'Sustainability' is the current buzz word. Any discourse on this term, by different stakeholders often takes on extreme approaches. Either the term is oversimplified, used loosely in an imprecise manner or in such a complex manner that attaining sustainability seems like a utopian dream.

Looking back at history, the genesis of this term comes from the core word - 'sustain' which has its roots in the Latin word 'sustinere' which means to 'hold up, hold upright or furnish means of support'. The current trend is to use the closest synonym of the term 'sustain' that is 'maintain', which when used at times by different stakeholders manages to alter the depth and perception of the discourse on the term (Phillip Sutton, April 2004).

The word sustain (and its derivatives, sustainability, sustainable, sustaining) was first used to mean systematic management of forests (forestry) to keep it going on as productive system for a long period of time as innovated by the Germans and the Swiss. The idea was then extended in its usage from sustainable forestry to include sustainable fisheries.

Left: The Arabian Oryx (Courtesy: EAD)
Bottom: Growth and sustainability by Jra0243 (Purchased from www.cartoonsstock.com)

In pursuit of 'the future we want', we face multiple challenges:

Helping people move out of poverty and protect the environment,

providing access to clean energy for everyone, without contributing to climate change,

ensuring everyone gets water, food and nutrition they need,

shaping our cities in a way that everyone can enjoy a decent quality of life,

providing better transportation systems, without causing too much congestion and pollution,

ensuring that oceans are healthy and marine life is not threatened by pollution and climate change, and

building communities that are resilient in the face of natural disasters.

Where? To where? The 'Sustainability' journey of the world

The context and usage of the term 'sustainable' expanded and widened in its application with the introduction of the word 'sustainable development' by the World Commission on environment and development in 1987, It now meant a 'development that meets the needs of the present without compromising the ability of the future generations to meet their own needs'.

At the 1992 Earth Summit held at Rio de Janeiro, Brazil, while discussing the global path to achieving sustainable development, countries across the globe pledged to reorient their growth towards sustainable development and promised to initiate policies and actions towards achieving this goal.

Since then, failure of countries to deliver on their promises, widening wealth gap, the roller coaster ride of globalisation, increasing consumptive life styles, armed conflicts, scarce water resources, overfishing, species extinctions and spread of diseases such as AIDS; have borne testament to the fact that balancing the social, economic and the environmental well-being of the planet and its people is indeed a complex process.

This led the world to rethink and reorient the path taken in the name of promoting economic development. The Earth has finite sources. These sources have been continuously exhausted to support a growing population and its even-more-rapidly growing demands and needs. A strong move thus arose to pursue a path that allocates economic value to the environmental and social well-being. The result? environment gets accounted for in all our economic equations of growth and development. A need to push forward for an economy that invests in environmental technologies such as renewable energy and natural capital (such as productive soil, forests and water resources) or an economy that respects green principles and the one that is fair and inclusive to all sections of the society, was thus born.

Green growth or green economic development can only be pursued when we move away from a linear economic system.

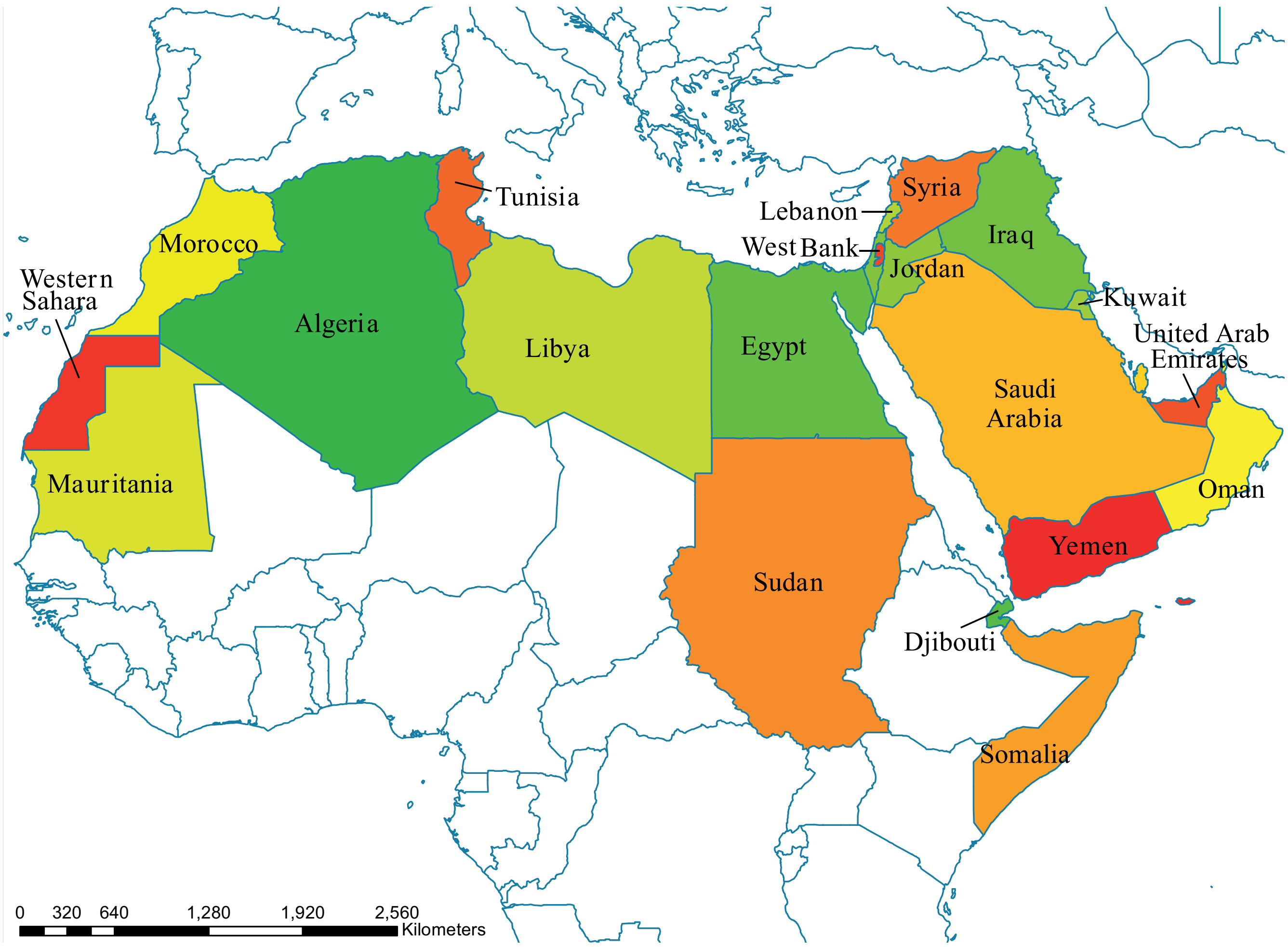
Top left: Rio+20 Future We Want logo (Courtesy: http://eu-un.europa.eu/pictures/Rio20_EN.png)

Green growth or green economic development, can only be pursued when we move away from a linear economic system that generates mounds of waste and exhausts the bio-capacity of this earth, to a circular economy that reduces the consumption of resources and generation of waste, and reuses/recycles wastes throughout the production, distribution and consumption processes.

In fact, twenty years down the line after the first Earth Summit in the United Nations conference on sustainable development held once again at Rio (Rio +20), the world leaders recognised that:

"The world's population of 7 billion is likely to increase to 9 billion by 2050. The demand for diminishing natural resources is growing. Income gaps are widening. Sustainability calls for a decent standard of living for everyone today without compromising the needs of future generations."

Countries in the Arab World



With limited fresh water availability in the region 19 out of 22 countries face severe water scarcity.

Bottom: Countries in the Arab World (Courtesy: EAD)

Need for sustainability in the Arab World

The Arab region, of which the United Arab Emirates is a part, stretches from Morocco and Mauritania in the west through northern Africa and the Levant to the Arabian Gulf in the east, comprising 22 states and territories of the Arab league (see map on previous page). While this region is politically and economically heterogeneous, within it are shared common religious, cultural and ethnic profiles. Despite the fact that countries within the region vary in size and resources, it is a unique region with distinctive environmental circumstances and challenges.

Rapid urbanisation, depleting natural resources, vulnerability of this fragile region to environmental risks and natural disasters due to its unique geography are some of the shared common issues.

With limited fresh water availability in the region 19 out of 22 countries face severe water scarcity. The *per capita* water availability in these countries is expected to be halved by 2050. Biodiversity is on the decline due to habitat loss and degradation. The total number of threatened species in the region stands at 1,746 with the majority of them critically endangered. Desertification and land degradation has further reduced the already limited arable land in the region.

'The Arab Regions Atlas of the Changing Environment', produced by the Abu Dhabi Global Data Initiative and the Environment Agency- Abu Dhabi, clearly encapsulates the rapid urbanisation, degradation of marine and coastal areas, altered hydrology and shrinking water bodies, loss of habitats and impacts of climate change in the region. While the atlas tracks progress towards tackling issues of environmental sustainability in the region, it reveals a slow and an uneven progress in different countries. It lists lack of aid or assistance, current economic crisis, climate change and its impacts and lack of effective governance as some of the obstacles towards progress in the region.

Strong education and awareness is often considered as one of the major vehicles in achieving sustainability. This, it is believed would lead to strong action from all the stakeholders. In a survey conducted by the UN programme for youth, with over 50% of the population in the youth category aged between 15-24 years, environment or sustainability does not feature as a major concern. Understandably, it is lack of employment opportunities that features as the most important concern. While there are variations between disparate countries within the Arab region, on issues of environment, climate change has been cited as a matter of concern by 51% of respondents in the survey: this is in stark contrast to countries in the West where 79% of respondents had reported their concern for climate change in a similar survey.

The export of the first oil cargo from UAE in 1962 helped with the development of schools, housing, hospitals and roads

Bottom: ENOC Oil station (Courtesy: http://www.arabianoilandgas.com/article-10576-enoc-and-aldrees-to-open-petrol-stations-in-ksa/)

The sustainability story so far

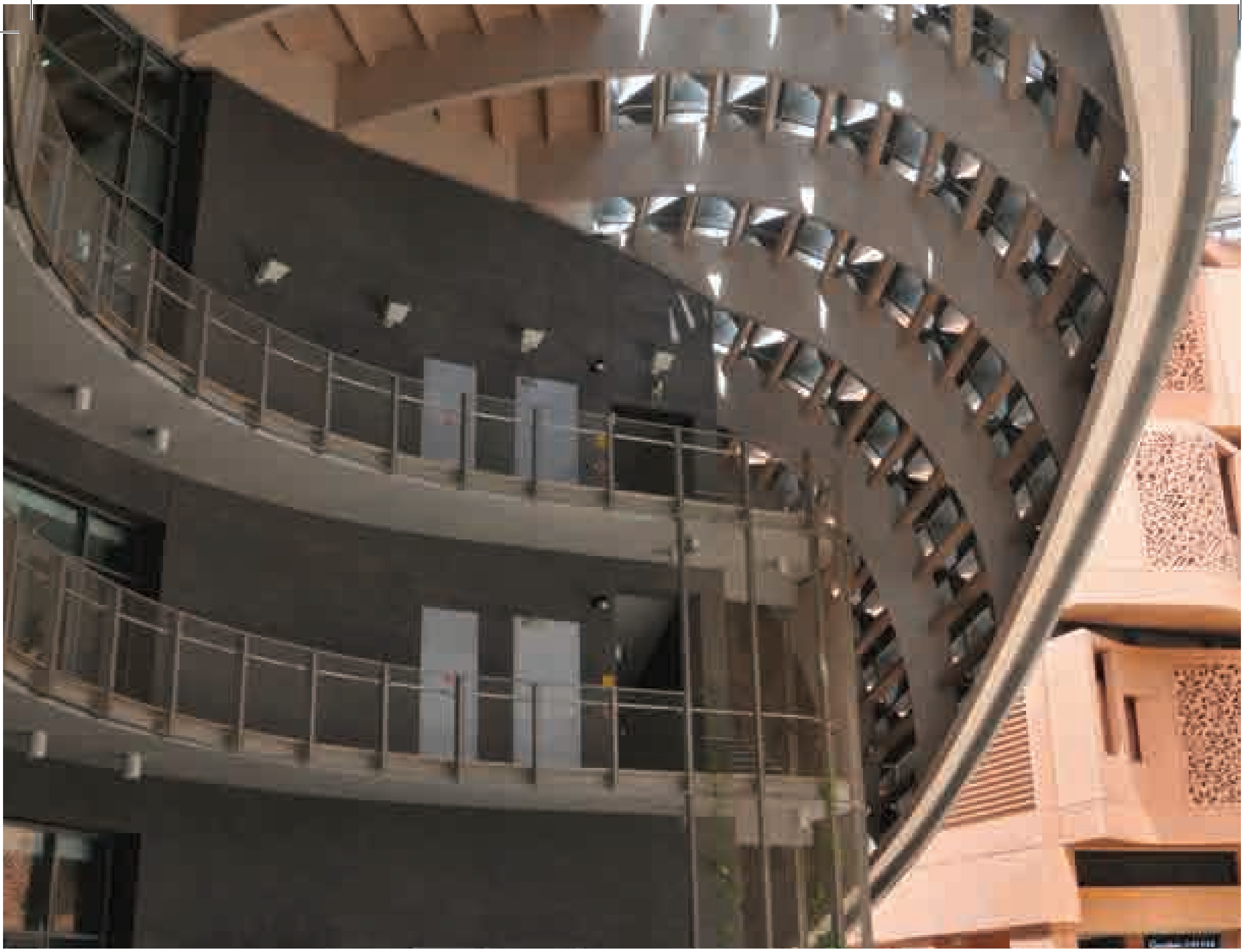
United Arab Emirates is a young country only over four decades old. The country has experienced a steep spike in economic growth and development over a short period of time. How? by moving from a traditional economic base to a globalised one. Traditionally, grazing, fishing, and pearling during the summer months and tending to date gardens with efficient water irrigation systems known as the 'Falaj' formed the economic basis for surviving the harsh desert environment. The First World War, the economic depression of the 1930's and the rise of Japanese cultured pearl industry dealt a severe blow to the income of the country.

Despite their resourcefulness, the population faced hardships including lack of opportunities for education and modern infrastructures like roads, hospitals and so on. During the late 30's, oil companies like Shell, Total, BP and a few others, came to prospect for oil in the country. The export of the first oil cargo in 1962 helped with the development of schools, housing, hospitals and roads. It is after the formal establishment of UAE as a country on 2 December, 1971, by the father of the Nation, Late Sheikh Zayed bin Sultan bin Al Nahyan, that developing a robust infrastructure to aid in the economic progress of the country became a priority. In the face of ensuing development, preserving the country's heritage and conserving its natural resources became the foremost concern and challenge for its rulers.

Much of UAE's current growth, has been fashioned (as in the rest of the world) by externalising environmental costs, much to the detriment of its fragile natural heritage. The growth has also been dependent upon anchoring external knowledge and expertise. Vast hydrocarbon reserves, fossil fuels and wealth steered the economic growth and development. This not only enhanced the standard of living but also encouraged unbridled consumption of goods and services. Many of which were not even produced locally thus increasing carbon emissions and subsequent ecological foot print.

Masdar city symbolises Abu Dhabi's commitment to sustainable growth

Bottom: Masdar city transport (Courtesy: EAD)



The Masdar Institute drives innovation in sustainable building material, construction and design

Economically, UAE is counted as one of the comparatively robust countries with a high GDP and one of the highest *per capita* incomes in the world. While in terms of natural resources, like other Arab countries, UAE has a fragile arid environment with low fresh water availability, hot climate, poor soil and the biodiversity surviving under adverse conditions and on threshold levels. Culturally it is a multicultural country attracting people with diverse nationalities and ethnicity. The country's population has grown from only 2,72,000 people in 1961 to about 8,100,000 people as *per* a 2008 census. The high *per capita* income coupled with a large moving population, the need for energy to desalinate water, cool living spaces and high consumptive lifestyle led to a quantum jump in the *per capita* ecological footprint. This was much beyond the bio-capacity of the country to support its current population's high demands.

Ecological footprint is a measure to assess a country's impact on Earth to highlight whether the country and its people are living within the limits of resources provided by the planet. With a twenty nine times increase in population between 1961-2008, the bio-capacity available *per* person decreased by 96% in the UAE. About 80% of this *per capita* footprint is attributed to consumption of energy and other carbon emitting goods and services.

Currently while UAE ranks third (2012 living planet report) in the world in terms of *per capita* ecological footprint, in the year 2008, they were the highest in the world, a position that UAE never wanted to be in. It is through the efforts undertaken by the ecological footprint initiative nationwide through building awareness and education, initiating policy and sound implementation that they managed to reduce UAE's ranking to the third position.

While UAE is totally committed towards sustainable development and is also a signatory of Agenda 21, Abu Dhabi Emirate in particular, in its Vision 2030 and in the Policy Agenda, emphasised the importance of pursuing the path towards sustainable development while promoting economic growth in the Emirate. Keeping in mind the economic aspiration and future growth, five major environmental concerns are identified:

- Adaptation and mitigation to climate change,
- sustainable water use to match economic growth and increase in population,
- providing clean safe and healthy living / working environmental conditions,
- sound management of waste, and
- protection and conservation of our natural heritage and biodiversity.

Top: Knowledge center and Institute of science and technology, MASDAR (Courtesy: EAD)

Currently, Abu Dhabi is busy setting policy and engaging stakeholders from the public and the private organizations to set in place actions to address the environmental concerns mentioned above.

Another exciting development post Rio+20, is the UAE's efforts to initiate a green growth strategy for promoting a green economy. One must not forget that education, training and skills development has been stated as one of the important enablers in moving towards the green economy. Having stated that, one must also have a look at the calibre and competency of our human resources to achieve the green growth dream. The greatest human resources which can help catalyse this dream and be the main 'change agents' are our 'youth'.

Role of youth in making a more sustainable world

Around 20% of the population in the world falls within the age group of 15-24 years. The involvement of today's youth in environment and development decision-making and in the implementation of programmes is essential to our survival. It is imperative that youth from all parts of the world participate actively in all relevant levels of decision-making processes because it affects their lives today and has implications for their futures. In addition to their intellectual contribution and their ability to mobilise support, they bring a unique perspective that needs to be taken into account. One out of every five people in the Arab world falls within the (15-24 years) youth category. More than 50% of the total population is under 24 years. Hence youth plays an even more critical role.

The UAE youth: torchbearers of change

Switching to a green growth in the future would mean enhancing innovation and green competency in almost all fields of production, distribution, consumption and economic diversification. To achieve this, a 'divergent' and 'out of the box' approach would be needed. This is where youth comes in. With their penchant to lead and experiment, their skills and openness to new concepts and ideas, they would be the right target group to lead the change.

We need to remember that today's 18-25 olds will become 34-41 years old in 2030 and it is they who will be in the forefront. Whether it is spurring green growth or leading implementation of the 2030 vision in the economic/ social or environmental front. Thus there is a need for the youth to be equipped with right knowledge, attitude, skills and capacity to be able to innovate and power the engine of sustainability in the future.

In the UAE, youth constitutes a large part of the total population. Regarding their engagement with environmental action, the annual survey conducted by the Environment Agency–Abu Dhabi reveals that awareness regarding environmental issues ranks high amongst the youth in comparison to other target groups. This is still not something that one can be complacent about. The survey (2010) also reveals that while 54.9% of youth aged 15-24 showed awareness regarding Abu Dhabi's environmental issues like water scarcity and quality, increasing waste, climate change, loss of biodiversity and so on, the behaviour quotient was only 39.9%. This signified a deep disconnect between stated concern for the environment and action on ground.

Mobilising the youth action for adapting sustainable life style practices has always been a major challenge in most societies. The young generation has complex needs. While emerging as adults and entering the workforce, they are shaped by the market mechanism revolving around them and are influenced by trends set by current icons or role models that they look up to. With all the doomsday scenario, currently portrayed in the media and all the social networking channels regarding the environmental crisis, it is disconcerting to see increased complacency and acceptance among youth that it is beyond them or their capacity to affect change. Youth are the main 'change agents' and that is why it is imperative that they be engaged and involved in matters regarding environmental sustainability. In addition to their intellectual contribution and ability to mobilise support, they can bring in a fresh perspective and innovate the Emirate's efforts of moving towards a sustainable world and realising its 'Vision 2030' goals.

It is true that UAE is committed to provide a high quality standard of education to all across the country and has invested in establishing noteworthy universities such as 'Masdar Institute for Science and Technology' for encouraging research and innovation in the field of environment and energy. However, there was a need for an informal networking platform for the youth from different universities and colleges to engage in and debate on issues of sustainability. This is why the Environment Agency-Abu Dhabi launched the 'Sustainable Campus Initiative' to provide a platform for youth for environmental action.

The main objective of the Environment Agency, Abu Dhabi is to strengthen and build leadership capacity amongst the Emirate's youth to address issues of environmental sustainability. Also, to enable them to be the main agent of change in the Emirate in working towards and shaping sustainable communities.

We need to remember that today's 18-25 olds will become 34-41 year olds in 2030.

Sustainable Campus Initiative and 'Global Universities Partnership for Environment and Sustainability' (GUPES)

The 'Global University Partnership for Environment and Sustainability' is an initiative established by the United Nations Environment Programme (UNEP), Environmental Education and Training Unit, in collaboration with other United Nations (UN) agencies. It is a global programme that reaches out to 100 Universities from across Africa, Asia and the Pacific, Latin America and the Caribbean, West Asia, Europe and North America.

GUPES, as it is commonly known, has come up with a toolkit for students across universities and colleges globally to assist youth to come up with a framework for working towards establishing a green or a sustainable campus. The toolkit will inspire, encourage and support universities to develop and implement their own transformative strategies for establishing green, resource-efficient and low carbon campuses (http://gupes.org/index.php?=3234).

The Sustainable Campus Initiative, while aligning itself to the broad framework provided by the GUPES toolkit, conceptualises campus action to regional and local specific needs and context.

Top right: UNEP logo (Courtesy: http://cep.unep.org/iwcam/images/unep-logo/image_view_fullscreen)

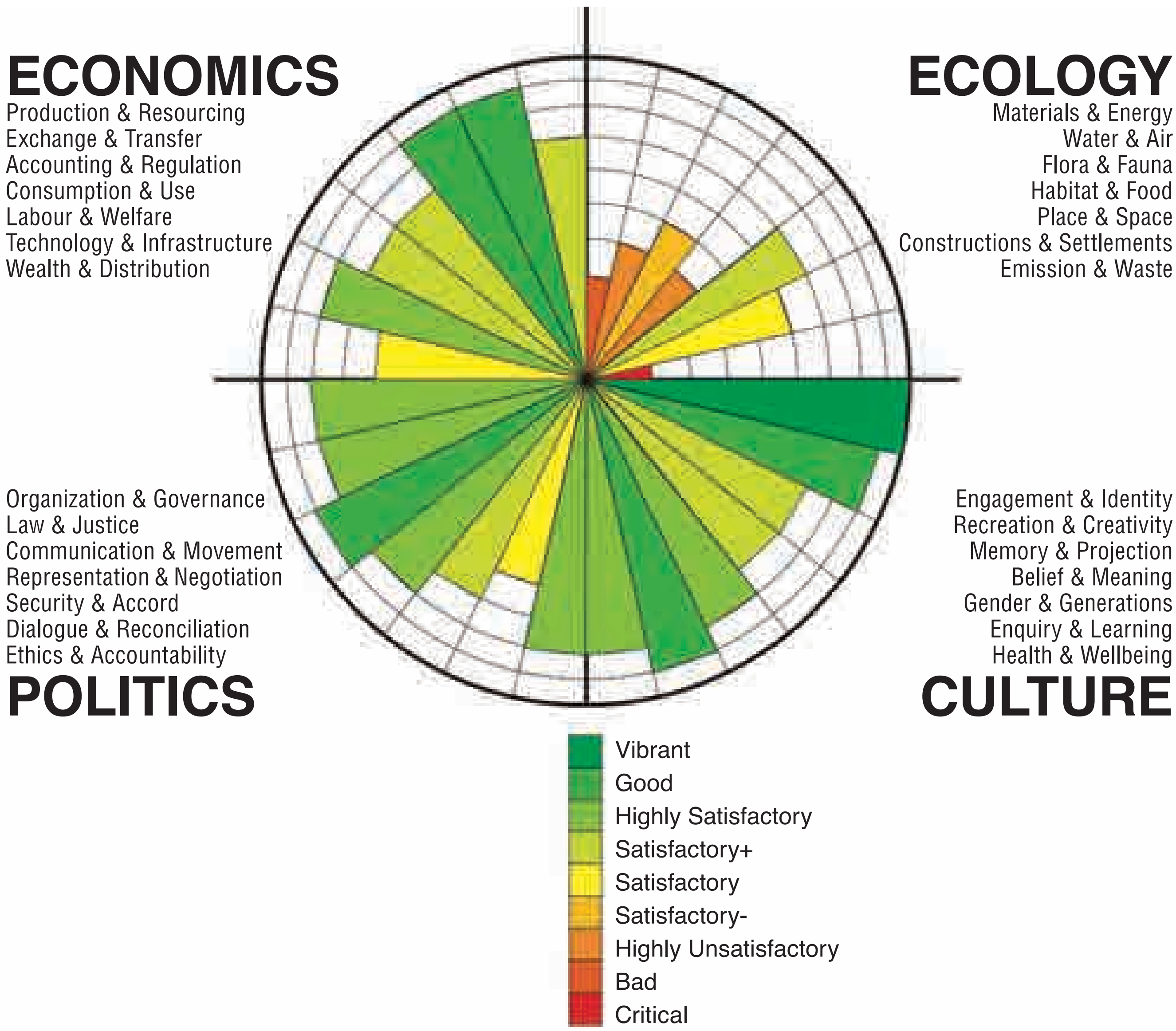
The Sustainable Campus Initiative's audit manual provides a framework for students to identify, assess and address the sustainability issues of local colleges and universities. The audit manual encourages youth to come up with innovative solutions.

The Sustainable Campus Initiative is founded on the belief that the goal of academic sustainability programmes is to enable students to plan, conduct and engage in sustainability research and problem solving based on the interplay of systems, anticipatory and normative thinking. It builds capacity for strategic and interpersonal competencies.

- Systems thinking - helps understand and address the root causes and the complexity on or about issues of sustainability,
- Anticipatory thinking - assists with the future oriented thinking for any approach on sustainability,
- Normative thinking - assists in dealing with the Justice, equity, integrity and ethical part of the debate on addressing issues of sustainability,
- Strategic competencies - assist in building the ability to design interventions and practice good governance to address challenges of sustainability, and
- Interpersonal competency - helps motivate students, promote strong communication and negotiation skills, as well as a participatory approach towards facilitating research and problem solving skills on issues of sustainability.

Source: 'Key competencies in sustainability' (Arnim Wiek, Lauren Withycombe & Charles L. Redman, March 2011.

Top: Arab youth (Courtesy: www.cop18.qa)



Circles of sustainability

Circles of sustainability is the method for understanding and assessing sustainability and for managing projects directed towards socially sustainable outcomes. It is intended to handle 'seemingly intractable problems' such as outlined in sustainable development debates. The method is mostly used for cities and urban settlements.

Top: Circles of sustainability (Courtesy: http://en.wikipedia.org/wiki/Sustainable_development)

The Sustainable Campus Audit

The Sustainable Campus Audit provides a structure that translates the goal of academic sustainability programmes to what it could actually mean on ground for young people learning at colleges and university campuses within the UAE. To start with, it will enable the participating colleges/university communities to look at sustainability in context of their own campus resource base. This will set young minds thinking to develop practices that make resource use within their campuses more sustainable. Once they have attempted the self-evaluation and established good practices, the framework also urges young people to take the lead on extending its benefits and outcomes to the community beyond the confines of the college/university.

The concept of 'learning by doing' is at the heart of the audit framework and the processes it recommends. The campus serves as a laboratory where sustainability is intelligently conceived and practised.

Key elements

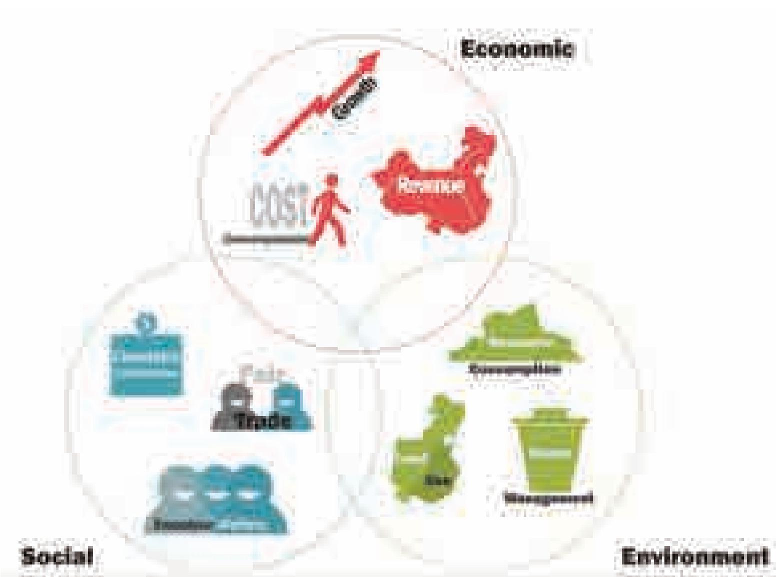
The Sustainable Campus Audit covers five major resources that is water, climate, land, energy and solid waste. Practices related to these govern the sustainability quotient of people's life within the campus. The framework relies on the logical cycle of Assess–Plan-Act that would work by assisting the participating college/university youth to understand and comprehend their role at an individual, institutional and the community level. By doing so, the framework hopes to put young people at the heart of social change.

Bottom: Youth as Change Agents (Courtesy: EAD)

Participation in the Sustainable Campus Initiative

Who can participate?

- College/University/youth club catering to youth aged between18-25 can register,
- Participation in the Sustainable Campus Initiative can be kick started by a Lecturer who engages a group of students from his/her own class or students from a different class,
- Activity coordinators at the colleges/universities engage with students from different years and disciplines too can put together a group for participating with the initiative,
- Group of youth from the same college/university committed to or working for the cause of environment can also initiate participation, and
- Even though this initiative is designed for a college/university campus, any cultural or sports club catering to the youth in the above mentioned age bracket can also register.



The framework relies on logical cycle of:
ASSESS – PLAN - ACT

Addressing sustainability issues within the campus is a progressive process:

Step 1 is when a group of diverse young people commit to use the Sustainable Campus Audit,

Step 2 comprehend and understand the environmental theme to be addressed within the campus audit from the global/ regional and local perspective,

Step 3 the audit group expands to enroll representatives from different stakeholder groups on campus to facilitate the audit,

Step 4 identify necessary protocols and establish a system of communication between members of the audit group,

Step 5 form sub groups to audit five major resources,

Step 6 establish baseline by conducting water, climate, land, energy and solid waste audits,

Step 7 analyse results, identify practices related to sustainability that need to be improved,

Step 8 set targets and initiate improvement in practices that would lead to more sustainable resource use,

Step 9 repeat the audit related to practices that were improved to evaluate change,

Step 10 publish/communicate achievement to a wider audience beyond the participant group, and

Step 11 strategise and set plans to share the learning and the process of bringing about change people both within and outside the campus.

Bottom: Triple bottomline graphic by Triplebotline (Courtesy: http://en.wikipedia.org/wiki/Triple_bottom_line)

Register 'Now' and:

1. Assess, improve practices related to use and environmental impact of water, climate, land, energy and solid waste,

2. form an environmental working group within the college/university and undertake projects through which they will reach out to the neighbourhood community,

3. participate in the Green youth Majlis–a platform provided by the Environment Agency-Abu Dhabi for participating youth from different colleges/universities for collaborating and networking locally/ nationally on environmental issues on a regular basis,

4. participate in the opportunities provided by the Agency to network with other regional and international youth forum for environment, and

5. quarterly and annual reporting on progress with all of the above activities.

Initiating the campus audit

- Before initiating the campus audit, it is suggested that separate working groups are constituted to assess and address the five major themes, with at least 2-3 young people in each group, if possible. This will reult in better functioning,
- it is also admissible for the audit to be undertaken by a learner/ a set of learners/ a particular faculty as a part of academic requirement in terms of project to be submitted for evaluation. Care needs to be taken that during the next academic session, the project is repeated otherwise the learnings will not be translated into action at the campus level,
- it is suggested to include youth from diverse disciplines or faculties while forming the audit working groups for different themes. Such a multidisciplinary and collaborative work would lead to strong outcomes and results,
- roles and responsibilities for everyone working in the audit process should be clearly outlined and understood,
- it is most important to identify and engage with relevant stakeholders who will be able to assist, provide data (Campus facility/Department in charge) and review the audit process (Lecturer/Professor), and
- at all times, it must be remembered to take a collaborative approach for conducting, discussing and addressing the audit issues with all sub groups and with relevant stakeholders.

Method

These audits aim to make sustainability issues tangible for youth by making the flow of resources within the campus quantifiable. Participating youth get an opportunity to compare their own resource management with the established global, regional or local standards/practices. Based on this comparison, the working groups can bench mark, prioritise and chart a course of action for more sustainable management of resources within their campus.

These audits aim to make sustainability issues more tangible for the youth.

The comparison helps the youth to identify issues and gaps that need to be addressed thus urging students to device strategies that can be effectively implemented for action. Timelines for evaluation of implemented strategies are set by the students themselves. It is also their responsibility to check the efficacy of their strategies and see whether or not they have accomplished what they set out for themselves in terms of better resource use within their campus.

If successful in bringing about a change in resource use, the working groups need to define the rate of change. If not, they need to find out what went wrong and why. Subsequently, they need to device and implement a new strategy that they believe will work.

All stages in the audit are quantifiable. This is so that the college/university or the Institution will be able to report on their Assess-Plan–Act cycle for resource use.

Sustainability in day to day life

Today, almost all countries of the world have taken stock of the natural resources available within their political boundary. This is true for UAE as well. It is ideal for a country to live well and sustainably with its own available resources. In fact it was, the prevalent practices of the society in the UAE as well as in many other countries in the past. They never exceeded the limits or the bio-capacity of their land. However, in the current globalised world, most countries including the UAE, have enhanced their standard of living at the expense of heavy imports and over exploitation of their natural resources. This has resulted in increasing their ecological footprint.

"Humanity's ecological footprint exceeded the earth's biocapacity by more than 50 percent in 2008."

These audits will assist the youth to identify, assess, and improve resource use within their own campus. In addition, the framework enables the youth to initiate a similar process within neighbouring communities.

Technology limitations

Technology is known as an enabler in reducing resource use by enhancing both the product and the process efficiencies. While economically this made sense and helped the end products reach a wider target audience and enhanced the material use, at the same time it also led to further exploitation of the resource due to increased outreach. For example, with fuel efficiency introduced in cars, people with cars drove more than usual, more people bought cars and in some cases, the money saved was directed to consuming goods which entailed over use of some other resources. In the context of the campus audit, the framework would assist in estimating the level of efficient technology provided in the campus facility for resource efficiency.

People of UAE have enhanced their standard of living at the expense of heavy imports and over exploitation of their natural resources.

Taking care of the environment today and for tomorrow

Closing the loop of resource use

To close the loop of resource use, an important factor to consider is the rate of replenishment. Natural systems regenerate, renew and recycle all the time. That is why there is no waste in nature. Since most of our resource use is beyond the rate at which they are replenished by natural processes, interventions, whether technological or through other social or economic incentives or stimulations, are needed to close the loop. Such interventions too need to be measured to know the deceleration in resource depletion. The audit framework also assists in estimating such efforts from the youth and articulates them in terms of handprints' or measurable actions towards sustainability. Handprints assist in offsetting the ecological footprint. This provides the much needed optimism to tackle the sustainability dilemma.

- Net availability of resource,
- its rate of use,
- the level of technology use, and
- rate of recovery or replenishment

Top: Taking care of the environment today and for tomorrow (Courtesy: EAD)

Engaging all stakeholders

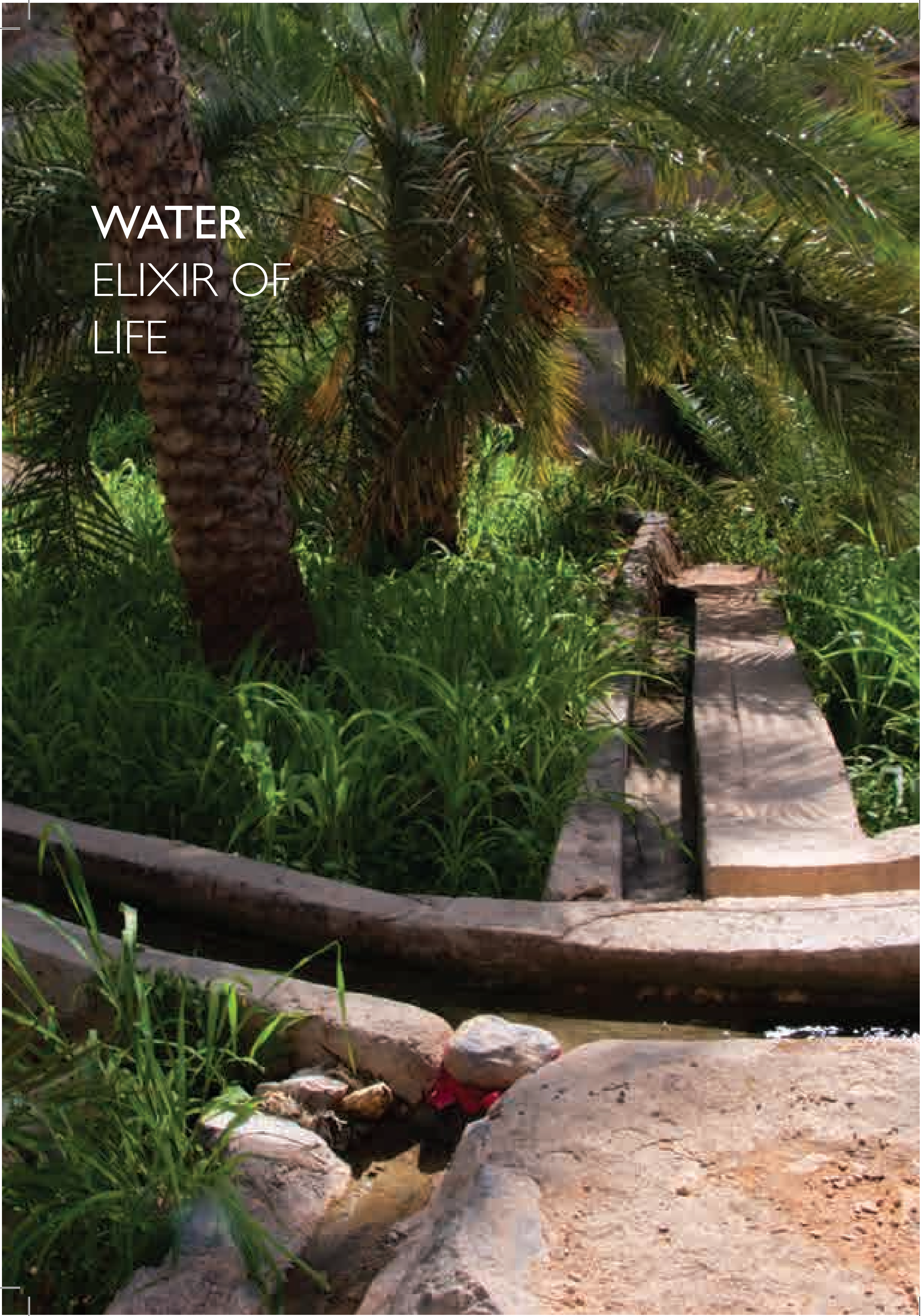
It is critical for the audit working groups to recognise that while striving to make the college/university campus sustainable, involvement of all stake holders is paramount. The student community, college management, administrative staff, the campus facility and maintenance department, and the faculty staff, all play a role. An effective strategy for bringing about change would be to engage with all the stakeholders with a realistic expectations and a clear understanding of their roles and willingness to participate in sustainability efforts. The working groups should also have a good plan for motivating these diverse stakeholders to effectively support the campus audit.

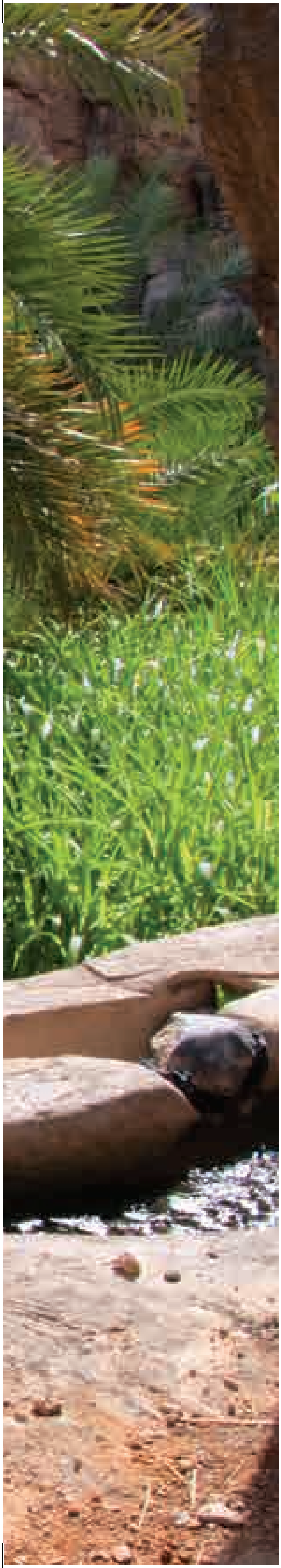
Sustainability options

Sustainability can be about comprehending environmental capacity and learning to fit our aspirations within this. It can also be discovering innovative ways in which our growing numbers and our growing aspirations can help reinforce the capacity of the environment.

Top: Youth participation in international dialogue (Courtesy: EAD)

WATER
ELIXIR OF LIFE





"And Allah has sent down rain from the sky and given life thereby to the earth after its lifelessness. Indeed in that is a sign for a people who listen." - (Al A'raf 7:57)

"Water is the driving force in nature." - Leonardo da Vinci

NATURE OF WATER

The capacity of water to quench one's thirst is unparalleled to any other liquid, man-made or otherwise. Water is the prime requisite for all 'life' on earth. With its versatile characteristics and unique molecular structure, water is the most compatible liquid that has the capacity to support life as we know it, on earth and probably on other planets as well.

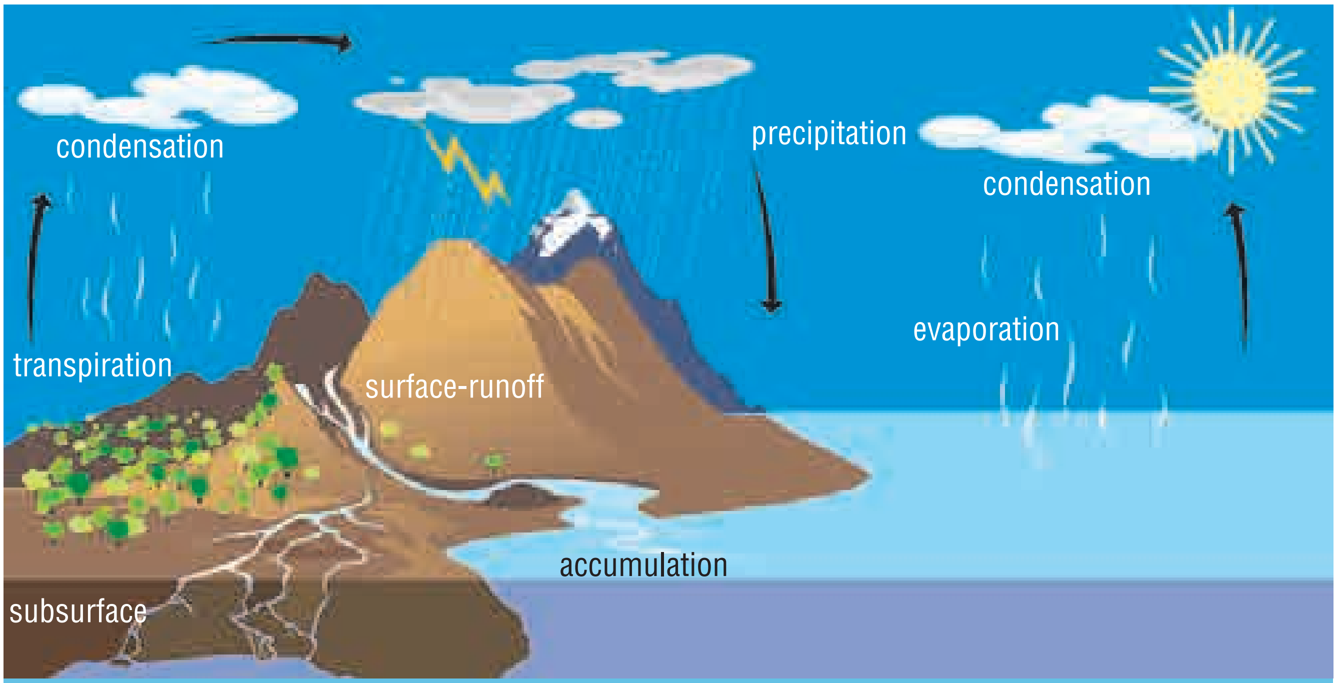
Since the formation of earth, a process of global water balance ensured that the total volume of water on earth always remained constant. The hydrological cycle or the water cycle, helps to ensure that enough water is available to be utilised by life forms in different realms. Nature constantly recycles water, thus fortifying its quality and renewability at all times.

IN THE FUTURE, WARS WILL BE FOUGHT OVER WATER

To most of us, delivery of water to our homes using solar power and gravity, while ensuring the quality of water through recycling and other biophysical processes would seem like a far-fetched utopian concept. Yet, natural processes do that all the time.

Left: Image of a '*falaj*' (Courtesy: http://upload.wikimedia.org/wikipedia/commons)
Right: War over water by cman390 (Purchased from www.cartoonsstock.com)

Water cycle



Tucked away for posterity

Total amount of water on Earth is 1.4 billion cubic kilometres (km^3), but only around 41,000 km^3 circulates through the hydrological cycle, the remaining being stored for long periods in the oceans, ice caps and aquifers.

Of the total water available on this blue planet, only 3% is fresh. Out of this, just 0.5% is available to be shared between our entire human needs and for maintaining the health of our ecosystem. Over 2% of this available fresh water lies frozen as ice on earth. The limited fresh water is unevenly distributed. Less than 10% of countries possess 60% of the total available fresh water for use (USGS).

Fresh water supply is erratically distributed over time and space. Global water systems face formidable challenges like excessive withdrawal from surface water sources such as rivers and lakes, underground aquifers, increasing degradation of water and aquatic ecosystems, inefficient use of fresh water, climate change and so on. *Per capita* availability of fresh water in the world is steadily declining. Demand for fresh water has more than tripled since the last 50 years. This has gone hand-in-hand with ground water abstraction, which has also tripled over the past 50 years and continues to increase at the annual rate of 1-2%.

Globally agriculture accounts for 70% of our water use, industry 20% and domestic water consumption 10%. The way we manage water, directly impacts our economy, health and the environment. Nearly one out of every nine people in the world does not have access to safe drinking water. More than 3.4 million people die each year from water sanitation and health related causes. More people in the world have mobile phones than a toilet. It is predicted that by 2025, 3.5 billion people in the world could face severe water scarcity.

The World Business Council for sustainable development, a global association of close to 200 companies dating back to the 1992 Rio Earth Summit, states that by the time a child turns 18 in 2030, the demand for food in the world would go up by 50%, energy by 45% and water by 30%. Thus it is important to stress on the

Top: Hydrological cycle (Courtesy: EAD)

strong nexus between food, water and energy. For example, water is needed for energy production and energy is also needed for production, transportation and distribution of water. Production and manufacturing of food also entails use of energy and water. We eat more water than we drink as water is embedded in all the foods that we eat. Water is needed to produce most of our goods and commodities. Be it a laptop computer, a table or paper. Areas with scarce water resources have traditionally managed by importing items that need large amounts of water to produce, thus increasing their virtual water footprint.

Water management, be it at the country level or at the level of cities, pursue linear management practices for water. Linear management, unlike nature does not have any feedback loops; there is no constant reusing, filtering or recycling to ensure quality and sufficient quantity of water for all needs. As a result water management for most countries is constantly hampered in trying to balance the complex and competing needs for water. Demands are made on water use by agriculture, industries, energy suppliers, people and ecosystems.

Currently almost half the world's population lives in urban areas. Increasing urbanisation and complex urban water needs and usage are making it increasingly necessary to tackle point source pollution and waste water disposal into our water bodies. Untreated waste water from urban areas can negatively impact the environment and human health. Yet, quite a large percentage of waste water from cities remains untreated before disposal greatly compromising and altering the hydrological cycle, much to the human detriment of humans and the environment.

Sustainable use of water for any place in the world would mean:

- Sustaining the physical, chemical and biological health of its sources,
- optimal use of energy in extraction, treatment and distribution of water,
- consumption that would ensure globally acceptable standards of hygiene and sanitation,
- collection and treatment of waste water using optimal amount of energy,
- recovery from waste water in order to reduce the need for freshwater extraction from other sources, and
- end point disposal that ensures physical, chemical and biological health of its sources.

Water is their in everything!

Hidden cost of H_2O

Virtual water is an economic concept. It corresponds to the volume of water required to produce a foodstuff or a given object (and should not be confused with its water content).

It is normally expressed in litres of water per kilogramme (kg). For example, it takes approximately 1,500 litres of water to produce one kg of wheat, 4,500 litres for one kg of rice and 100,000 litres for one kg of aluminium.

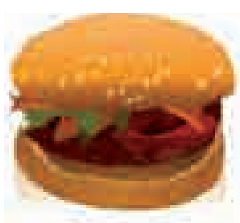
1 apple

70 litres

1 glass of milk

200 litres

1 hamburger



2400 litres

Right: Virtual water adapter (Courtesy: http://www.sciencemediacentre.co.nz)

Lake Mead, river Colorado in 2010, showing the "bathtub ring" left behind by low water levels

Thirsty rivers

A National Geographic report states that the eight mighty rivers -Colorado, Indus, Amu Darya, Syr Darya, Yellow, Teesta and Murray are drying up due to over use. Stories of lakes drying up, such as China's Poyang Lake (largest fresh water lake in the country), Lake Chad in West Africa, and the shrinking Aral Sea in Kazakhstan, Uzbekistan and Central Asia do not augur well for the already limited availability of fresh water on earth. Estimates already suggest that water will be scarcer by 2020 in about two third areas of the world. This is based on projected demands for water from the agriculture sector, growing populations and the expected spike in economic growth.

Water tank in a wadi in Abu Dhabi

Top: Lake mead by Cmpxchg8b (Courtesy:http://en.wikipedia.org/wiki/Colorado_River#mediaviewer/File:Lake_mead_july_2009.jpg)
Bottom: Water tank in wadi (Courtesy: EAD)

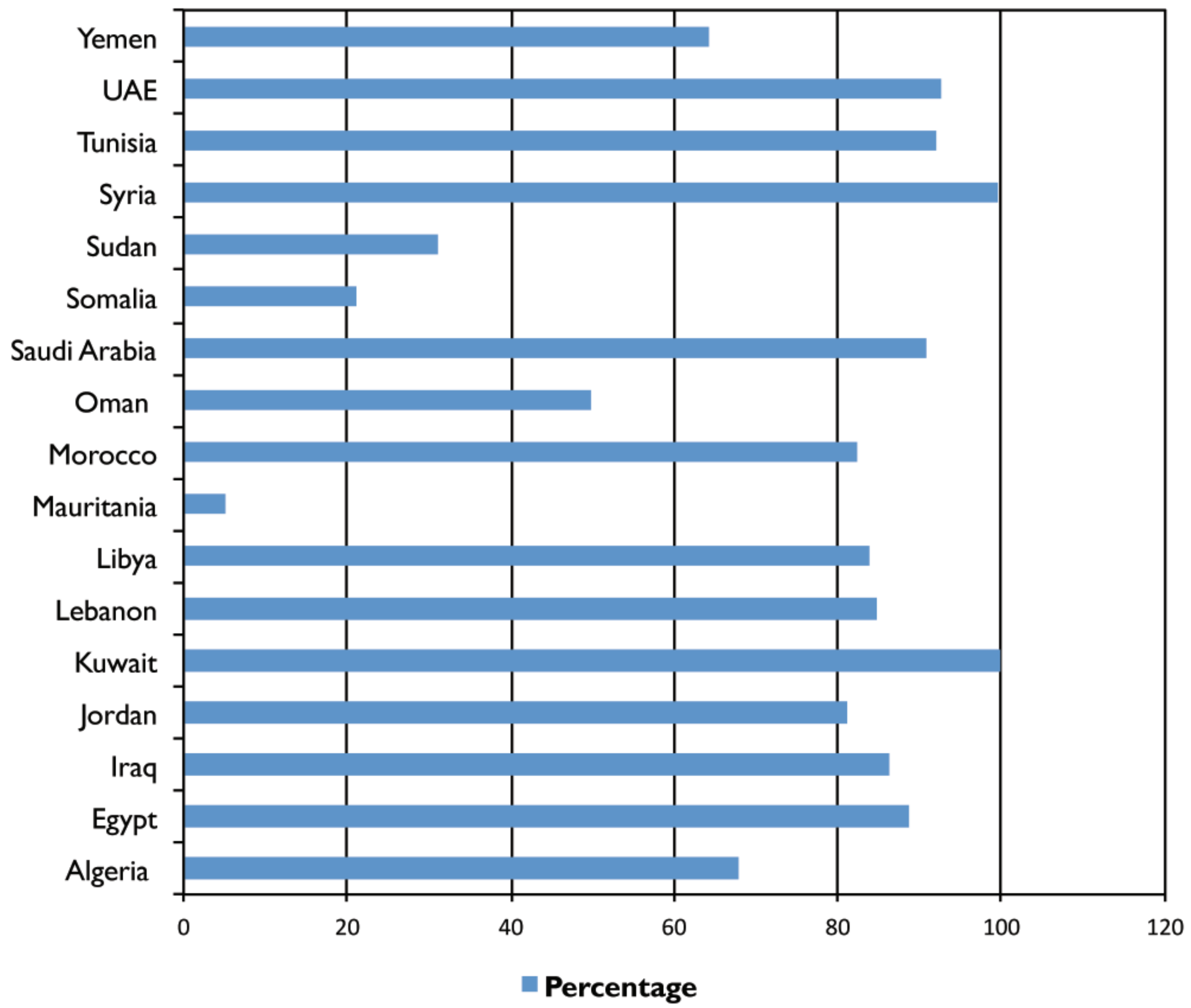
Arab predicament: Scarce water, limited sources

The 22 Arab League nations are located in one of the driest, water scarce regions of the world. Of these, eight countries have the lowest *per capita* water availability in the world. The Arab states contain 5% of the Earth's population and 10% of its area but only one% of the Earth's fresh water resources.

The main water sources in the region are as follows:

- Renewable surface water, including six major river basins, which account for 66% of fresh water sources, renewable shallow ground water sources,
- non-renewable ground water sources also known as fossil water,
- desalinated water, and
- treated waste water.

Water stress in the Arab countries *(Per cent)*



Bottom: Water stress in Arab countries (Courtesy: Arab Region Atlas of the changing world)

Water use in the Arab region

Water use in the Arab region is dominated by agriculture which utilises about 85% of the water resources. Irrigation efficiency is also low in this region as compared to global best practice. There is an increasing demand for water from the growing population and economic growth, a fact that is likely to increase the water scarcity that the region is already facing. It has been estimated that as early as 2015 the Arab region is likely to face severe water scarcity, when the annual *per capita* water availability would fall down to less than 500 cubic metres, in comparison to the world average of 6,000 cubic metres.

Challenges to the water issues in the Arab world include population, subsidised and low water pricing encouraging high *per capita* consumption, increasing drive for food self-sufficiency, over extraction of underground water and subsequent salinisation, impacts of increasing desalination-such as energy use and brine, discharge of untreated effluents into water bodies and climate change. The Arab world is soon likely to experience 25% drop in precipitation and 25% increase in evaporation rates, of which, both do not augur well, for already low fresh water availability.

Arab nations cannot afford to waste a drop of water. While most of the Arab nations have already started formulating and initiating the implementation of integrated water management plans with all the relevant stakeholders, good policy, institutional reforms, education, research and public awareness campaigns would go a long way in tackling the water scarcity in the region.

Issue of water in the UAE

With less than 120 millimetre of annual rainfall, UAE falls in one of the hyper arid regions of the Earth. With the exception of some permanent wadis, UAE does not have any free flowing fresh water. Up until 50 years ago water requirements were solely met with ground water sources using traditional extraction methods. In fact, in the past, societies in the Emirate were fully aware of and appreciated the finite nature of water and used it judiciously.

Traditional context of water

Narratives in Abu Dhabi Island illustrate the factors that prevented human groups (as in the case of the Bedouins) from becoming bound to a specific place in the harsh desert environment. When water resources dried up, or became unable to sustain the increased needs of the group, it was necessary to move. The search for water remained a constant theme of desert life. Now, water remains the indispensible lifeline to a future that promises greenery and prosperity.

Tradition, culture and water – sharing of the ‘commons’

Singing, either individually or collectively, is one of the traditional arts performed by Bedouins in the desert during their long travels and during the extraction of water from wells to provide water to their animals. It is believed that singing at wells was one of the first poetry arts known to Arabs.

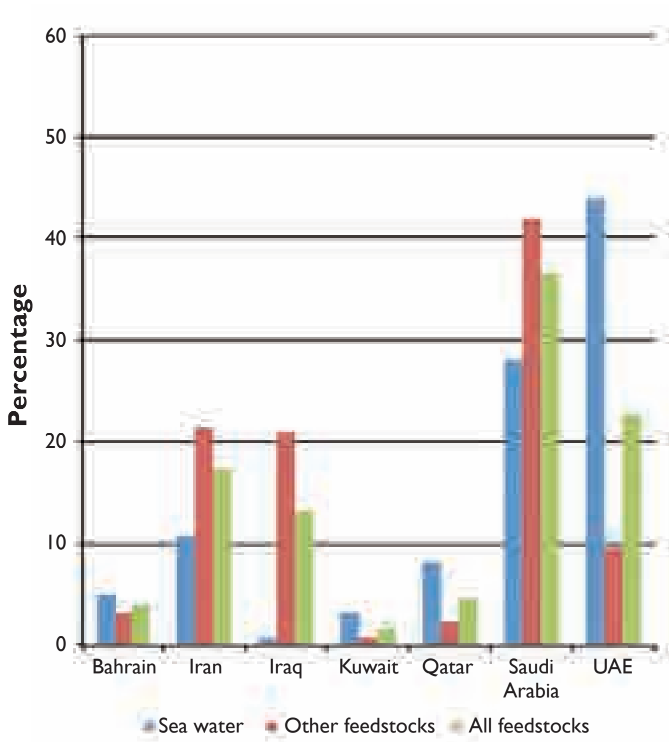
Mohamed bin Said bin Jasim al-Raqraqi al- Mazrouei narrates a poem from the past:

"There is no god but God
Mohammed is his Prophet
Camels come
Following shades
They want attention
They want water
They need care
In darkness and next to the well"

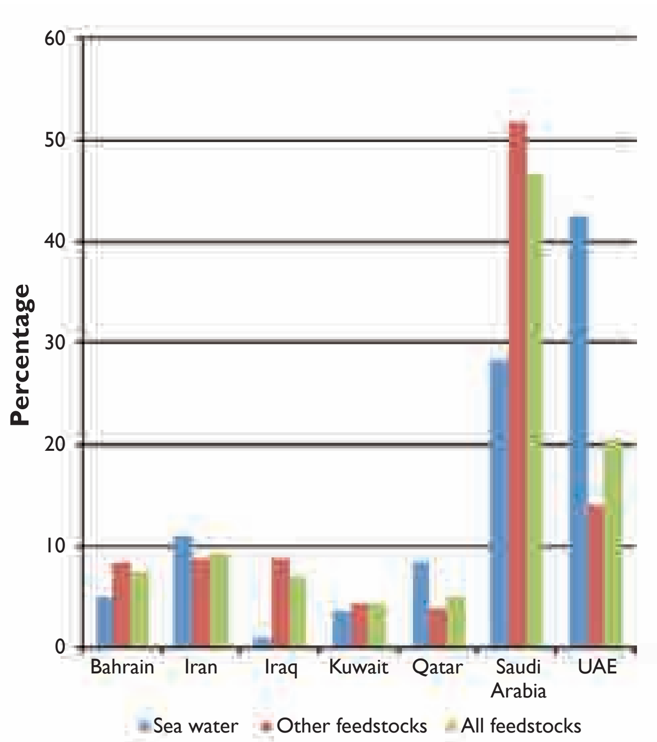
While ground water remains the dominant source of water in the UAE, the first desalination plant constructed in Abu Dhabi Emirate in 1960 slowly helped diminish the dependence on natural fresh water sources. There has been a multi-fold increase in demand for fresh water over the past 4 decades. However, continuous extraction of groundwater, beyond the rate at which it can be replenished, has resulted in a dramatic drop in the ground water level.

Distribution of desalination plants in the UAE

Operational



Operational + under construction + planned



Graph: Data Source - Research study - Karlsruhe University

In the UAE, agriculture, with 67% of total water use, remains the foremost user of ground water (SCAD). Decreasing water tables have led to salinisation of the soil (due to excessive irrigation and growing water thirsty crops) and increasing ground water salinity. The decrease in ground water availability has also led to an increasing dependence on desalinated water.

Desalination is a costly process and contributes to high carbon emission due to high energy use, thus increasing the global warming potential in addition to harming the marine ecosystem and fish stock, due to discharge of brine from the desalination plants into the sea. In Abu Dhabi, the combined water and power generation plants accounted for 31% of greenhouse gas emission in 2010. Desalination is the main source for supplying potable, domestic water for consumption. Domestic water accounts for 24% of total water consumed. Industries account for only 10% of the total water usage.

With increasing access to water with desalination, deep drilling and treatment technologies, the *per capita* consumption of water has reached an all-time high. Average *per capita* consumption of water in the UAE is 500 litres *per* day, 82% above the global average. The *per capita*, *per* day consumption of desalinated water in Abu Dhabi Emirate is 1.24 cubic metres (1240 litres – 2012 SCAD).

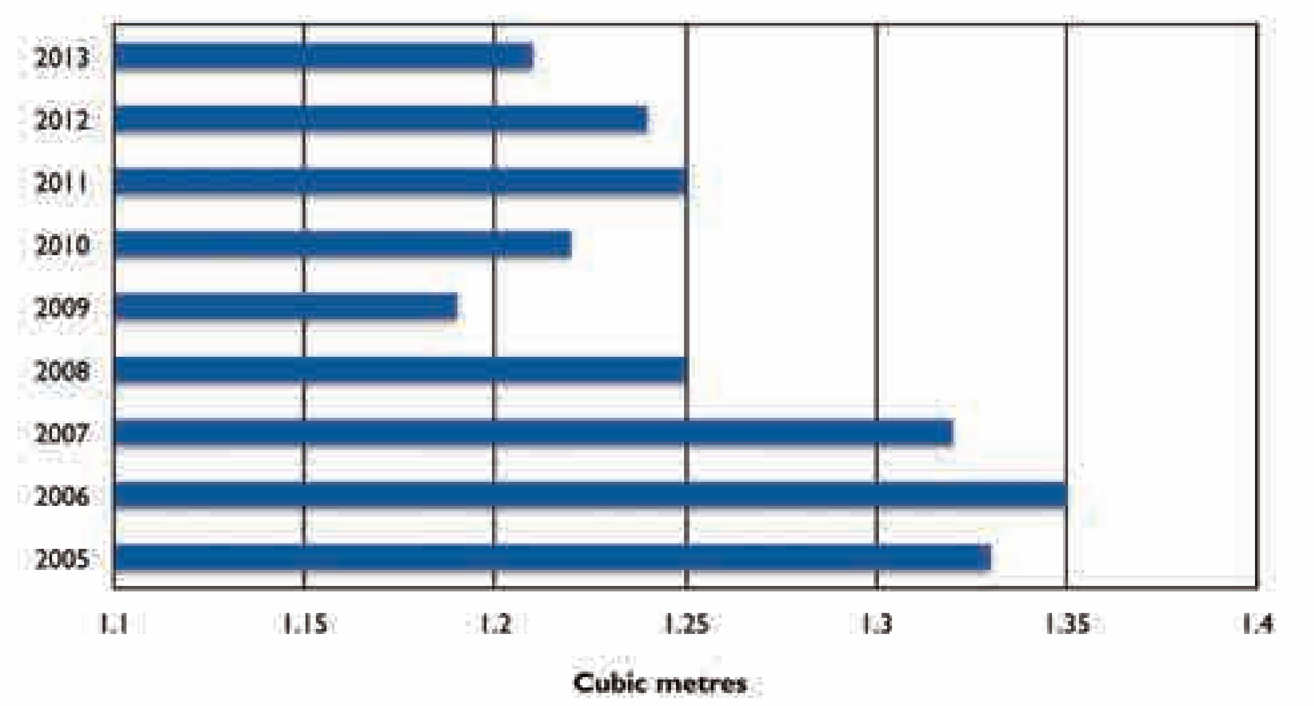
Ground reality of water use in the Emirates:

- Water requirements of large populations will have to be met by desalinating sea water,
- use of water will be high to support large populations in a desert ecosystem,
- the rate of evaporation will be high because of temperature and aridity, and
- virtual water footprint will continue to be high because it is a desert.

Over 97.5% of Earth's water contains salt. Desalination is the process of removing salt from water. It is a challenge for engineers world wide to find a desalination process that is cheap enough to bring desalinated water to the poor and remote regions of Earth. Currently, there are several techniques used for the desalinating water in large quantities, including forward osmosis, carbon nanotubes and biomimetics. Evaporation desalination, however is still the most commonly used. All desalination processes produce dangerous by-products, such as concentrated brine, that pose environmental hazards to fresh water and animals.

Desalination plant

Per capita daily consumption of desalinated water in Abu Dhabi



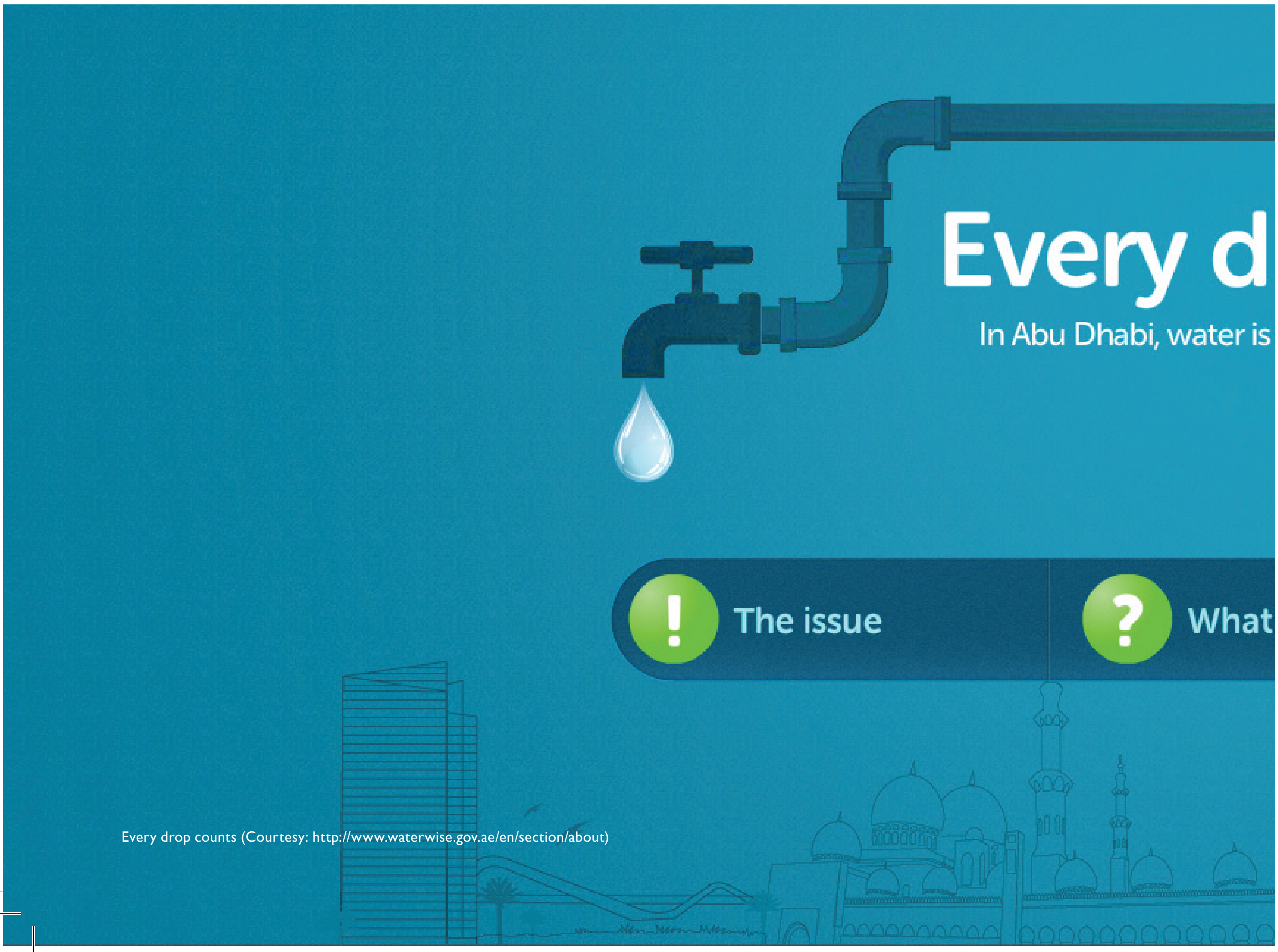
Top: Sea water co-generation desalination plant (Courtesy: EAD)
Bottom: Per capita daily consumption of desalinated water (Courtesy: Environment in figures 2013, Statistic centre)

Efforts to tackle the issue

With lowering ground water reserves and high carbon emission due to desalination, UAE will soon reach a tipping point in terms of meeting growing demands for water from competing users. Efforts are underway by the country to address the issue. Abu Dhabi Emirate is leading the way with a master plan. Efforts to address the issue in the Emirate could be summed up as:

- Better coordination with all relevant stakeholders,
- introducing sound regulation and enforcement to curb overuse and misuse,
- using 'xeriscaping' (which uses less water) and salt tolerant plants for landscaping and amenities,
- reducing subsidies in agriculture and promoting sustainable agriculture,
- limiting water use for afforestation purposes and encouraging plantation of only local trees,
- introducing water tariffs,
- exploring alternative technologies,
- better desalination techniques to curb energy use and enhance efficiency, and
- education and awareness.

Water conservation campaign of Abu Dhabi government



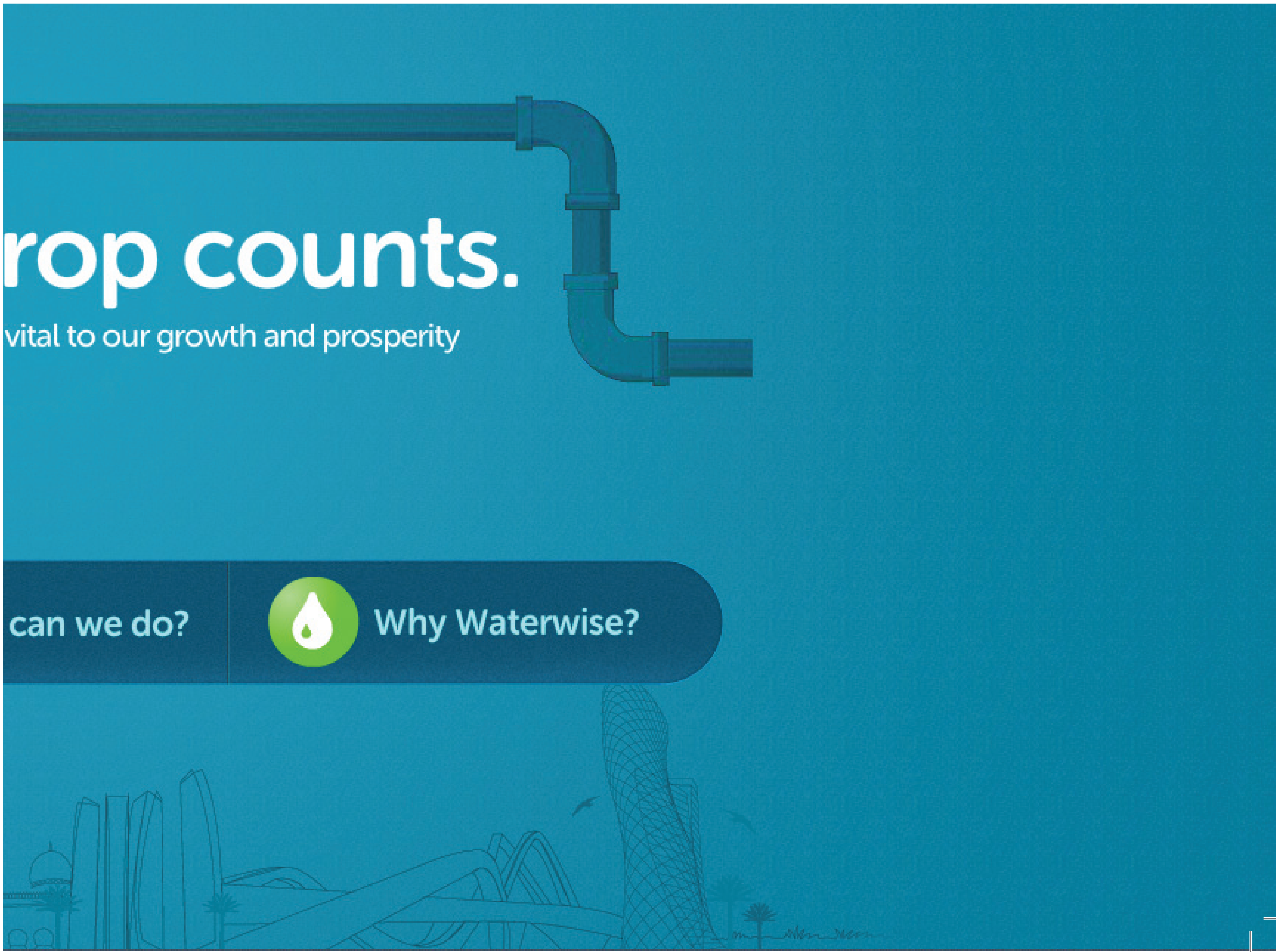
Every drop counts (Courtesy: http://www.waterwise.gov.ae/en/section/about)

In a survey conducted by Abu Dhabi based Emirates centre for strategic studies in 2013 for 1000 residents in the UAE revealed that 84.5% of respondents agreed that water resources are being wasted in the country.

The survey concluded with a recommendation that there is an intense need to engage with schools and in particular with universities to raise awareness and educate about this issue, so that the future custodians of this precious resource have the right attitude, skills and competencies to address this crisis.

The following pages provide a framework for young people to understand issues related to sustainable use of water by looking at water management practices in their college/university campus. They get an opportunity to make use of water on their campus more sustainable. From the social point of view they realise the role an individual plays in making institutions and communities more sustainable. This would require:

- Understanding the relation between their water requirements and the sources,
- finding out how much water is consumed and how to meet national targets,
- handling common psyche to reduce consumption of packaged drinking water,
- realising how to meet the national target of returning water to sewer,
- minimising energy use in management of water, and
- finding out ways to reduce the virtual water footprint for their campus and community.



WATER AUDIT

Stage 1: Sources of water in your region?
Stage 2: Current consumption of water?
Stage 3: Wastewater management?

Stage 1: Sources of water in your region?

The rapid depletion of underground water sources is pushing the Emirates to meet its water demand by desalinating sea water. The needs of a growing population, close linkages between water-use, energy, climate change, declining quality of water sources and rising costs of energy are together forcing the agencies managing water in the Emirates, to rethink water management. With provision of water being subsidised, the difficulties faced by the water managers are not hard to imagine.

Step 1

Members of the audit group must be aware of the agency that manages water in their region. A few members of the audit group could either visit the water management agency's office or conduct a telephone interview of the person responsible. While data can also be obtained on the internet, a first-hand interview is recommended. Internet can be used to validate the collected information.

Agencies managing domestic water in Abu Dhabi:

Abu Dhabi Water & Electricity Authority (ADWEA)
ADWEA researches, develops effective ways for production, distribution of water and electricity. The agency is owned by the government but is financially and administratively independent.
www.adwea.ae

Abu Dhabi Distribution Company (ADDC)
ADDC is responsible for distributing water and electricity in the emirate of Abu Dhabi, excluding the Al Ain region. ADDC's core business is planning, designing, construction, and operation of the Abu Dhabi water and electricity distribution network.
www.addc.ae

Al Ain Distribution Company (AADC)
AADC is the supplier and distributor of water and electricity in the Eastern Region of the Abu Dhabi Emirate.
www.aadc.ae

Abu Dhabi Sewerage Services Company (ADSSC)
ADSSE was established on 21.06.2005 to collect and treat waste-water discharged from residential and commercial sectors in the Emirate of Abu Dhabi and safely dispose both the solid and liquid wastes thereof.
www.adsse.ae

Regulation and Supervision Bureau (RSB)
General responsibilities of the Bureau encompass a wide range of subjects including the protection of customers and the development of safe and reliable water, wastewater and electricity networks. Primary duty of the Bureau is to ensure the continued availability of potable water for human consumption and electricity for use in hospitals and centres for the disabled, aged and sick.
www.rsb.gov.ae

Table 1: Present cost of water : Find out the cost of water/unit.

YEAR: MONTH:		
Source	**Quantity**	**Cost / Unit**
Non conventional source - Desalination process		
Treated water*		

Table 2: Previous cost of water (Before 10 years)

YEAR: MONTH:		
Source	**Quantity**	**Cost / Unit**
Non conventional source - Desalination process		
Treated water*		

**Treated water here means treated sewage water used for irrigation or other purposes.*

The water audit group can compare the data collected in Table 1 and Table 2 before a few of its members interview the person responsible in the water distribution agency of the region to seek answers to the questions given in the table below:

Question	**Reply** (Tick the applicable)	**What does it indicate?** (Tick the applicable)	**What needs to be done?**
Has the proportion of water drawn from the two sources changed over the years?	Yes / No	• Technology has improved/not improved over the years and **has/has** not enabled recovery of more water for re-use. • Social beliefs **have/have not** changed to make use of treated raw water more acceptable.	
Has the cost of sourcing water increased over the years?	Yes / No	• Cost of manpower and material engaged in water management has changed. • Cost of available technology has changed. • Cost of energy used in management of water has changed.	

The water and electricity distribution company in your region incurs expenditure in treating and distributing water. This cost is incurred on installation of infrastructure initially and subsequently on infrastructure maintenance in addition to the regular cost of energy. Authorities calculate these costs periodically and try to keep them under control. The heads on which the company incurs these costs also indicate important sustainability issues. If these costs are rising, then the sustainability factor is certainly low.

Desalination

LTD (Low Temperature Distillation) system with one cascade can produce water at less than 1 kilowatt hour per cubic metre in contrast to SWRO (Sea Water Reverse Osmosis) which typically uses 3.5 – 4.5 kilowatt hour per cubic metre of water produced. Membrane-based desalination consumes 1.5 kilowatt hour per cubic metre of water produced. According to RSB the process of sea water reverse osmosis currently consumes < 4.5 kilowatt hour per cubic metre of water. The real cost of producing one kwh of electricity stood at 32 fils on 07.04.2013.

The cost of producing 1 cubic metre of water is AED 10.32 (As of 2013) which includes production, transmission and distribution of water. If the cost is split:

AED 6.86 for production

AED 1.97 for transmission

AED 1.50 for distribution

Learning from nature!

If you want to learn and understand the rules of using water sustainability, any natural system is a very good example. Remember, the quantity of water on Earth is finite. Water is treated and distributed across the planet by the 'Hydrological Cycle'. The characteristics of the hydrological cycle that makes it sustainable are:

Water gets treated, distributed and recovered at ambient temperature and
Water gets treated, distributed and recovered using only renewable energy.

Make a flow chart of the process followed by the water management company to calculate the costs of sourcing, treating, and distribution of water. Few members from the water audit group must contact a person responsible in the water management company to understand the process and cost of providing water.

FLOWCHART		COSTS
Sourcing water	=	
Treating water	=	
Transportation per kilometre	=	
Treating sewage	=	
End point disposal	=	

Stage 2: What is your current consumption of water?

In this stage the water audit group has the options either to:

a) Identify and quantify uses of water for different purposes within the campus and calculate the *per capita* daily water consumption to compare it with expected standards. This will help them to assess the sustainability of their water use.

Or

b) If the campus infrastructure is older than 10 years and the data is available, track their *per capita* water use over the past 10 years to evaluate whether they have become more or less sustainable based on the questionnaire given below.

If the campus is older than 10 years and would like to attempt both the options for better understanding, they are welcome to do so.

Arriving at *per capita* daily water consumption

You can find out the total water consumption of your campus from the water bill, available with the campus administration. The Building Management System will also have the required information on water consumption. To derive the LPCD (Litres *per capita*, per day) consumption of water for your campus:

Your water bill will show monthly consumption in kilolitres or cubic-metre. To convert it to litres, use the conversion formula given below:

1 kilolitre = 1 cubic-metre = 1,000 litres of water

Daily consumption of water = Monthly consumption / Number of days in that month

Per capita, *per* day consumption = Daily consumption of water / Number of people on the campus

The *per capita* consumption of water on your campus will be far lower than the average *per capita*, *per* day domestic consumption of water in the Emirates. This is because water is used for several purposes at home which are not applicable on campus. It is important that use-specific consumption of water is calculated because that will help in identifying areas where water use could be restricted.

Quantity of water consumed everyday is strongly linked to availability of water, cultural habits and technology that brings water in our house taps. How much water would you have used if you had to fetch it from a deep well or from a water body few kilometres away?

Calculating use-specific water consumption is not rocket science

It is common to think that calculating use, specific consumption for large numbers of people is a very complex and time consuming task. Interestingly, it is not so due to one primary reason which is the fact that the audit group does not have to find out use specific consumption that is accurate to tens or even hundreds of litres.

The task could be as simple as choosing few volunteers who appear to have different range of water uses and those uses are broadly representative of the range that is available on the campus. All that needs to be done is to monitor water consumption of these people for two separate days during months having different seasons in a year to arrive at a reasonable average.

For consumption of water in common spaces on campus like landscaping, washing and others, the people who use water in these spaces should be consulted. Some general methods for arriving at reasonable averages would come handy for accomplishing the task of determining use-specific consumption.

Determining quantity of water used for drinking in a day could be as simple as volunteers drinking out of a bottle of known capacity. Determining the quantity of water used in washing hands for instance, could be, using water from a container of known capacity. Similarly, ways of determining quantity of water consumed for the four different uses mentioned in the Table 3 are not hard to devise. Once use-specific averages are known, extrapolating them to the entire campus is a simple multiplication with number of people on the campus and number of days.

The people engaged in campus maintenance and administration could make the task even simpler. Personnel handling the Building Management System (BMS) would have a lot of information that could be used to determine use-specific consumption.

Table 3: Water consumption by Actual Use vs. Target

Uses of Water	Ideal Quantity consumed (LPCD)*		Current consumption (LPCD)	
	Non-residential	Residential	Non-residential	Residential
Drinking*	3	6		
Washing*	6	161		
Flushing*	15	25		
Landscaping* (Litres Per square metre)	5	5		
Others (please specify)*	6	18		
Total water consumption	35	215		

**The ideal quantity consumed is based on Abu Dhabi Emirate's target of reducing water consumption to 350 litres per capita, per day, discounting some uses in homes that are not relevanton the campus and the fact that the collective use on campus brings down per capita, per day consumption.*

If your campus has been in existence for more than 10 years, you can speak to the water management agency or your campus management facilities in-charge, collate the relevant data and analyse, to answer questions given in the table below:

Question	Reply (Tick the applicable)	What does it indicate? (Tick the applicable)	What needs to be done?
Has the *per capita*, per day consumption of water increased during the past ten years?	Yes / No	• New water sources **have/ have not** been found. • Treatment, distribution, collection and disposal of water **has/has not** improved. • Environmental awareness levels of users **have/have not** changed. • Cost of energy **has/has not** gone up.	
Will the *per capita*, per day consumption of water increase of decrease during the coming ten years?	Yes / No	• New water sources **can be/ cannot** be found. • Treatment, distribution, collection, and disposal of water **will/will not** improve. • Environmental awareness levels of users **will/will not** change. • Cost of energy **will/will not** go up.	

Calculating resource efficiency:

- If the campus consumes less water than the ideal consumption in Litres *per capita*, *per* day (LPCD), the resource efficiency is 100%.

Alternatively:

If the *per capita*, *per* day consumption of water on the campus has not risen during the past ten years, the resource efficiency is 100%.

- If your campus consumes equal to or more than double of ideal consumption in LPCD, the resource efficiency is 0%.

Alternatively:

If the *per capita*, *per* day consumption of water at the campus has doubled over the past ten years the resource efficiency is 0%.

If your campus consumption is more than the ideal consumption but less than double of it, calculate resource efficiency per cent using the formula given below:

c (Excess LPCD) = a (Current LPCD) – b (Ideal LPCD)

d (Resource efficient quantity) = b – c

$$\text{Resource efficiency per cent} = \frac{d}{b} \times 100$$

Where a = Current LPCD, b = Ideal LPCD, c = Excess LPCD, d = Resource efficient quantity

Alternatively:

If the *per capita*, *per* day water consumption of the campus has increased but not doubled over the past 10 years calculate sustainability per cent using the formula given below:

c (Increase in LPCD) = a (Current LPCD) – b (Previous LPCD)

d (Resource efficient quantity LPCD) = b – c

$$\text{Resource efficiency per cent} = \frac{d}{b} \times 100$$

Where a = Current LPCD, b = Ideal LPCD, c = Excess LPCD, d = Resource efficient quantity

Example:

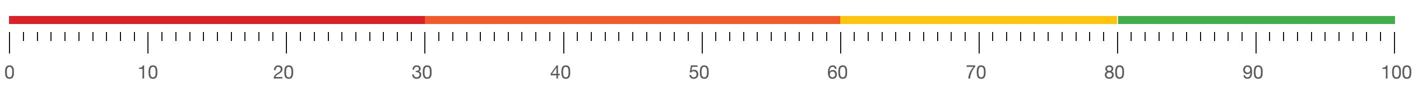
If the *per capita*, *per* day water consumption on a campus is 200 litres against the ideal *per capita*, *per* day water consumption of 150 litres, then

c = 200 – 150 = 50 litres

d = 150 – 50 = 100

$$e = \frac{100}{150} \times 100 = 66.66\%$$

Depict the resource efficiency of your campus on the number line given below:



Community practices survey

It would be good if the working group on water could identify few households in the community around the campus and calculate their use-specific water consumption. The chosen house-holds should represent different strata's of society typical of your locality. The sizes of the household should also represent the range to arrive at a reasonable average.

Is this a viable option?

The United Arab of Emirates (UAE) government has made provisions for supply of clean and healthy water in taps, with the municipalities regularly checking the quality in schools, shopping centres, commercial buildings and hospitals. Despite this, people trust bottled water more than tap water. Drinking water is purified in state of the art treatment plants, built at a huge expense. But the consumers continue to be wary as they have no information about the origin of water and how it reaches their taps. Last but not the least; the tap water is always warm.

"UAE has one of the highest *Per capita* consumption of bottled water at 153 litres *per* person *per* year."

The government supplies quality water which is fit for drinking after normal filtration. Any normal membrane filter will be adequate to ensure removal of particulates from tap water. UAE citizens pay more to buy bottled water as the manufacturing companies make them believe it is the safest. Use quality water filters to ensure clean potable water.

Activity

Form a group of like-minded people. Try and reduce the consumption of packaged drinking water on the campus. It will not only help people save money, but also protect your health, and rid the environment of waste plastic bottles.

Find out how many packaged drinking water bottles are used on the campus every day by conducting a survey of the campus. Use the format given below to collect data or request the canteen/pantry in-charge to provide the required information. The house-keeping/ waste collection team should also be involved in the survey.

Top: Bottled water consumption (Courtesy: EAD)

Table 4: Pre-campaign packaged drinking water survey

SOURCE OF INFORMATION	NO. OF BOTTLES USED					QUANTITY OF WATER
Capacity in litres	20	5	2	1	½	
Canteen/Pantry						
House-keeping/ Waste Management						

Stage 3: Wastewater management

Challenges facing waste water reuse are:

- limitation of distribution networks,
- gaps in regulation and distribution responsibilities,
- institutional and legal challenges,
- environmental challenges, and
- economic and technical challenges.

Suggested recommendations:

- Environmental sustainability: reduce emissions and pollutant discharges into water bodies and enhance their quantitative and qualitative status(surface- water, groundwater and coastal waters) and the soils,
- economic efficiency: alleviate scarcity by promoting water efficiency, improving conservation, reducing wastage and balancing long term water demand and water supply, and
- contribution to food security: growing more food and reducing the need for chemical fertilisers through treated wastewater reuse.

Treated sewage being disposed in the sea at eastern Corniche

Water from sewage treatment plant being disposed in the sea (Courtesy: EAD photo stock)

Abu Dhabi has 33 waste water treatment plants that treat 284 Mm^3 (2013) of waste water produced by the people of Abu Dhabi every year. Total daily production is 1117437 m^3. The quantity of waste water managed by various treatment plants every day is:

Al Mafraq – 260000 m^3
Al Saad – 80000 m^3
Al Wathba 1 – 300000 m^3
Al Wathba 2 – 300000 m^3
Al Hama – 120000 m^3

54% of waste water produced is reused by the city while 46% is disposed in the environment. By 2030 people of Abu Dhabi will be producing 1435 Mm^3 waste water every year accounting for a pessimistic annual growth rate of 10%. It is very important for the people of Abu Dhabi to reuse waste water.

In Abu Dhabi treated waste water is used to grow Rhodes grass, Maize and Fodder. Some amenity areas in Abu Dhabi have been irrigated by treated waste water for more than 20 years now. Abu Dhabi as a city has achieved 0% treated waste water discharge.

In future waste water could be used:
Agriculture 55.8% Domestic 24% Forestry 11.6% Amenity 7.5% Industry 2.2%

Regions longest sewerage system

Abu Dhabi has completed the first phase of the largest and the longest gravity-driven sewerage tunnel. It is about 27 metres deep at the start and about 87 metres deep at the end.

Adapted from presentation of Dr. Mohamed A Dawoud, Adviser – Water Resources, Environment Agency, Abu Dhabi

The water audit group can provide vital first-hand information about how much waste water is generated on the campus and how much actually ends up in the sewer, to Residential End Use Water (REUW) project of Regulation and Supervision Bureau (RSB).

This particular task can contribute to the Return to Sewer (RTS) initiative of RSB. Estimate the quantity of waste water being generated on the campus and its locations. Look at the use specific water consumption in Table 5. Fill in the Table below to estimate *per capita* use-specific generation of waste water on the campus.

Table 5: Waste water generation

Uses of Water	Ideal Quantity consumed (LPCD)*		Waste water generation	
	Non-residential	Residential	Non-residential	Residential
Drinking*	3	6		
Washing*	6	161		
Flushing*	15	25		
Landscaping* (Litres Per square metre)	5	5		
Others (please specify)*	6	18		
Total water consumption	35	215		

Repeat the steps taken to fill Table 5 after the water audit group leads the campus community in changing practices to meet the return to sewer rate target of 20%. Inform RSB of your efforts if you manage to increase the rate substantially.

The aim of this exercise is to enable people to understand which areas can be targeted to contribute to RSB's objective of increasing the return to sewer (RTS) rate to 20% of water consumption. It is also important to understand that an increase in RTS will lead to greater availability of treated water that can be used for irrigation. It would be interesting to see whether 20% of water consumption is enough to meet campus landscaping requirement.

It is important for the audit group to understand the larger picture. The government spends energy to source water, it spends energy to treat water and then distribute it. But this is not the end point. Energy is spent to collect used water, transport it, treat it, and eventually dispose it. Where does the disposed water go? Does it end up in a water body that is used as the source? If it does, is the quality of water at the source deteriorating? How does the government take care of this?

Abu Dhabi aims to significantly increase the RTS to 60% (RSB). When achieved the treated raw water would significantly contribute to reduction in use of desalinated fresh water for landscaping. In turn this would translate in reducing the carbon footprint of Abu Dhabi.

Contact the waste water management agency to find answers to the questions stated above and the table below:

Question	Reply	What does it indicate?	What needs to be done?
Where does the sewage ultimately end up?			
How much energy is spent on treating 1 cubic metre of sewage?			
How much energy is spent in transporting 1 cubic metre of sewage?			

ADSSC provides treated water and bio-solids to the Municipalities for horticulture purposes. Over 60% of the recycled water is used for irrigation purposes, thereby, contributing towards environmental preservation (2013). With the completion of treated water delivery pipelines, in the near future, 100% of treated wastewater produced by ADSSC will be reused.

Calculating resource efficiency:

If the campus manages to return 20% of the total water it consumes *per* annum to the sewer it meets the objective set by RSB and therefore is 100% resource efficient for now.

If the campus returns less than 20% of the total water it consumes *per* annum to the sewer, then calculate your resource efficiency per cent using the formula given below:

a (Ideal quantity of water that must be returned to the sewer) =

$$\frac{\text{b (Water consumed } per \text{ annum)}}{100} \times 20$$

$$\text{Resource efficiency per cent} = \frac{\text{Current\% of water returned to the sewer}}{20} \times 100$$

Example:

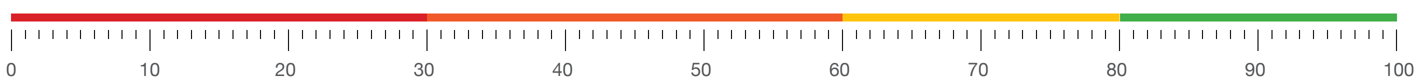
If the quantity of water your campus consumes per annum is 10,000 litres and the amount of water it manages to Return to Sewer (RTS) is 1,400 litres what would be your campus resource efficiency per cent when it comes to managing its waste water?

$$a = \frac{10{,}000}{100} \times 20 = 2{,}000 \text{ litres}$$

$$\text{Current percentage of water returned to sewer} = \frac{1{,}400}{10{,}000} \times 100 = 14$$

$$\text{Resource efficiency per cent} = \frac{14}{20} \times 100 = 70\%$$

Depict the resource efficiency of your campus on the number line given below:



Community practices survey

It would be good if the working group on water could identify few households in the community around the campus and assess wastewater return to sewer rate. The chosen house-holds should represent different strata's of society typical of your locality. The sizes of the household should also represent the range to arrive at a reasonable average.

List down the steps that need to be taken to ensure overall sustainability of water in the region:

INDIVIDUAL	INSTITUTION	COMMUNITY

Sustainable water management

Sustainability of water would mean that the growing needs of current population are met without affecting the availability of water for future generations. This can be done in two ways:

- following practices that preserve the present water sources, and
- developing technology that will make new resources available for future generations.

Humans have a history of exploiting water sources beyond their capacity to regenerate. We depend on technology to enable us to tap new sources. Increased dependency on desalination to meet our water needs is a typical example of our approach.

The weather conditions in the Emirates pose a strange paradox. Though the water resources are limited, more water is needed to survive in the hot, desert climate. Recharging underground aquifers with rainwater is not enough since there is very little rainfall and there are no large fresh water bodies either. The depletion in quantity and degradation in quality of underground water sources is leaving desalination as the only option. Growing population, increasing water use, increasing costs of treatment and distribution of water are constant challenge to sustainable management of water. There are several ways of achieving sustainability under the current circumstances. They are:

- Assessing the capacity of current water sources and establishing limits of their exploitation to ensure that the sources are affected within tolerable limits,
- reducing water consumption through use of efficient water networks, fixtures and public awareness,
- most important of all, recycling and reusing every drop of used water,
- assessing the capacity of natural systems used to treat waste water and increasing their capacity to match the quantity of waste water disposed, and
- increasing the capacity of treating waste water to the quality before disposal to ensure the natural systems are not overburdened or threatened.

All the above-mentioned goals have to be achieved by consuming less energy since energy sources are finite and use of energy contributes directly to climate change. Of the five ways of achieving sustainability given above we have managed to look at the first three ways of achieving sustainability both on the campus and within a small community close to the campus. The other two ways are longer-term studies and would be taken up agencies who manage water for the people of Emirates.

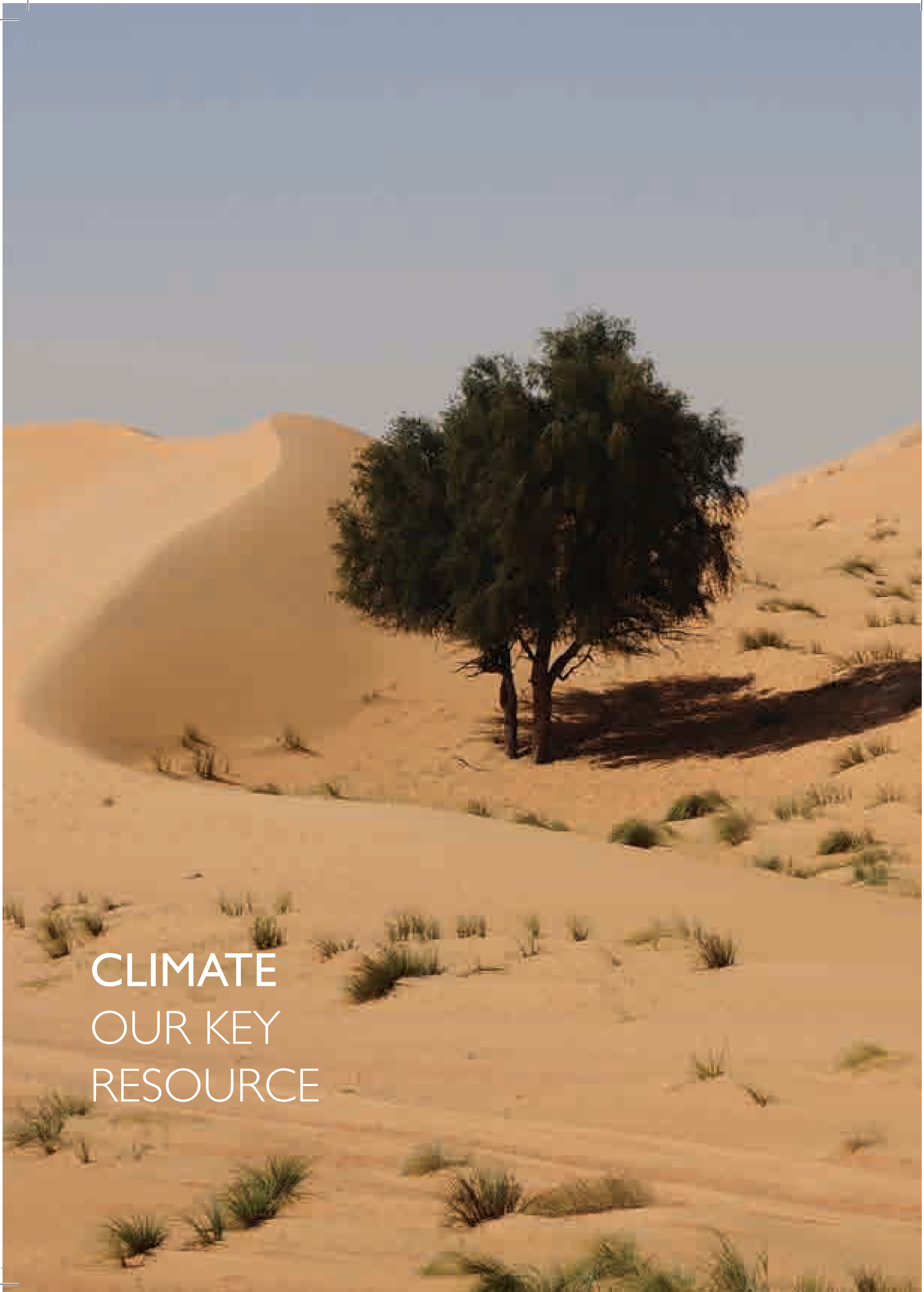
The working group should organise a meeting with the core group to discuss its findings. If the group thinks there is something that needs to taken up at the policy level with campus administration or government, a draft should be prepared and submitted for consideration through proper channel.

Research and experimentation on new ways to improve water management at any level should be taken up as a project related to the discipline people are studying on the campus. The same can also be taken up as an independent research or internship project with private parties with the due permission of competent authorities.

Device reduces pressure of water which results in less consumptions and wastage

Bottom: Pressure reducing device (Courtesy: EAD)

CLIMATE
OUR KEY
RESOURCE



"As human beings, we are vulnerable to confusing the unprecedented with the improbable. In our everyday experience, if something has never happened before, we are generally safe in assuming it is not going to happen in the future, but the exceptions can kill you and climate change is one of those exceptions." - Al Gore

WHAT IS THE WEATHER TODAY?

Sunny, humid, rainy, cold, hot, windy are some of the words we often use to describe weather in our day to day life. These weather patterns are subsets of the global climatic patterns that have been established over thousands of years due to interactions between water, air, sunlight, and the living world. The actual difference between weather and climate is only the measure of time. Weather is what conditions of the atmosphere are over a short period of time, and climate is how the atmosphere 'behaves' over relatively longer periods of time.

Weather conditions are often chaotic. Even with the launch of weather satellites and advances in meteorological sciences, it is difficult to predict weather conditions accurately beyond a few days. Perhaps this is the reason why scepticism exists regarding the validity of current pronouncements on climate change or crisis, as it is better known as. Most find it hard to believe that, while it is difficult to predict interaction between parameters such as wind, pressure, humidity, precipitation, temperature, and so on over smaller periods of time, it can be predicted with a fair precision over longer periods of time. It is here that one tends to forget that climate values are averages collated over a long period of time and show trends rather than exact values observed at a certain point in time in the future.

Left: Desert landscape (Courtesy: Karan Raghwa)
Right: Climate and fossil fuels by ttl120122 (Courtesy: Purchased from www.cartoonsstock.com)

Roots of Climate Change

Today, fossil fuels drive our civilisation and it is no wonder that their burning drives climate change too. Crude oil was being used in our society even during the days of the Mesopotamian empire. The modern use of petroleum can be traced back to 1847.

In 2009, the world used 85 million barrels a day and it is believed to have been doing so since 1999. At 42 gallons to the barrel, that's three billion five hundred and seventy million gallons of oil (3,570,000,000).

1 Gallon = 3.785 litres. 1 barrel of crude Oil produces 317 kg of Carbon Dioxide.

Popular weather icons

Weather and climate are important to us because they govern the essential needs for all life forms to survive-that is air, water, and food. Earth processes (bio-geochemical cycles) operate as open complex systems, full of interdependencies-one that is best understood using systems thinking. It is common knowledge that output from any system or action depends on inputs and throughput (processes that govern the system). This stands true in case of our weather and climate as well. With our toxic and excessive inputs, we have altered the constitution of our air, water, land, and the living world and initiated processes that have resulted in accelerating and triggering changes in global climatic systems with all its complex connections in a manner not conducive to the wellbeing of life on earth.

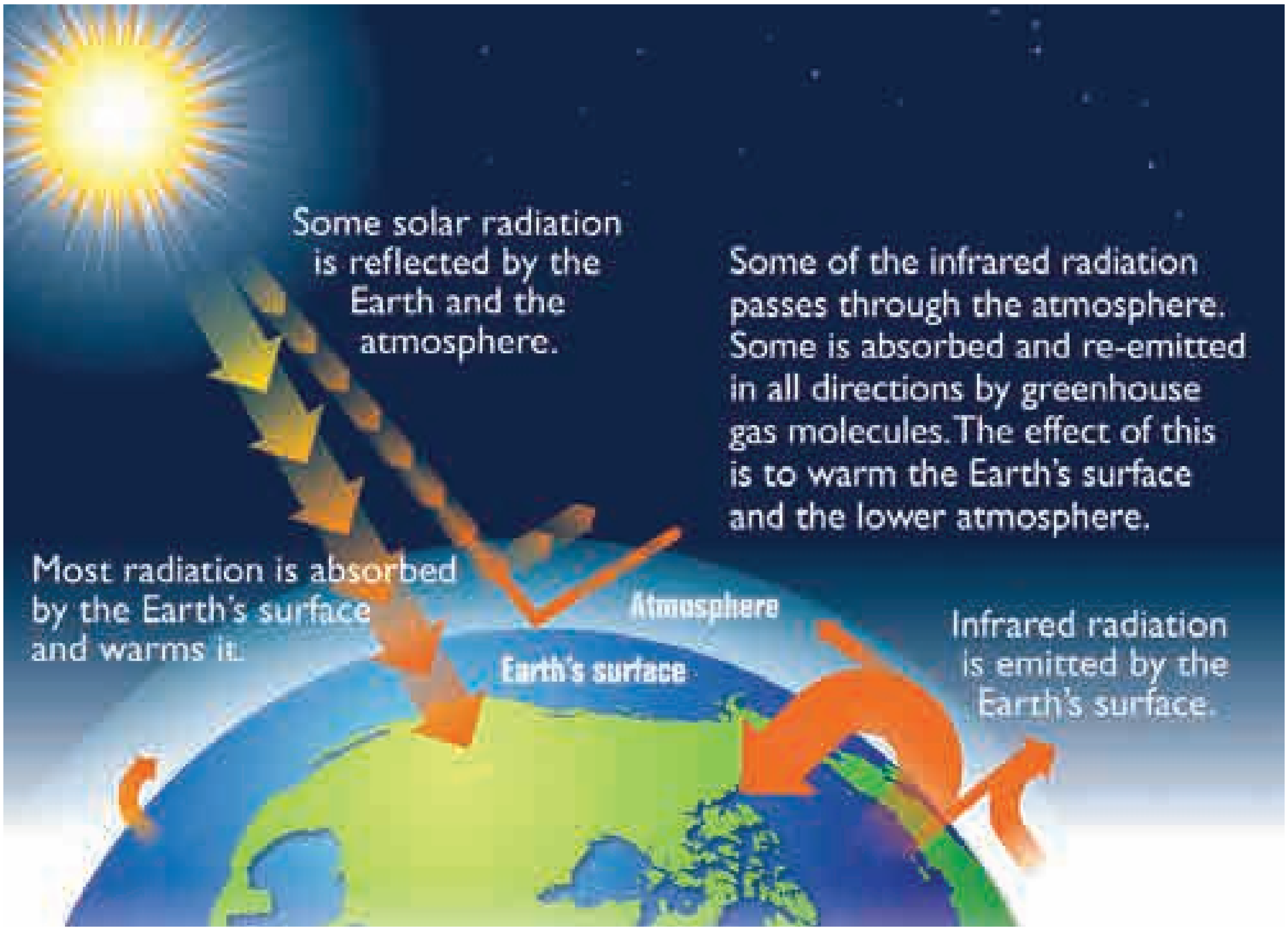
In the discourse on whether the cause of the current crisis is due to natural processes such as continental drift, comets, meteorites, and so on or due to some anthropogenic actions, it has been unequivocally stated by the scientists that the current crisis is due to the steep increase in the greenhouse gas emissions (GHG) from burning of fossil fuel since the beginning of the industrial revolution. Global warming caused by the increased greenhouse gas emissions has triggered large scale changes in the global climatic patterns and related processes.

There remains the potential for a natural reinforcing feedback loop whereby global warming increases even further than the anthropogenic impacts as the ice caps melt and the Earth's albedo decreases. As the frozen methane in the permafrost is released, climate change becomes inevitable. Many scientists believe that this may occur above a threshold of a global average temperature increase of 2°C.

It is also true that economic development and production of GHGs are directly proportional. Dealing with climate change thus becomes a complex issue. We are willing to accept anything today, but limits to growth. Especially a growth translated as a better quality or standard of life realised through the use of resource intensive technologies.

Top: Weather Icons (Courtesy: http://commons.wikimedia.org/wiki/File:Weather-symbols.png)

The science of greenhouse effect

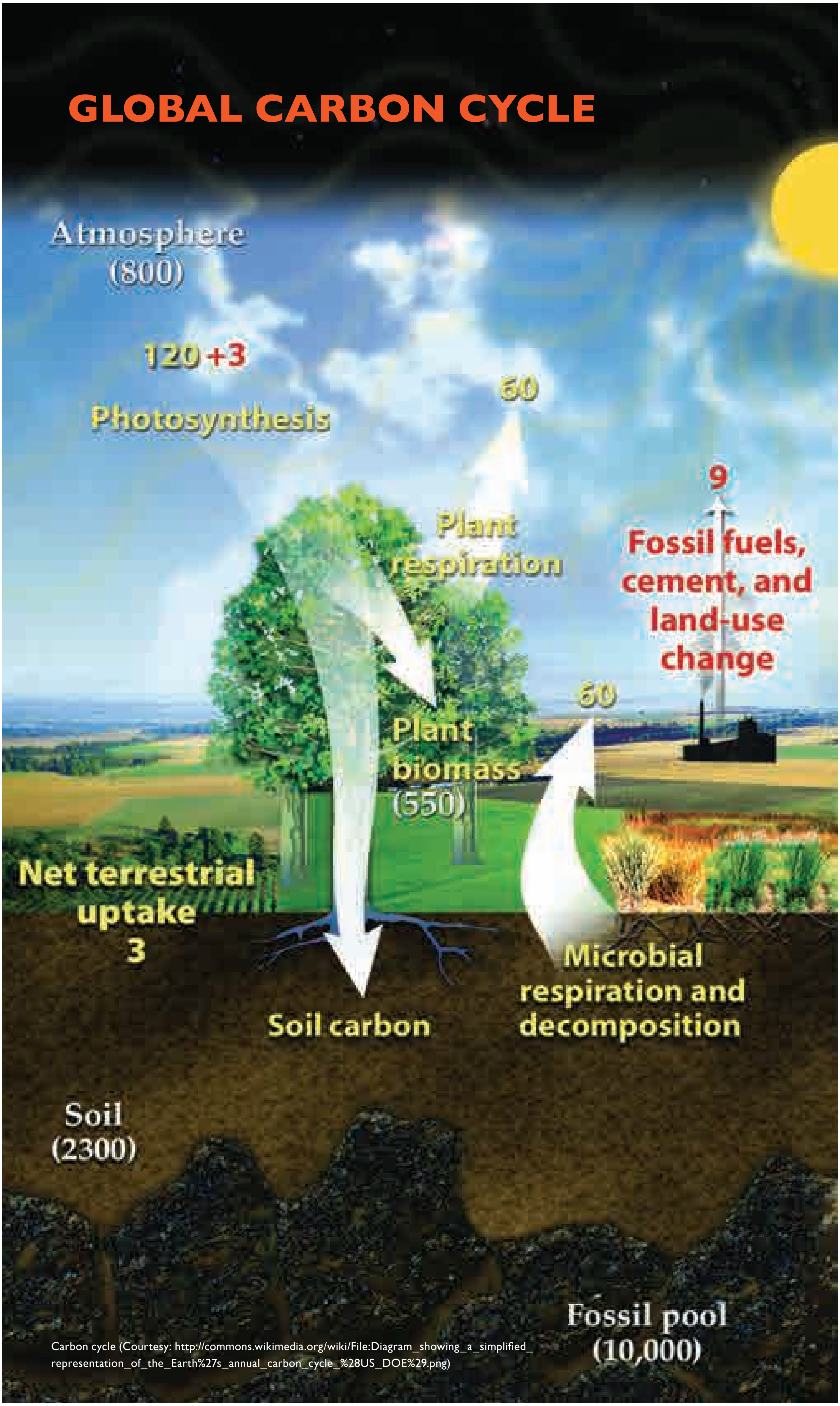


Climate change either impacts on-or is impacted by-global issues, including poverty, economic development, population growth, sustainable development, and resource management. With the social and economic implications, solutions for climate change need to come from all disciplines and walks of life. It is natural for us, in the wake of this understanding, that this global issue has to have a strong local context and action.

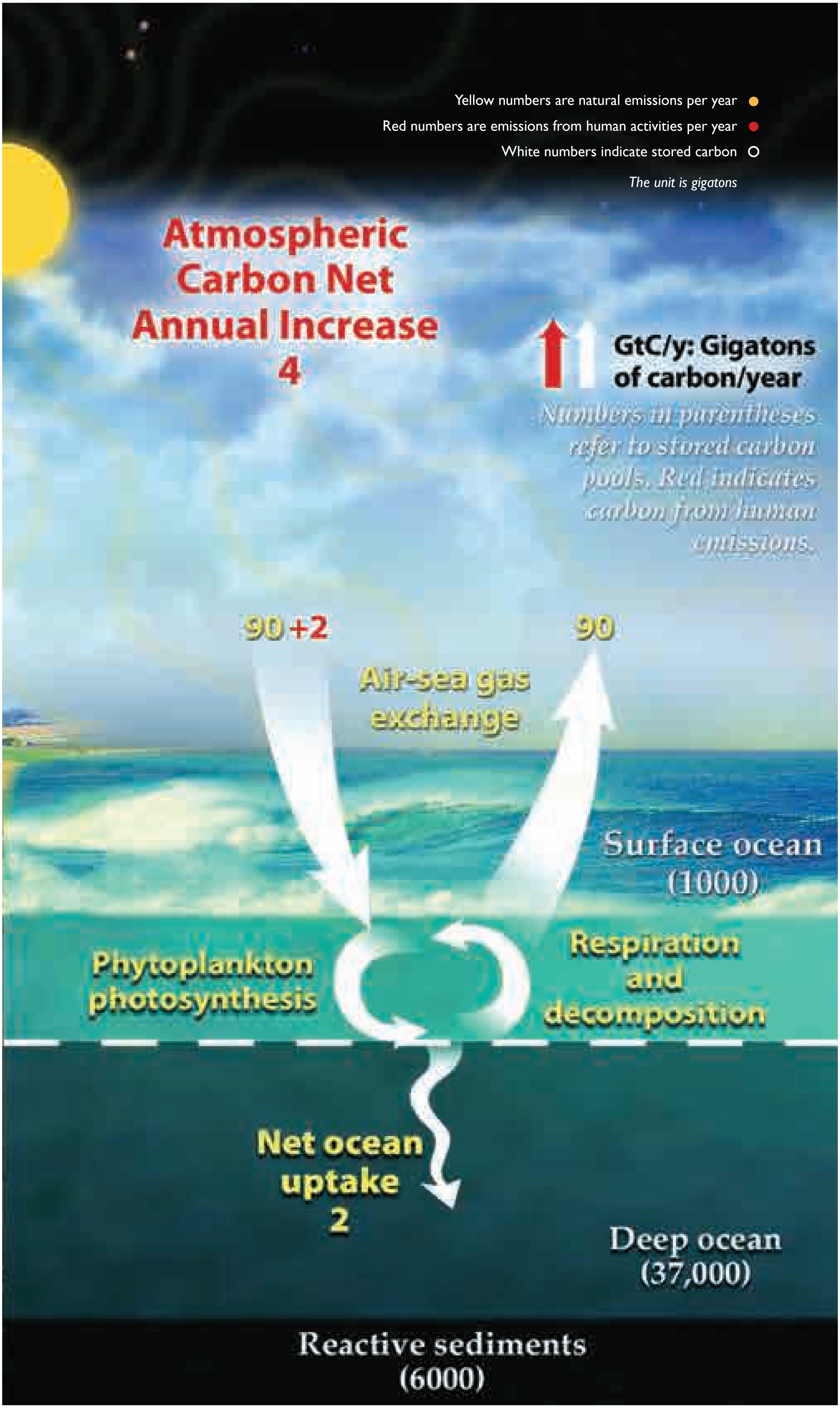
Simply put, greenhouse gases have the tendency to absorb and retain more solar radiation and heat. So the body of air surrounding the Earth warms up. Air does not recognise political boundaries and plays a major role in creating our weather and climate by interacting with water, land, and the living world.

To explain, burning is central to human progress as it is also central to production of carbon dioxide which happens to be a green house gas. By constantly burning one thing or the other, we change the constitution of air, which now absorbs and retains more heat from the sun and hence warms up. The warm air evaporates more water from certain areas and since balancing is its natural tendency, precipitates more water elsewhere.

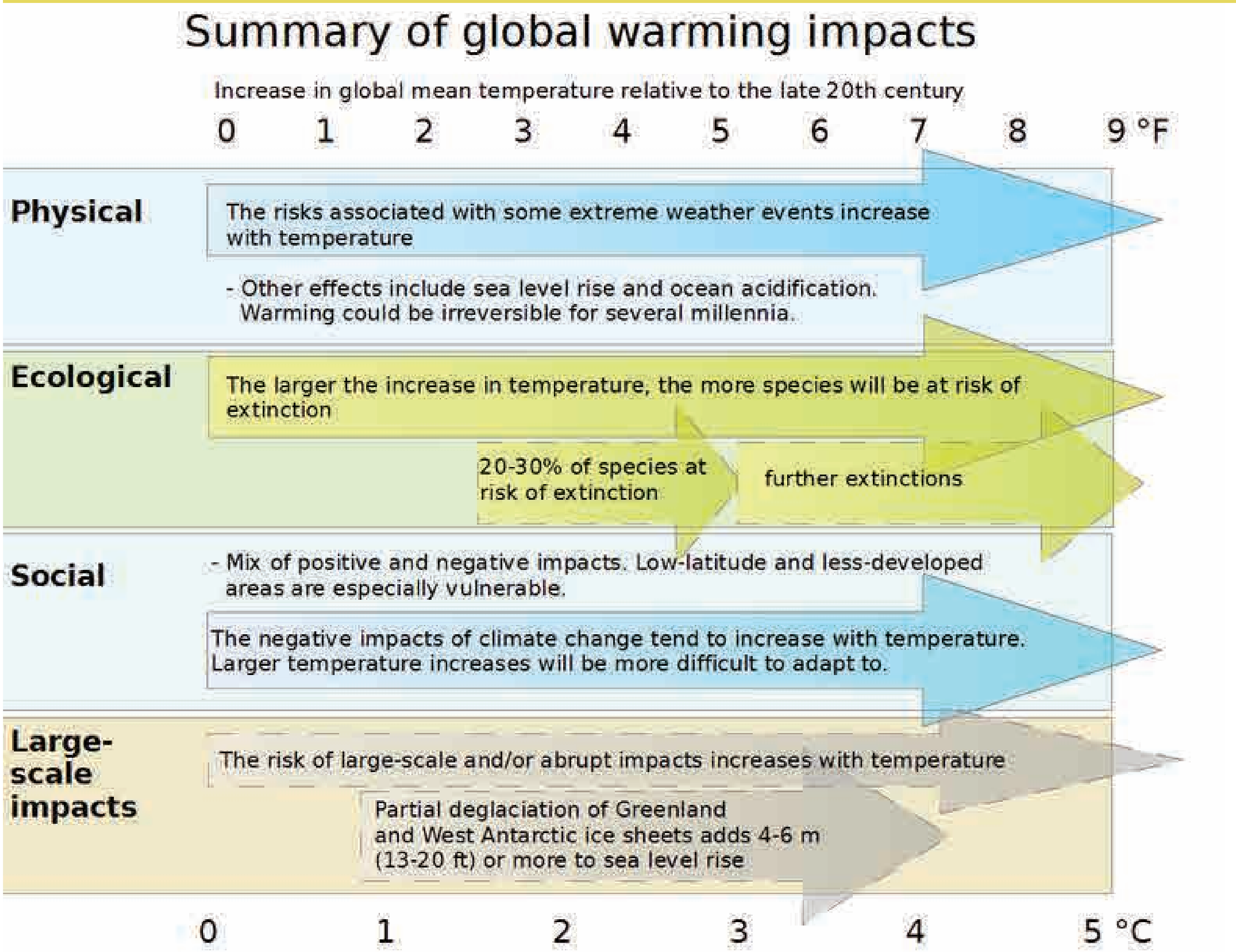
Top: Green house effect (Courtesy: http://upload.wikimedia.org/wikipedia/commons/8/8e/Earth%27s_greenhouse_effect_%28US_EPA%2C_2012%29.png)



Carbon cycle (Courtesy: http://commons.wikimedia.org/wiki/File:Diagram_showing_a_simplified_representation_of_the_Earth%27s_annual_carbon_cycle_%28US_DOE%29.png)



Yellow numbers are natural emissions per year
Red numbers are emissions from human activities per year
White numbers indicate stored carbon
The unit is gigatons
Atmospheric Carbon Net Annual Increase 4
GtC/y: Gigatons of carbon/year
Numbers in parentheses refer to stored carbon pools. Red indicates carbon from human emissions.
90 +2
90
Air-sea gas exchange
Surface ocean (1000)
Phytoplankton photosynthesis
Respiration and decomposition
Net ocean uptake 2
Deep ocean (37,000)
Reactive sediments (6000)



Climate action A period of flux extended from the mid 1980's to 2007

1988

United Nations Environment Program and World Meteorological Organisation established International Panel for Climate Change (IPCC) to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts.

1992

Countries joined an international treaty, the United Nations Framework Convention on Climate Change, to cooperatively consider what they could do to limit average global temperature increases and the resulting Climate Change, and to cope with whatever impacts were, by then, inevitable.

1994

On 21 March, United Nations Framework Convetion on Climate Change (UNFCCC) came into force.

Bottom of the timeline: Melting ice (Courtesy: http://commons.wikimedia.org/wiki/File:Greenland_Melt_Ponds_%28wallpaper%29.jpg)

Indicators of a warming world

Liwa sandunes by Charles Gibson (Courtesy: Purchased from CanStockPhoto)

1995

Countries realised that emission reductions provisions in the Convention were inadequate. They launched negotiations to strengthen the global response to Climate Change. Two years later, adopted the Kyoto Protocol.

2008 to 2012

The Protocol's first commitment period started in 2008 and ended in 2012.

2013 to 2020

On 1 January, 2013 the second commitment period began. There are now 195 Parties to the Convention and 192 Parties to the Kyoto Protocol.

Bottom of the timeline (Image courtesy: EAD)

Climate change in the Arab world

While as a region, Arab states contribute to less than 5% of global greenhouse gas emissions, individually some of the Gulf States such as Qatar, Saudi Arabia and the UAE are among the highest per capita carbon emitters. The region is immensely vulnerable to climate change (Mustafa K Tolba and Najib Saab,2009).

In fact, climate change is already being experienced in the six Gulf countries of UAE, Oman, Saudi Arabia, Qatar, Bahrain, and Kuwait. While the region is well-known for its very hot summers and low annual rainfall, the region has become even hotter over the last 50 years (Zhang, et al., 2005). These six Gulf countries have also ratified the international treaty on a framework for action on climate change (UNFCC) and the protocol framed (Kyoto) for action on climate change. However, under the protocol, these countries are not required to abide by any binding carbon emission reduction so far.

'The Arab Regions Atlas for Changing Environment', 2013, published by the Abu Dhabi Global Data Initiative (AGEDI), the Environment Agency- Abu Dhabi, UNEP and State of Qatar states that the ramifications of climate change on the Arab region will be severe given the region's already arid climate and scarce water resources. Rising temperatures, lowered precipitation, and sea-level rise will be some of the impacts. Temperatures in the Arab region are expected to face an increase of 2.0 to 4.4 degree Celsius by the end of this century. Higher temperatures will exacerbate desertification, increase the incidence and intensity of droughts, heat waves and forest fires, and increase weather variability, causing extreme weather events. Higher temperatures will also increase water scarcity in the region, with per capita water availability predicted to fall by half by 2050, causing acute water shortages. The region's biodiversity is expected to be another casualty of global warming. A 2 degree increase in temperature could cause up to 40% of all species in Arab countries to become extinct. Above all climate change will increase competition for many resources within and across borders, and cause displacement of populations, increasing the risk of conflicts in the region.

A public perception survey conducted by AFED (Arab Forum for Environment and Development) suggested a rising awareness (98%) on climate change issues with 89% of respondents believing in the anthropogenic causes to the issue. The public also believed that reducing consumption of energy, followed by education awareness, and lastly ratifying international treaties and protocols as the best measures to mitigate the climate change.

While the Arab Youth climate movement from countries across the Middle East and North Africa (MENA) was launched at the COP (Conference of parties) meeting held at Doha in 2012, the current political and the economic instabilities are a major road block to strong climate action from the Arab youth. The launching of the youth movement does send a strong message to all, about the priority of taking action to address climate change in the Arab world.

Climate change and the UAE

Located in one of the most hyper arid ecosystems of the world, UAE supports some of highly vulnerable habitats in the world. Most of the biodiversity within the UAE survive under critical threshold conditions of temperature and aridity. It is predicted that even a minor change in the long term variation of temperature and precipitation could lead to adverse effects on productive activities due to the fragile nature of the country's precious natural resources and interconnectivity with national, regional and global economic activity.

UAE is vulnerable to climate change induced sea level rise, even with one metre rise by the end of the 21st century; almost 1,000 Square kilometres of land would be inundated. With 90% of the country's infrastructure and 85% of population residing near the coast, this is indeed a cause of worry. Sensitive habitats such as the mangroves, corals, sabkhas, wadis, and the dry lands are under severe threat. Changes in temperature and precipitation are also expected to affect the availability of water, especially in Abu Dhabi emirate.

Abu Dhabi's climate action

1. 5 year strategic (2014-2018) Action Plan for climate change and mitigation,
2. the MASDAR initiative,
3. improving air conditioning efficiency,
4. reducing ecological footprint initiative (Al Basma Al Beeyiah),
5. Estidama Initiative – Green building code for resource efficient new buildings,
6. introduce public transport,
7. reduce emission from waste, and
8. ADNOC (Abu Dhabi National Oil company) – elimination of carbon from flaring, optimisation of land, energy and raw material utilisation within the oil and gas sector.

Bottom: Al Bahr towers Abu Dhabi (Courtesy: EAD)

The Young Future Energy Leaders (YFEL)

Vision

To be the world's pre-eminent program that develops tomorrow's leaders in the fields of advanced energy and sustainability.

Mission

To educate, inspire and position students and young professionals to become future leaders capable of solving the world's most pressing challenges in advanced energy and sustainability.

The Young Future Energy Leaders Program plays a key role in engaging and educating the next generation of the UAE and beyond in the importance of sustainability to our economy- and our shared future.

In addition to comprehending the impacts on habitats, species, sea level rise, and diminishing water supply studies are underway to assess the impact of climate change in the UAE on food security, public health, and power supply. UAE imports most of its food, globally, thus all projections on diminished food supply with climate change has financial implications for the UAE. Water supply stresses, increased demands for air conditioning, diminished power plant cooling capacity, impaired performance of generation and transmission assets, and sea level rise is likely to have a great impact on power supply. The only way is to manage risks and soaring demands.

While the global contribution to the greenhouse gas emission, considered the most important cause of the current acceleration of climate change by the UAE is less than 0.5%, the country stands amongst the top ten in *per capita* carbon emission.

Recently, a Greenhouse gas inventory exercise undertaken in the Abu Dhabi Emirate (EAD, 2013), revealed that CO_2 (78.6%) is the main greenhouse gas emitted followed by Methane (8.8%), Perflurocarbons (7.6%) and finally Nitrous oxide (5%).The major contributor within the UAE to the Greenhouse gas emission is from the energy sector (over 90%) . Maximum energy is consumed by the power and water sector (Desalination process) followed by transport sector and the oil and gas sector. The industrial sector, followed by waste, agriculture, and land use changes contributes to the rest of the Greenhouse gas emissions.

UAE plays a central role in the world's energy economy as a supplier of fossil fuels, which gives us an important stake in finding solutions to cutting emissions while still providing the world with the energy it needs. UAE has committed to producing 7% of its energy requirement through renewable energy by 2020. The UAE is engaged in the fight against climate change both because it recognises the risks of not acting and because they are responsible global citizen committed to multilateral action. The Emirates is convinced that in rising to this challenge there lies a real opportunity. New clean energy technologies will play a major role in economic growth in the next few decades. With its investment in renewable energy and its role in hosting the International Renewable Energy Agency (IRENA), UAE is at the heart of the clean energy revolution.

Top: YFEL (Courtesy: http://dev9.cactimedia.net/masdar_main/images)

Can the youth and public contribute?

Youth as agents of change can play a critical role in fostering the intellectual and action based approach among the community. It would be good to reiterate the fact that UAE's *per capita* carbon emission is high, thus the implication of high *per capita* electricity consumption, (among the top 10 in the world) high *per capita* water consumption, high transport emissions, and high *per capita* waste production cannot be missed.

In an annual survey conducted by the Environment Agency – Abu Dhabi to assess the level of awareness and behaviour among the Abu Dhabi Society, statistics revealed that youth between age 18-24 had a high degree of awareness on issues pertaining to climate change, but their behaviour to address some of the identified issue lagged behind by almost 80%.

A WORD OF CAUTION!

We seriously need to question conventional technology-based solutions to manage climate change because technology has never been known to have reduced resource of energy consumption. It is simple, we need to burn less and to do that we need to consume less and travel less.

To mitigate or adapt to climate change on the campus three things are very important to establish:

- Green house gas emissions from activities in the campus,
- quantity of green house gases sequestered on campus, and
- reduction in emissions

There is an alternative too. If we learn to insulate our civilisation in a way that it does not impact our land, water and air, we can continue to do what we are doing. Put simply this would mean, 'How do I drive my car, fly my jet, run my airconditioner without negatively affecting land, water, air and the living world?'

Case study from Greening Universities Toolkit, GUPES, UNEP

University of Copenhagen

- The university aims to reduce its energy consumption and greenhouse gas emissions by 20% between 2006 and 2013,
- the energy savings projects are expected to result in annual reduction of 1700 tons of CO_2 emissions, and
- partnered in creating the Green Lighthouse, Denmark's first carbon-neutral public building, which provides for its total energy needs with 35% of solar energy and 65% of district heating with heat pump. 76m^2 of solar cells on the roof power the building's lighting, ventilation and pumps.

Bottom: University of Copenhagen (Courtesy: http://www.tu.no/karriere/2006/10/12)

CLIMATE AUDIT

Stage 1 **: Carbon dioxide generated on the campus?**
Research **: Carbon dioxide sequestered on the campus?**
Stage 3 **: Reduction in emission of carbon dioxide?**

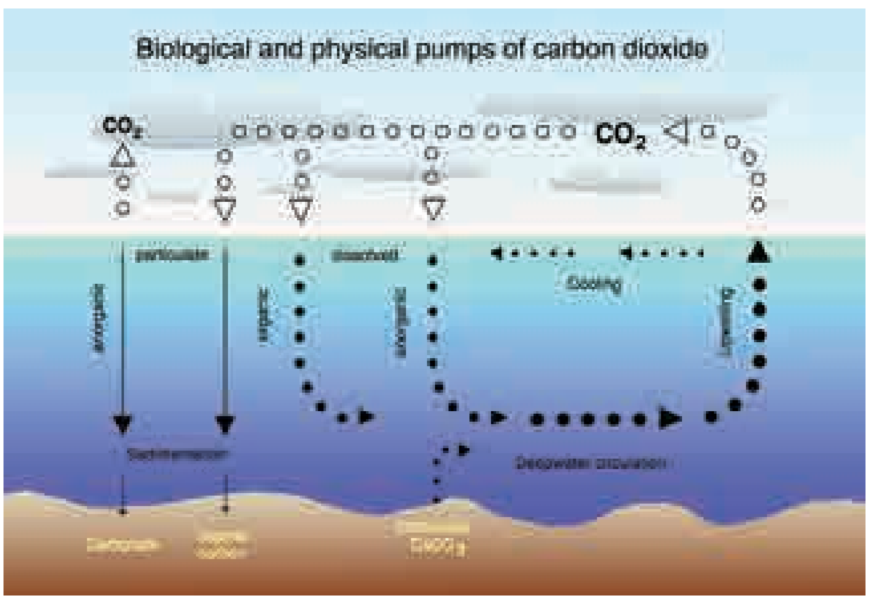
Stage 1: Carbon dioxide generated on the campus?

Usually for any facility, the routine energy consumption figure is used to arrive at the amount of CO_2 (Carbon dioxide) that facility contributes to our environment. But any human facility is made up of material and that material consumes energy in its production and transportation thereby generating CO_2 that enters the environment. The energy consumed in production of any material is known as embodied energy and CO_2 generated in the process is known as embodied CO_2 (CO_2e). However, it does not stop here since all human facilities have a lifespan and a similar amount or more energy will be consumed once again and same amount or more CO_2 will be released once again when the facility is replaced.

Routine Energy Consumption and CO_2 Generation

Any electricity, gas, oil, or even renewable energy consumed to keep the campus functional from day to day falls under routine energy consumption. It is myth that renewable energy sources do not contribute to increase in CO_2. The campus administration and building management staff will have the information you need to compute the amount of CO_2 generated by your campus. Organise a meeting with the representatives of both and explain to them the work you are planning to do. Adopt participatory approach and do not indict anyone or any authority. All appliances on the campus have their consumption standards mentioned on them. Please look carefully or take help of campus administration. The Building Management System (BMS) has accurate information on consumption of electricity. Use the following tables to compute information you collect.

Natural carbon cycle



Natural processes too generate a lot of CO_2

The amount we generate (29 Gigatons) is miniscule when compared to the amount of CO_2 the natural Carbon cycle handles every year (750 Gigatons). But there is a difference. In fact slightly more CO_2 is sequestered by natural systems than produced.

Top: Biological and physical pumps of carbon dioxide (Courtesy: http://upload.wikimedia.org/wikipedia/commons/c/c2/CO2_pump_hg.png)

TABLE 1: Implied emission factors

FUEL TYPE	gCO_2 / kWh
Gas works gas*	420
Coke oven gas*	420
Other recovered gases*	2,000
Natural gas	400
Crude oil*	630
Natural gas liquids*	480
Gas/diesel oil*	690
Fuel oil	670
Petroleum coke*	1000
Industrial waste*	400-2,000
Municipal waste (non-renewable)*	450-3,500

These fuels represent less than 1% of electricity output in the OECD. Values will be less reliable and should be used with caution.

TABLE 2: Calculation of CO_2 emissions

FUEL TYPE	Kg OF CO_2 *PER* UNIT OF CONSUMPTION
Grid electricity	43 *per* kWh
Natural gas	3142 *per* tonne
Diesel fuel	2.68 *per* litre
Petrol	2.31 *per* litre
LPG	1.51 *per* litre

Carbon Capture Technology (CCS)

Carbon capture technology (CCS) can capture CO_2 from large point sources and store them in places away from the atmosphere (for instance in the underground wells). UAE and the neighbouring countries are looking at the feasibility of planning CCS projects.

TABLE 3: Transport conversion table

VEHICLE TYPE	Kg CO_2 *PER* LITRE
Small diesel car 1.4 litre engine	0.17/km
Medium car (1.4 - 2.1 litres)	0.22/km
Large diesel car	0.27/km
Small petrol car (>2 litres)	0.12/km
Large petrol car	0.14/km
Average petrol car	0.13/km
Bus (40 - 60 seater)	0.51/km
Mini Bus (18 - 35 seater)	0.30/km

Contact the local utilities office in the area where your campus is located to find out the mix of fuels used to generate electricity provided to the campus (In Abu Dhabi this is Abu Dhabi Water and Electricity Authority (ADWEA)).

TABLE 4: Fuels used for electricity generation

Fuel type	Percentage of Electricity generated	Percentage of CO_2 generated
Gas		
Others		

How to calculate the CO_2 emission level from the fuel consumption?

Diesel: 1 litre of diesel weighs 835 grammes. Diesel comprises 86.2% of carbon, or 720 grammes of carbon per litre diesel. In order to combust this carbon to CO_2, 1,920 grammes of oxygen is needed. The sum is then 720 + 1,920 = 2,640 grammes of CO_2/litre diesel.

Average consumption of 5 litres/100 km corresponds to 5l x 2,640 g/l / 100 (per km) = 132 g CO_2/km.

Petrol: 1 litre of petrol weighs 750 grammes. Petrol consists for 87% of carbon, or 652 grammes of carbon per litre of petrol. In order to combust this carbon to CO_2, 1,740 grammes of oxygen is needed. The sum is then 652 + 1,740 = 2,392 grammes of CO_2/litre of petrol.

Average consumption of 5 litres/100 km corresponds to 5 l x 2,392 g/l / 100 (per km) = 120 g CO_2/km.

LPG: 1 litre of LPG weighs 550 grammes. LPG comprises 82.5% of carbon or 454 grammes of carbon per litre of LPG. In order to combust this carbon to CO_2, 1,211 grammes of oxygen is needed. The sum is then 454 + 1,211 = 1,665 grammes of CO_2/litre of LPG.

Average consumption of 5 litres/100 km corresponds to 5 l x 1665 g/l / 100 (per km) = 83 g of CO_2/km.

How to calculate the CO_2 emission level from the fuel consumption?

CNG: CNG is a gaseous fuel (natural gas), stored under high pressure. Consequently, the consumption can be expressed in Nm^3/100km, but also in kg/100km. Nm^3 stands for a cubic metre under normal conditions (1 atm and 0 °C). Consumption of natural gas vehicles is, most often expressed in kg/100km.

Different types of natural gas are available, roughly divided into two categories: low and high calorific gas (L- and H-gas). CO_2 emissions differ between both categories, and strongly depend on the composition and origin of the gas. The calculations below are therefore merely indicative.

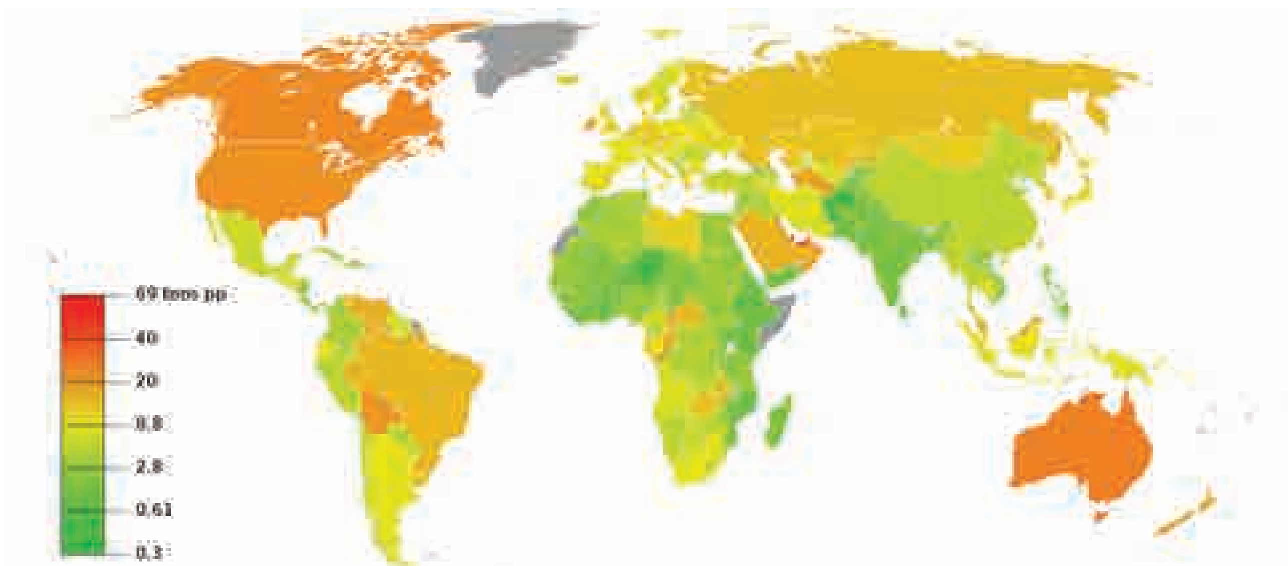
Low-calorific:
1 kg of L-gas comprises 61.4% of carbon or 614 grammes of carbon per kg of L-gas. In order to combust this carbon to CO_2, 1,638 grammes of oxygen is needed. The sum is then 614 + 1,638 = 2,252 grammes of CO2/kg of L-gas.

Average consumption of 5 kg/100 km corresponds to 5 kg x 2,252 g/kg = 113 g CO_2/km.

High-calorific:
1 kg of H-gas comprises 72.7% of carbon or 727 grammes of carbon per kg of H-gas. In order to combust this carbon to CO_2, 1,939 grammes of oxygen is needed. The sum is then 727 + 1,939 = 2,666 grammes of CO_2/kg of H-gas.

Average consumption of 4.2 kg / 100 km corresponds to 4.2 kg x 2,666 g/kg = 112 g of CO_2/km.

Per capita GHG emissions per person in tonnes



Right: Per capita GHG emissions (Courtesy: http://en.wikipedia.org/wiki/List_of_countries_by_greenhouse_gas_emissions_per_capita)

Use Table 5 to compute CO_2 generation from oil. Private or/and campus provided means of transport will be considered. Electricity consumption in kWh will also be considered. Figures for the latter can also be borrowed from the Energy audit group. Electricity consumption for use and distribution of water should also reflect.

TABLE 5: Monthly CO_2 generation from Oil derivatives

Source of energy	Quantity of energy fuel used/month	Quantity of CO_2 generated/month	Uses	Per cent
Electricity			Lighting	
			Cooling	
			Heating	
			Equipment /Appliances	
			Others	
Diesel			Lighting	
			Cooling	
			Heating	
			Equipment /Appliances	
			Transportation	
			Others	
Petrol			Transportation	
			Others	
Aviation fuel			Transportation	
			Others	
Gas (CNG/LPG)			Equipment /Appliances	
			Transportation	
			Others	
Others (specify)			Lighting	
			Cooling	
			Heating	
			Equipment /Appliances	
			Transportation	
			Others	
Total				

Group people travelling by similar modes of transport and sum up the kilometres they travel. Multiply the sum of kilometres travelled with the CO_2 equivalent given in Table 3. Fill the CO_2 production by fuel type in Table 5.

TABLE 5a: CO_2 production

Individuals name	Pupils/ Faculty/Staff	Number of Kilometres	Mode of Transport

Collate data collected in Table 5 in Table 6 given below.

TABLE 6: CO_2 production by source and use

Source	Electricity	Gas CNG/LPG	Oil/Petrol/Diesel/ Aviation fuel	Others
Lighting				
Cooling				
Heating				
Equipment / Appliances				
Transportation				
Others				
Total				

Embodied energy

Embodied energy is the total energy inputs consumed by a product over its life-cycle. Initial embodied energy includes energy used for the extraction of raw materials, transportation to factory, processing and manufacturing, transportation to site, and construction. Once the product is installed in a building, recurring embodied energy includes the energy used to maintain, replace, and recycle materials and components of the product throughout the life of the building. Embodied energy is typically expressed in MJ/kg, where a mega joule (MJ) is equal to 0.948 kBtu or 0.278 kWh. Use the following tables to compute information you collect.

The figures included in the following table are a much-shortened and abbreviated adaptation of a survey published by the Sustainable Energy Research Team (SERT) of the University of Bath. The survey, 'Inventory of Carbon & Energy (ICE)' V2.0, was compiled and written by Prof. Geoff Hammond & Craig Jones, 2011. The full detailed survey, complete with original data, methods and notes, is available at www.bath.ac.uk/mech-eng/sert/embodied/.

Further information: Sustainable Energy Research Team (SERT), - University of Bath.

Determining embodied energy by kilogrammes of material used is not an easy method especially in case of already constructed buildings. This is due to the lack of information on material use from the construction phase. Averages and means that are less accurate but easy to use are provided in the table given below. All that needs to be done is to determine the area in square feet by categories of description in the table given below using the feet measurement side on the tape-measure.

Area by description x Embodied energy factor = Net embodied energy.

Example

The most typical type of space use in a college is a classroom. Classroom is made out of different materials. The audit group needs to find out the weight of different materials used for making the classroom. The weight of the materials could be directly measured or gathered from the nearest supplier of that material in your area. Then use the factors given in the toolkit to arrive at energy consumed and CO_2 produced as a consequence of using various materials.

Once the energy that has gone into making of a classroom and CO_2 generated as a consequence of making one classroom is known, the audit team can count the number of classrooms in the college and multiply it with the energy consumed and CO_2 generated in making of one classroom. Similarly, compute embodied energy for different uses of space. Add up everything to get the embodied energy for the entire campus. Also find out from the College administration the life time for which the facility is constructed.

Left: A typical classroom on campus (Courtesy: EAD, SCI College)

Use **Table 8** to collate information.

TABLE 8: Energy embodied in the campus facilities

Description	Embodied energy (Mega Joule/sq.ft.)	Area (sq.ft.)	Net embodied energy (Mega Joule/sq.ft.)	Embodied Carbon Dioxide in kg
Classrooms Audio visual rooms/ Office space/ Pantry/Canteen/ Prayer room	175.63			
Corridors/Stairs/ Indoor unfurnished spaces/Rooms/ Sports	39.17			
Washrooms/ Toilets/Recreation/ Commercial	218.84			
Parking/Artificial surface	8.40			
Metalled road	4.20			
Gross values				

Sq.ft. is Square feet

Source: The above figures have been derived by a practical combination of embodied energy equivalents given by the Sustainable Energy Research Team, University of Bath.

Please note that the real amount of embodied energy on our campus will always be higher because many more factors like furnishings, appliances and facility hardware are not taken into count.

Given: Amount of carbon produced by diesel is used as emission factor since all heavy vehicles that are used in construction of buildings in UAE used diesel.

Amount of carbon dioxide contributed to the atmosphere by the campus will be:

One litre of diesel = 39 MJ which = 2640 grammes of CO_2 or 2.64 kg.

To convert embodied energy to carbon, use the formula given below:

Net embodied energy / 39 x 2.64 = *Embodied Carbon Dioxide in kg

Contact the campus administration of building architect to ascertain the life of the building in number of years.

_________________ (Write the life of the building in number of years).

It will be interesting to compare routine energy with per day embodied energy load.

$$\textit{Per}\text{ day Routine energy consumption} = \frac{\text{Monthly consumption}}{\text{Number of days in that month}}$$

$$\textit{Per capita}\text{ Routine energy consumption} = \frac{\textit{Per}\text{ day Routine energy consumption}}{\text{Total strength of the campus}}$$

$$\textit{Per}\text{ day Embodied energy load} = \frac{\text{Total Embodied energy}}{\text{Life of the facility in years x 365}}$$

$$\textit{Per capita}\text{ Embodied energy load} = \frac{\textit{Per}\text{ day Embodied energy load}}{\text{Total strength of the campus}}$$

Similarly compare routine CO_2 generation with per day embodied energy CO_2 load.

$$\textit{Per}\text{ day Routine } CO_2 \text{ generation} = \frac{\text{Monthly } CO_2 \text{ generation}}{\text{Number of days in that month}}$$

$$\textit{Per capita}\text{ Routine } CO_2 \text{ generation} = \frac{\textit{Per}\text{ day Routine } CO_2 \text{ generation}}{\text{Total strength of the campus}}$$

$$\textit{Per capita}\text{ Embodied energy load} = \frac{\textit{Per}\text{ day Embodied energy load}}{\text{Total strength of the campus}}$$

Community practices survey

It would be good to conduct CO_2 generation audits routine energy consumption and embodied energy load for few households around the college after the audit of the college premises. The household audits should sample houses representing different standard of living and different sizes. This would help the team to arrive at a reasonable average for the community. Any remedial measures taken to reduce CO_2 generation or sequestration should be spearheaded by the community.

Research: How much Carbon Dioxide does the campus sequester?

The climate audit group could contact Professors in their college/university or elsewhere to get information on the carbon sequestration rate of biomass in arid habitats. If such information is not available then this could qualify to be a good research option for interested youth. The campus could sequester carbon dioxide outside the campus in public or government spaces.

Any process that consumes more CO_2 than it generates can be considered as a process that sequesters CO_2. Photosynthesis is one such naturally supported (hence cheapest) process to use for CO_2 sequestration. To give you an idea, an average mature tree in the United States absorbs carbon dioxide at a rate of 48 lbs/year (21.772 kg) and release enough oxygen back into the atmosphere to support two human beings. One acre of trees annually consumes the amount of carbon dioxide equivalent to that produced by driving an average car for 26,000 miles. That same acre of trees also produces enough oxygen for 18 people to breathe for a year.

The increasing amount of Green House Gases (GHGs), especially CO_2, is not a problem unless we manage to contain it in safe places to avoid climate change. The issues of greater concern here are the technologies available and the finance required to put those technologies to work. Another very important issue in the Emirates is that the desert makes sequestering CO_2 by growing trees impractical and uneconomical. But there is a plus point too. The Emirate's long shoreline, promoting growth of mangroves, could help sequester CO_2.

Blue Carbon

Micro and macro plants that grow in the sea such as phytoplankton, sea weeds, sea grasses, salt marshes and mangroves help absorb 55% of all carbon soaked by plants and trees. This carbon stored in aquatic life forms is called 'Blue carbon'. Coastal ecosystems such as those in mangrove forests, continuously store and sequester carbon at rates much faster than tropical forests. Some healthy coastal marine ecosystems play roles in storing greenhouse gases, thereby helping to mitigate climate change. Blue carbon ecosystems are found throughout the globe, in all continents.

The Abu Dhabi blue carbon project began in 2012, with an aim to improve our understanding of coastal ecosystem and how they help sequester carbon and provide valuable services to coastal communities by AGEDI (Abu Dhabi global data initiative).

Bottom Right: Blue carbon (Courtesy: EAD)

What does One tonne of CO_2 mean?

Global emissions of carbon dioxide in recent years totalled over 30 Gigatons (or 30 Gt). People understand that is a lot of CO_2. But do people really have any understanding of just how much that is? It is, of course, 30,000,000,000 tonnes. But who knows how much space a tonne of carbon dioxide occupies?

This can be calculated using Avagadro's Hypothesis. One mole of a gas occupies 22.4 litres at 'standard temperature and pressure' (STP - zero degrees Celsius and one atmosphere of air pressure - or a freezing cold day at sea-level). One mole of CO_2 weighs 44 grammes. So 1 gramme of CO_2 will occupy 22.4/44 litres at STP and 1 kilogramme will occupy a space of (1,000 x 22.4 / 44) litres which is 509 litres. One tonne of CO_2 has a volume of 1,000 x 509 litres or 509 cubic metres (m3).

The audit group could collate the information gathered on CO_2 sequestration in the table given below:

TABLE 9: Quantity of CO_2 sequestered

Type of green area	Area (m^2)	CO_2 sequestration ($kg/m^2/year$)	Water intensity (litres/kg)	Cost *per* kg (AED)
Grassland				
Tree cover				
Planted walls				
Others (mention)				
Total				

Measuring area of tree canopy

Measure the green area on the campus in square metres, with the help of a tape measure. The green area will include patches of grass, flower beds, plants in clay pots and tree canopy area. To determine tree canopy area use the metre tape to measure the longest and the shortest diameter as per observation. Use the formulae given below to determine the tree canopy area in square metres.

$$\frac{\text{Longest diameter + Shortest diameter}}{2} = \textit{Average diameter}$$

$$\frac{\text{Average diameter}}{2} = \textit{Radius}$$

$$\pi r^2 = \textbf{Area}$$

Estimating utility:

If the campus sequesters equal to or more CO_2 than it generates, its sustainability is 100 per cent.
If college sequesters less CO_2 than it generates, use the formula below to calculate your points:

Total CO_2 generated *per annum* =

Per day routine CO_2 generation + *per* day embodied energy CO_2 load x 365

$$\text{Resource efficiency } per\ cent = \frac{\text{Total } CO_2 \text{ sequestered } per\ annum}{\text{Total } CO_2 \text{ generated } per\ annum} \times 100$$

Community practices survey

It would be useful to calculate CO_2 sequestration rates for few households around the college after the audit of the college premises. The household audits should sample houses representing different standard of living and different sizes. This would help the team to arrive at a reasonable average for the community. Any remedial measures taken to reduce CO_2 generation or sequestration should be spearheaded by the community.

Coccoliths can help you in absorbing CO_2

Microscopic organisms living in the upper, sunlit layers of the oceans have the potential to save human civilisation from collapsing due to Global Warming. The most abundant plankton in the oceans are members of a class called **coccolithophores** (**coccos** for short), so named because they sequester some of the carbon dioxide they consume from seawater into tiny plates called **coccoliths**.

The coccoliths act like microscopic mirrors, and if a bloom is big enough it can be seen from space as a milky white patch of ocean, because the coccoliths reflect a significant amount of the incoming sunlight back out of the water.

Coccos reduce Global Warming in three ways:

- The highly reflective coccoliths in bloom areas cause more light and heat to be reflected back out to space, rather than heating the ocean,
- huge numbers of coccoliths eventually sink to the ocean floor. In this way, carbon dioxide dissolved in the oceans is permanently sequestered, and
- the third way that coccos reduce Global Warming is due to their characteristic of releasing Dimethyl Sulphide (DMS), a gas which also gives the sea shore its distinctive smell.

Stage 3: Reducing carbon dioxide emissions?

This task needs to be done with the support of the Energy audit group. The energy use reduction targets directly translate into reduction in carbon dioxide emissions. The carbon emission reduction targets could also help the energy audit group to set targets for reducing energy use. Fill up the table given below to collate and compute reduction in carbon emissions managed by the campus. The reduction can be calculated for same season months in a year or same months of different years.

TABLE 10: Reduction in carbon dioxide emissions

Source of energy	Quantity of energy fuel used/month	Quantity of CO_2 generated/ month	Uses	Per cent
Electricity			Lighting	
			Cooling	
			Heating	
			Equipment /Appliances	
			Others	
Diesel			Lighting	
			Cooling	
			Heating	
			Equipment /Appliances	
			Transportation	
			Others	
Petrol			Transportation	
			Others	
Aviation fuel			Transportation	
			Others	
Gas (CNG/LPG)			Equipment /Appliances	
			Transportation	
			Others	
Others (specify)			Lighting	
			Cooling	
			Heating	
			Equipment /Appliances	
			Transportation	
			Others	
Total				

The campus can also achieve reduction in emissions of carbon dioxide by changing infrastructure. Though this will be more difficult to achieve in comparison to a similar reduction in routine energy consumption. If the campus manages to reduce embodied energy carbon emissions collate and compute the total amount in Table 11 below.

TABLE 11: Reduction in embodied energy carbon dioxide emissions

Type of Space	Energy (MJ/m^2)	Carbon ($kg\ CO_2/m^2$)
Boundary wall		
Lawns		
Roads		
Parking space		
Walking paths		
Open indoor space for assembly		
Corridors		
Classrooms		
Audio-Visual rooms / Auditoriums		
Laboratories		
Equipment rooms (Electricity, Water, Air-conditioning)		
Stores		
Office space		
Dining area		
Pantry		
Toilets		
Others (mention)		
Total		

Calculating sustainability

If the campus sequesters the entire amount of CO_2 it generates, its sustainability is 100 per cent. In such a case, your campus is free to set its own carbon dioxide reduction targets.

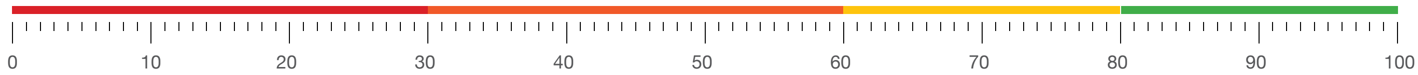
The target for reduction in carbon dioxide emissions is the quantity of carbon dioxide your campus is unable to sequester.

Carbon dioxide emission reduction target =

Total quantity of carbon dioxide generated – Total quantity of carbon dioxide sequestered

$$\text{Resource efficiency } \textit{per cent} = \frac{\text{Quantity of carbon dioxide reduction achieved}}{\text{Carbon dioxide emission reduction target}} \times 100$$

Depict the resource efficiency your campus on the number line given below:



Community practices survey

It would be good to set carbon dioxide emission reduction targets for few households around the college after that for the college premises. The household targets should sample houses representing different standard of living and different sizes. This would help the team to arrive at a reasonable average for the community. Any remedial measures taken to reduce CO_2 generation should be spearheaded by the community.

List down the steps that need to be taken to ensure stability of climate in the region:

INDIVIDUAL	INSTITUTION	COMMUNITY

It is strange that for sequestering CO_2, a lethal gas we produce as a by-product of enhancing our quality of life, we need to depend upon natural processes of sequestration that are mostly slow in comparison to the rate at which we pump out CO_2. All artificial processes to sequester CO_2 will produce more CO_2 as compared to the amount of CO_2 sequestered. A process that will enable us to offset climate change will have to:

- Self-assemble and function at ambient temperature,
- transport materials for self-assembly and functioning using renewable energy only, and
- reproduce itself in proportion to need.

Until then!

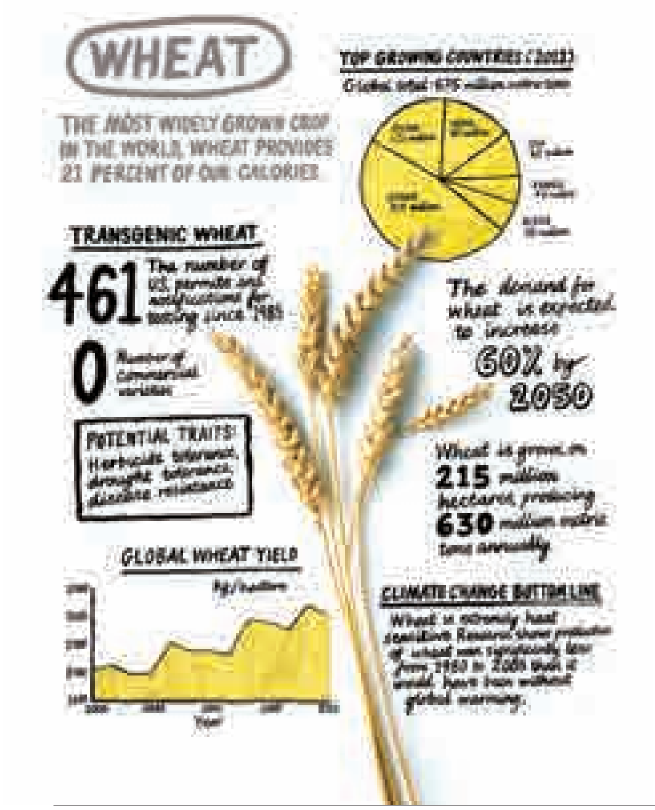
Report: Climate change may pose threat to economic growth

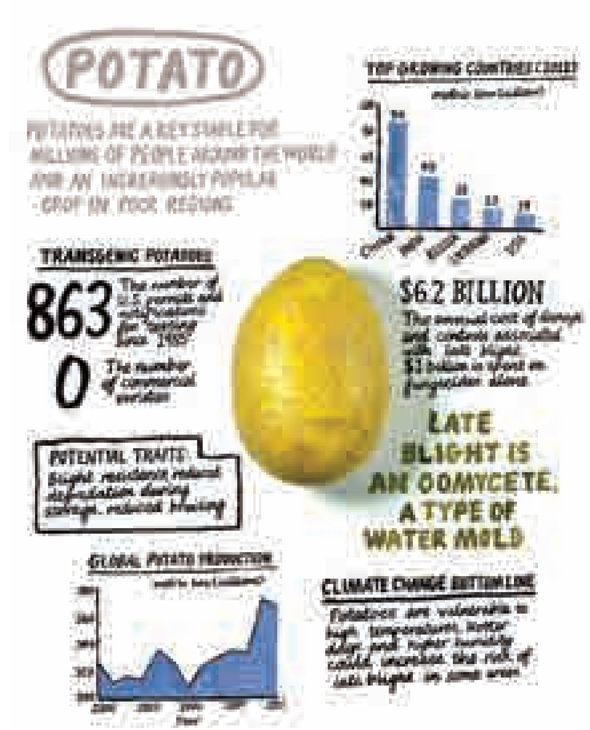
By Tim Hume, CNN
October 30, 2013 -- Updated 0529 GMT (1329 HKT)

Hong Kong (CNN) -- Nearly a third of the world's economic output will come from countries facing "high" to "extreme" risks from the impacts of climate change within 12 years, according to a new report.

The Climate Change Vulnerability Index, an annual report produced by UK-based risk analysis firm Maplecroft, found that climate change "may pose a serious obstacle to sustainable economic growth in the world's most commercially important cities."

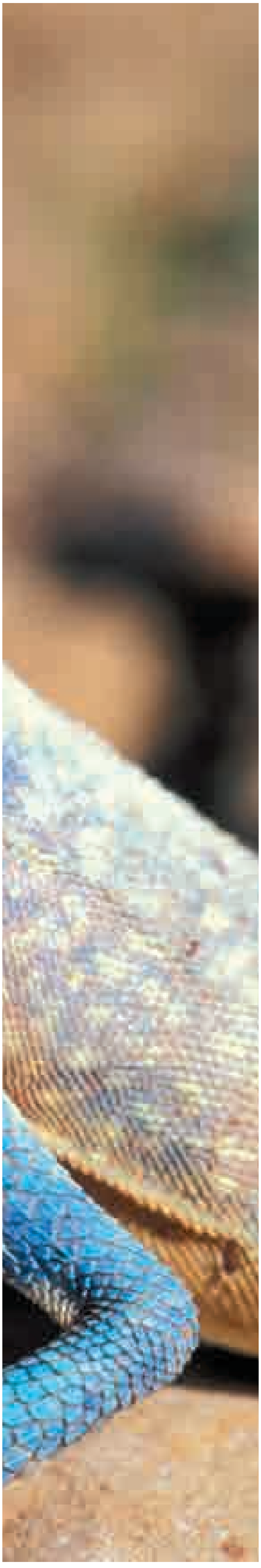
It said the combined GDP of the 67 countries classed as facing "high" or "extreme" risks was projected to nearly triple from $15 trillion to $44 trillion by 2025 -- meaning nearly a third of the global economy would be coming under increasing threat from extreme climate-related events. It projected the population of those countries -- currently estimated at more than 4.5 billion -- could exceed 5 billion by 2025.





Bottom left: Wheat infographic by Mary Mangan (Courtesy: http://www.technologyreview.com/sites/default/files/images/gmo.feature.potatox1000.jpg)
Bottom right: Potato infographic by Mary Mangan (Courtesy: http://www.technologyreview.com/sites/default/files/images/gmo.feature.potatox1000.jpg)

LAND
CRADLE OF TERRESTRIAL LIFE

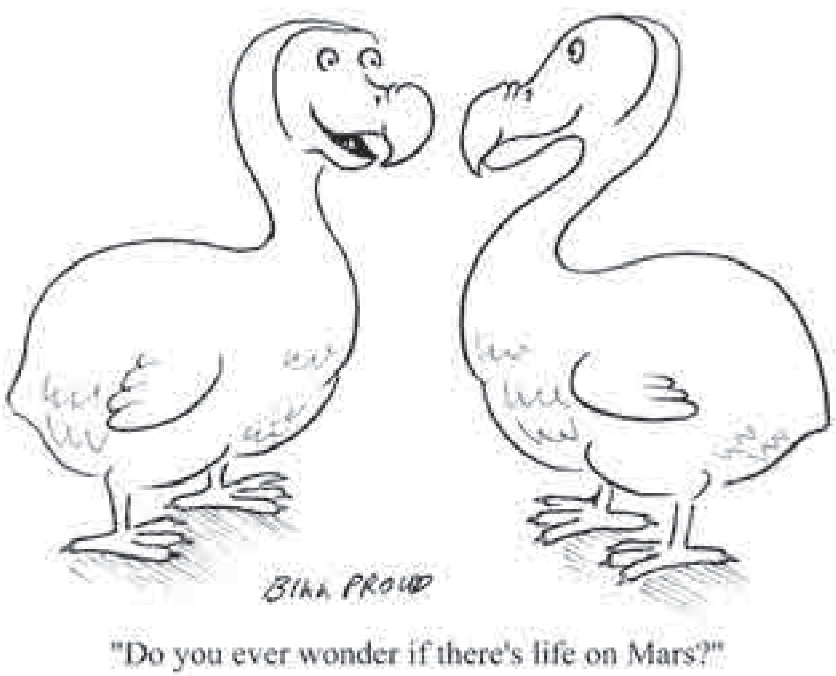


"On land and in the sea, our fore-fathers lived and survived in this environment. They were able to do so because they recognised the need to conserve it, to take from it only what they needed to live, and to preserve it for succeeding generations."

Late Sheikh Zayed Bin Sultan Al Nahyan
- Visionary, Father of the Nation

'ESSENTIAL' LAND

Land is an essential natural resource, both for the survival and prosperity of humanity and for the maintenance of all terrestrial ecosystems. The perceived indestructible nature of the land has always been a misconception. While one believed that natural calamities such as earthquakes, forest fires and so on had the ability to wreak havoc on land, there was a mistaken perception that land is strong enough to withstand any lasting impact due to human activity. The demand to meet competing and conflicting human needs on land, has resulted in sub-optimal and inappropriate use of land. This has resulted in irreversible damage to land in some parts of the world. Degradation of both quality and quantity of land due to human activities is now posing a grave threat for the sustainability of this planet and our wellbeing.



Left: Sinai Agama (Courtesy: EAD)
Right: Dodos migrating to Mars by wpr0039 (Courtesy: Purchased from www.cartoonsstock.com)

According the GEO 3 Global outlook report, changing climate patterns, economic globalisation, population growth, increasing use of natural resources and rapid urbanisation are putting pressure on terrestrial ecosystems as never before, and virtually all of them are under stress. It also states that 23% of all usable land (excluding mountains and deserts for example) has been affected by degradation to an extent that the productivity of these areas is severely hampered. Some 20% of the world's pasture and rangelands have been degraded, notably in Asia and Africa. Approximately 1-1.5 million people in the world are affected by land degradation. A global initiative for the sustainable management of land (ELD- Economics of Land Degradation), states that If the World's poor were paid for the services that they indirectly provide to the rest of the planet by preserving some of the World's key biodiversity hotspots, they could reap up to USD 500 billion!

Soil regions

Global challenges linked to unsustainable and disproportionate consumption levels

15 billion hectares of land worldwide

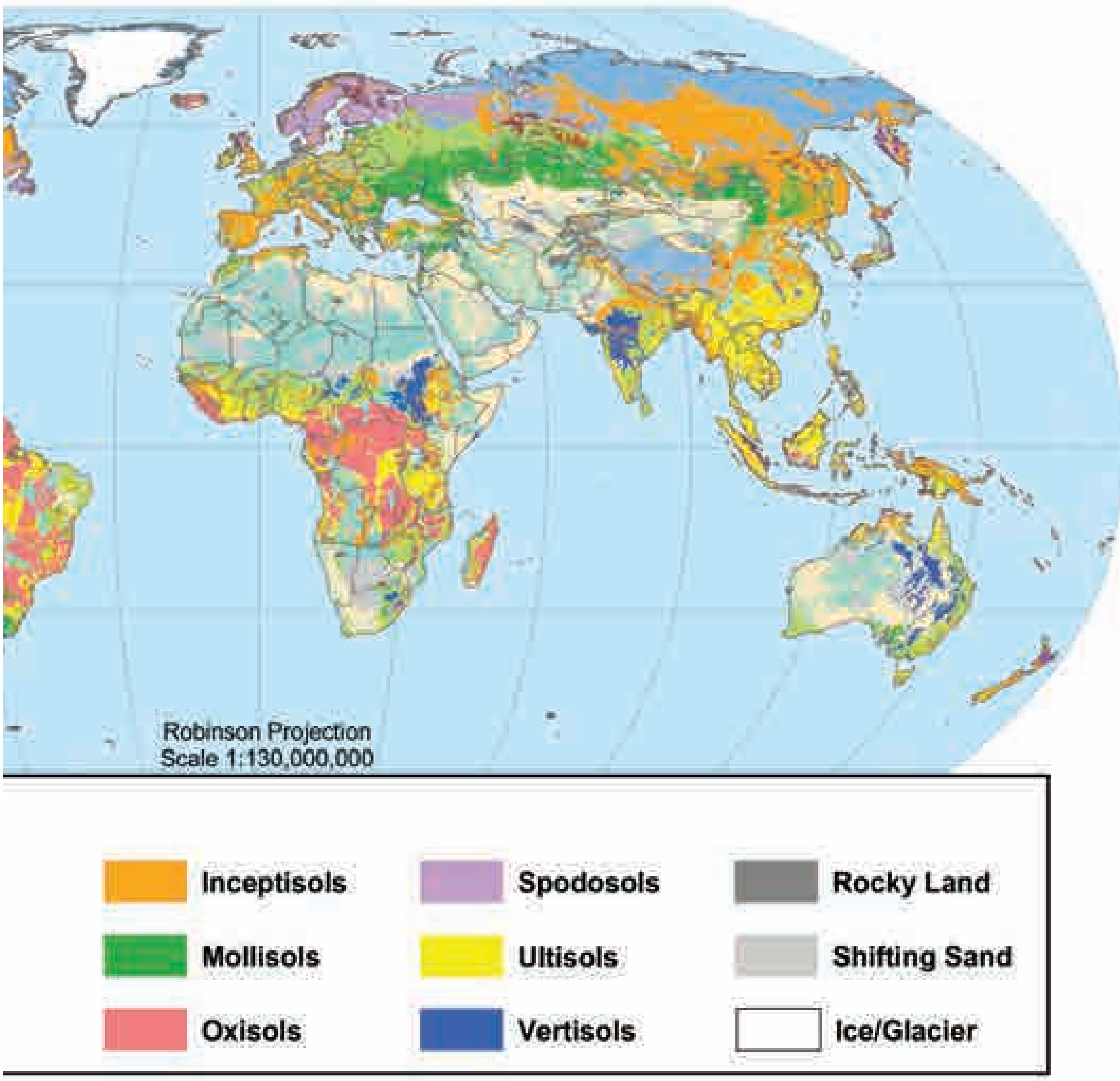
Nearly **50%** Population living in cities

- Growing demands for food and non-food biomass would lead to expansion of global cropland,
- Large areas of degraded soils need restoration,
- Reducing excessive consumption provides for untapped potential for 'saving' land,
- Need to have a sustainable land use management,
- Monitor and control level of global land use for supplying and catering to consumption needs, and
- Built up area expands at the expense of agricultural land and Agricultural land expands at the expense of forest.

Top: Assessing Global Land use (Courtesy: UNEP – International Resource Panel)

Change in land use is the largest single factor for natural habitat loss across the world. Only 263 years ago, which is not even a blip on the geological timescale; the Earth's surface would have been dark when seen from outer space. The transformation of the surface to one dotted with lights best signifies human expansion on planet Earth.

Natural ecosystems have evolved over millions of years and have resulted in phenomenal biological diversity. Climate change, degradation of land due to misuse and over-exploitation by humans has led to phenomenal loss of biodiversity. Should this continue, the Earth will become devoid of its rich diversity of life.



Top: Desertification (Courtesy: https://lh4.ggpht.com)

Arab 'land of fables'

Can Desertification affect the Deserts?

Desertification is 'Land degradation in arid, semi-arid and sub-humid areas resulting from various factors, including climatic variations and human activities.'

Dry areas are home to 2.5 billion people, cover more than 40% of the world's land surface and have to sustain on less than 8% of the world's renewable water resources. These areas are further challenged by extreme temperatures, frequent drought, land degradation and desertification. When fragile land in arid region is overexploited by expanding human populations, it loses it's productive capacity. Every year, 12 million hectares of land are lost to desertification, and the rate is increasing at an alarming pace.

UNCCD (United Nations convention to Combat Desertification) 1992

The Arab region covers approximately 14.1 million square kilometres, comprising of vast plains, plateaus, dry valleys with relatively limited highland and mountain areas.Pressing concern for much of the Arab world is with 89.3% of its area under arid and hyper arid conditions, the region faces enhanced vulnerability to climate change as well as water scarcity and variability. The land resources of the Arab region face three main challenges: aridity, recurrent drought, and desertification. 89.6 % of the GCC region is already desertified and the remaining area is vulnerable to desertification.

Due to limits set by the climate, only 6.7% of the total area is under forest. Sudan leads in the forest cover, followed by Somalia, Morocco, and Algeria in the North African part of the Arab world. Deforestation has reduced the forest cover and exacerbated the desertification. In West Asia, forest and woodlands constitute a mere 1.34% of the total area.

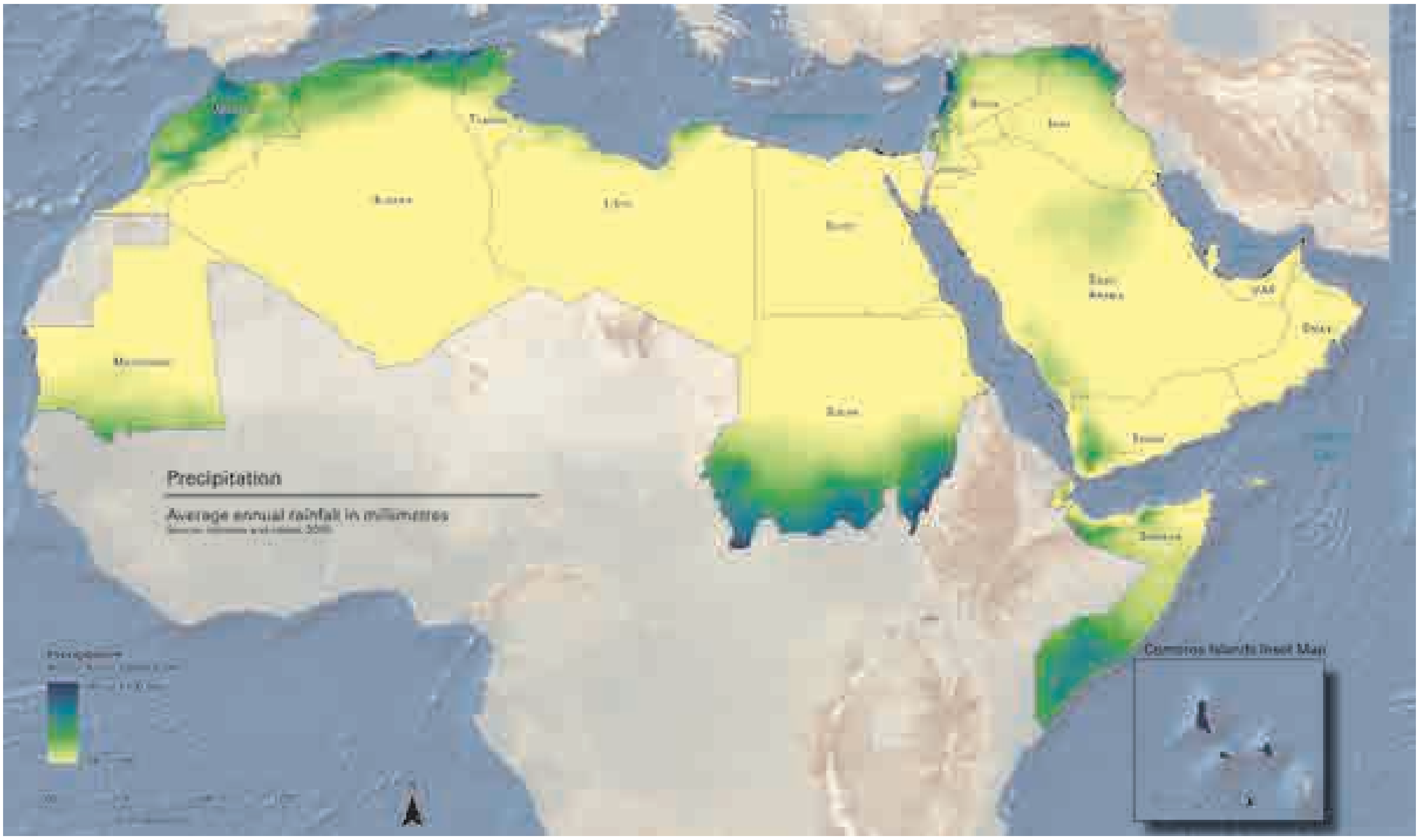
Soils all over the Arab region are generally poor, with thin soil profiles, reduced organic matter, low nutrient content, moderate to high salinity and alkalinity. With such limited productivity, issues of land degradation in the Arab world not only pose severe threats to the environment, economy, and the society but also negatively impact the socio-economic and political stability of the region. The 2009, UN Human Development Report states that 70% of dry lands in the Arab region are affected by degradation. Countries facing the greatest threat are Egypt, Jordan,and Libya. In the GCC Bahrain, Kuwait, Qatar, and the UAE are the most affected countries.

Though dry lands dominate the region, a variety of habitats such as Mediterranean forests, plains, rangelands, savannahs, oasis, mountains, rivers, mudflats, springs, marshes, and swamps are also found in the region and provide valuable eco-system services. Rangeland covers more than 33% of total area of the Arab countries.

Over grazing and misuse of land resources in the region is expected to increase degradation of its limited vegetative cover, enhance sand erosion, posing serious constraints to infrastructure and adverse impacts on health and social activities.

Arab Countries are net importers of food due to their arid conditions. With degradation and desertification, local food production would be further compromised thus putting a heavy strain on the economy through increased food imports. Thus there is an urgent need to develop an integrated approach to manage land recognizing the urgency of land degradation. Such an approach should encompass efforts from the scientific, industrial, social and legislative fronts. Promising examples are the initiatives in Saudi Arabia, Qatar, the United Arab Emirates and Egypt to establish funds for supporting research and programmes for the sustainable development and management of land resources.

Precipitation in Arab countries



Bottom: Precipitation in Arab countries (Courtesy: Arab Region : Atlas of the Changing world (AGEDI))

TABLE: Threatened species in each country by Taxonomic group

COUNTRY	MAMMALS	BIRDS	REPTILES	AMPHIBIANS	FISHES	MOLLUSCS	OTHER INVERTEBRATES	ANIMALS	PLANTS	TOTAL
Algeria	14	7	3	23	0	0	14	72	3	75
Djibouti	8	0	0	14	0	0	50	79	2	81
Egypt	17	11	0	24	0	0	46	108	2	110
Iraq	13	2	1	6	0	0	15	55	0	55
Jordan	13	5	0	14	0	0	49	89	0	89
Kuwait	6	2	0	10	0	0	13	39	0	39
Lebanon	10	6	0	15	0	0	3	40	0	40
Libya	12	5	0	14	0	0	0	35	1	36
Mauritania	14	3	0	23	0	0	1	49	0	49
Morocco	18	10	2	31	0	0	9	80	2	82
Oman	9	4	0	20	0	0	26	68	6	74
Palestine	3	4	1	1	0	0	1	17	0	17
Qatar	2	1	0	7	0	0	13	27	0	27
Saudi Arabia	9	2	0	16	0	0	53	94	3	97
Somalia	14	3	0	26	1	1	50	106	17	123
Sudan	14	3	0	13	0	0	45	88	17	105
Syria	16	6	0	27	0	0	6	68	0	68
Tunisia	14	4	1	20	0	0	7	54	0	54
UAE	7	2	0	9	0	0	16	42	0	42
Yemen	9	3	1	18	2	2	61	107	159	266

Top: IUCN, 2008

UAE - land resources

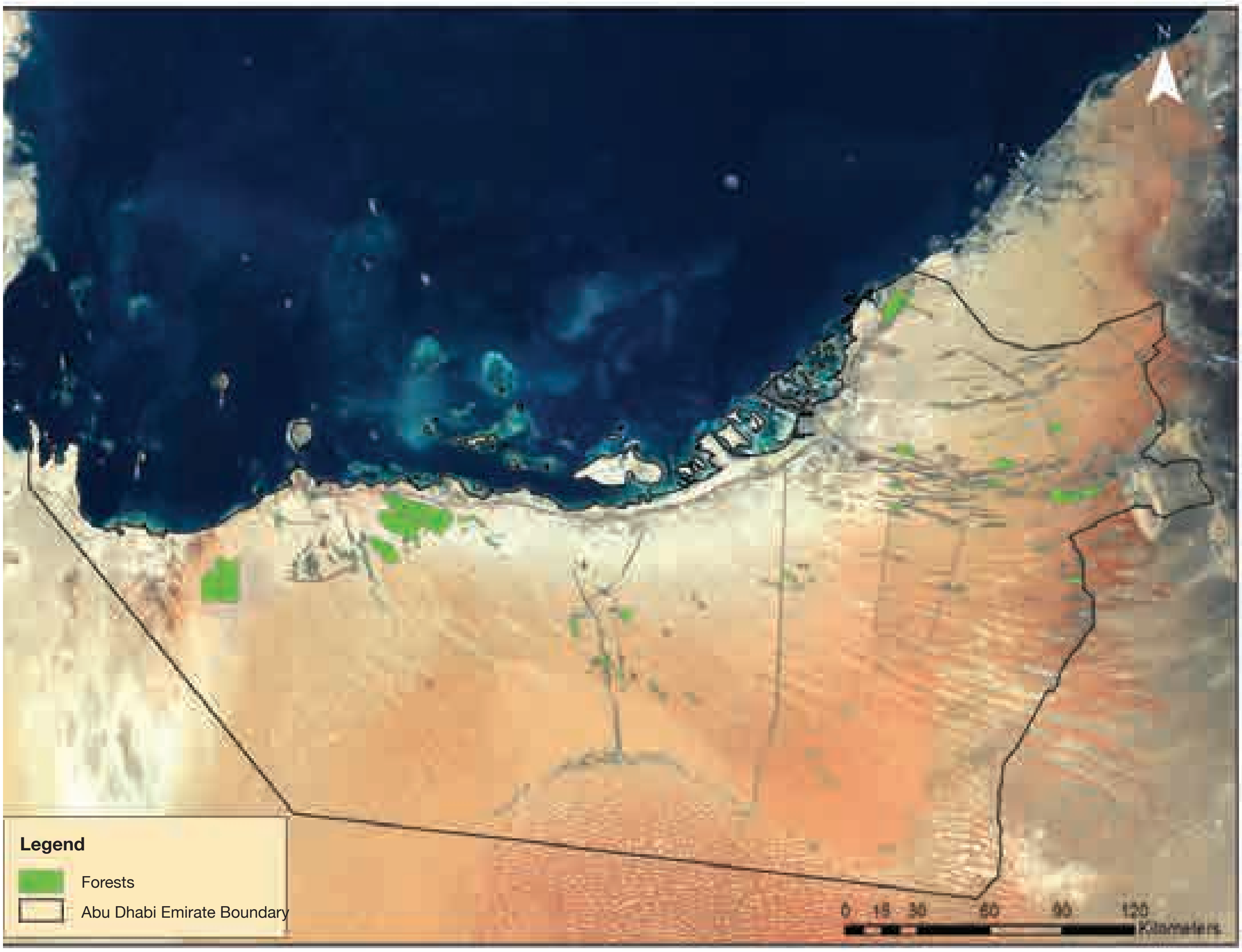
The United Arab Emirates, with an area of 71,023.6 km^2, located in a dry tropical zone is one of the most hyper-arid countries in the Arab region. The majority of the UAE is a sandy desert that supports a wide range of sparse seasonal vegetation. UAE receives only 85 mm of rainfall annually. Aridisols (found in arid or semi-arid regions) or entresols (young soils in the process of formation) dominate the soil type in this region. Despite a common perception that a desert is a featureless plain, UAE offers some of the most stunning habitats such as sand dunes, mountains, wadi's, alluvial plains, sabkhas, mangrove swamps, salt marshes, coastal islands, coral reefs, and sea grasses. Despite a challenging ecological climate, with low rainfall, hyper-arid soils with low organic content, UAE, Abu Dhabi emirate in particular hosts a rich floral and faunal diversity.

Wadis and mountains due to water availability are rich in different kinds of grasses, shrubs, trees, and flowers. UAE supports 678 species of plants, 54 mammals both native and introduced, 72 reptiles and amphibians and over 450 species of birds.

Since its inception in 1971, UAE's population has risen from 557,887 in 1975 to an estimated 8,190,000 in 2010. With this rapid increase in population, this fragile environment has been subjected to competing demands on land for agricultural use, urban development, mineral exploration, and infrastructure development. The 85-90% urbanisation rate poses further complexity in allocation of land for different uses. There is a heavy density of population in relatively small proportion of the total land area. A substantial area of land in the country has thus been transformed. The country has identified areas which need to be protected from this onslaught of change.

It is to be noted that most of the transformed areas such as agricultural areas, urban and built up areas have done so at the expense of using the scarce water resource. Most of the natural water drawn from the ground has been utilised for agriculture followed by domestic and industrial use. Desalination so far only meets potable water needs of the people. Increasing land under agriculture and depleting ground water reserves are leading to increase in demand of desalinated water. In 2012, 56% of treated waste water was used in public parks, green areas in the cities and in some farms. About 36% of waste water is disposed in the Gulf. This water can also be tapped for meeting increased demands for landscaping in the cities.

The transformation of the natural landscape and climate change has resulted in habitat degradation and destruction. Increased level of pollution, especially the increase in particulate matter (already high due to weather conditions) in the atmosphere is causing adverse health impacts. Increase in number of invasive and non-native species has led to significant reduction in bio capacity, habitat degradation, fragmentation and loss of biodiversity.



Abu Dhabi, the largest emirate in the UAE, accounts for 397 (1000 Ha) land under agriculture, 319.42 (1000 Ha) under forests. The rate of withdrawal of ground water for maintaining the agricultural land use far exceeds the capacity of water to replenish itself. This is due to the fact that agriculture is currently focusing on growing water intensive crops. It is to be remembered that good irrigation practises are essential for water conservation under arid and saline conditions. This requires maintaining soil water content in the root zone within a range sufficiently high that the crop can easily use the water but without incurring wastage due to unnecessary downward movement below the root zone.

Coastal lands in Abu Dhabi are also facing increasing anthropogenic stress due to growing urbanisation and industrialisation. Coastal zones are highly productive biological regions and important components of the global ecosystems. Over 80% of Abu Dhabi's population lives near the coastal areas.

In the face of ensuing development, important coastal land use such as wetlands and woody vegetation (mangroves and others) has been reduced (M.M. Yagoub & Giridhar Reddy Kolan, 2006).

Top: Forests Abu Dhabi (Courtesy: EAD))

Forests of Abu Dhabi Emirate

Abu Dhabi alone has 9518 hectares (85.6% of total) of Mangrove forests.

Arabian Oryx *(Oryx leucoryx)*

The Arabian Oryx is a stocky, pure white Antelope with prominent dark blue-black face markings and two long straight horns. It is exceptionally well adapted to the harsh desert environment and can survive for months without drinking water. It became extinct in the wild in 1972 due to over-hunting and habitat degradation. It survives today only as a result of captive breeding programmes. The historical range of the Oryx included the northern part of the Arabian Peninsula (including the western part of the UAE in the Manasir, Dhafra, and Liwa areas) and extended into Palestine, Syria, Jordan and Iraq. The UAE is currently host to the largest number of Arabian Oryx in the world, estimated at around 4,000 animals. Protected areas have been established to reintroduce Oryx in the wild and establish self-sustaining populations.

UPC (Urban Planning Council) constituted in 2007 in Abu Dhabi, has developed coastal land guidelines for addressing issues with regards to developing an integrated coastal zone management for meeting with the Vision Abu Dhabi 2030's aspirations.

While developing theEnvironment Vision for Abu Dhabi, the Environment Agency- Abu Dhabi recognised some of the following issues with regards to land degradation:

- The already low natural quality of soil makes it more prone to deterioration,
- there is a need to limit any further anthropogenic pressure to prevent further and fast degradation,
- with Camel population 400 times the carrying capacity and other cattle populations 600 times, overgrazing is a serious issue, and
- unsuitable and unsustainable agricultural practice of using brackish water for irrigation, tends to increase soil salinity.

Top: Arabian Oryx (Courtesy: EAD)

Biodiversity functions

A very important part of comprehending how the land is used is to learn about the biodiversity in a given area. This is to be done so, not only from the point view of species abundance and distribution but also from the point of view of its functions. Every species in addition to being a part of the food web also performs certain functions that help in sustaining the ecosystem of the given area. For example bees are eaten by birds and bees feed on nectar from flowers. In doing so, they pollinate plants which enables the plants to reproduce and also helps the bees by ensuring production of more nectar. Ecosystems collapse when a service done by species to maintain the ecosystem stops due to their decline. Humanity then needs to own up to this responsibility in the absence of species.

Some of the action to manage land as proposed by the Environment Agency- Abu Dhabi includes:

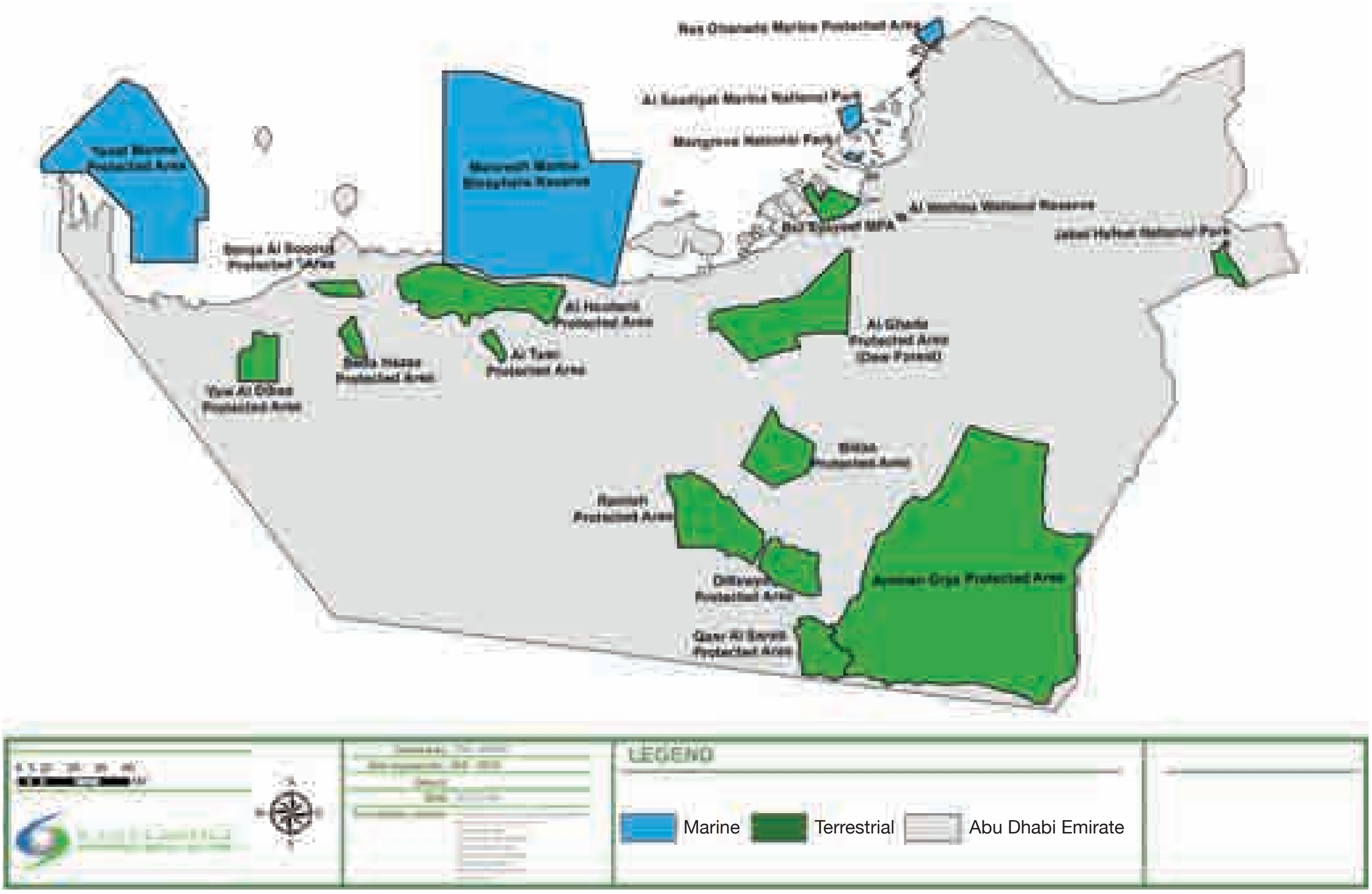
- Minimising loss of natural vegetation not dependent upon irrigation,
- establish more protected areas, and
- minimise loss of biodiversity and improve conservation efforts.

Sustainable management of land could mean several things within a given scenario:

- Land management that would ensure supply of limitless resources for sustenance and progress human populations of the Emirates,
- management of land using technology that would make land use more efficient to meet our limitless requirements, and
- reducing our requirement to fit within the limits of land use posed by natural environment of the Emirates.

Bottom: Wadi in Abu Dhabi Emirate (Courtesy: EAD)

Protected areas of Abu Dhabi Emirate



Flamingo breeding areas

The first flamingo breeding colony to be recorded in the UAE was in Al Wathba in 1993, and then again in 1999, when 10 chicks successfully fledged at the reserve. A breeding colony was also discovered in Shahama. The most successful and by far the largest breeding colony to date occurred at Bul Syayeef, in 2009. Continued regular monitoring of this flagship species coupled with habitat protection, is essential to conserving flamingo populations in the UAE. Sites that support flamingo populations in the Emirate, such as Bul Syayeef, must be afforded additional formal protections to ensure continued breeding.

Top: Protected areas of Abu Dhabi (Courtesy: EAD)
Bottom: Flamingo breeding areas (Courtesy: EAD)

LAND AUDIT

Stage 1: **Land use pattern on campus?**
Stage 2: **Change in land use?**
Stage 3: **Biodiversity of your campus?**
Stage 4: **Pesticide and fertiliser use on campus?**

Stage 1: Land use pattern on campus?

Land is a fixed resource and hence is precious. Land use in a given area is a factor of needs and demands made on it by the users of that land. While planning the use of land one needs to take into account the capability of the land to support such a use. Varied demands often leads to haphazard land use . Using the land efficiently without affecting the quality of that land to perform the eco system functions that it has the potential to perform is a challenge. Nature of land use also alters the constitution of surfaces which in turn has diverse impact on our environment.

We could divide land use on the campus under the following categories:

- **Built environment** – Area which has any artificial surface,
- **Landscape** – Area that is under greens of any sort, and
- **Water bodies** – Area that has water body of any sort.

Data on the above land use categories will be readily available with the campus administration or the same could be easily derived from the available building plan. Use Table 1 below to collect land use information of the campus.

TABLE 1: Campus land use

Campus Landuse		Area in square metres
Built environment	Buildings (Main and sub buildings)	
	Metalled road (Roads, driveways, parking areas)	
	Artificial surface (Other areas having artificial surface)	
	Other use (specify)	
Landscape		
Water bodies	Fountains, Ponds, Swimming pool/s	
Total		

Urban climate and geographical variation

A city's land use and its effect upon climate are influenced by its geographical setting. Latitude has an influence through basic solar forcing (the amount of energy received from the sun); location on the continent influences seasonal extremes; and the sequence of expected fronts and pressure systems affect the range of meteorological conditions a city experiences.

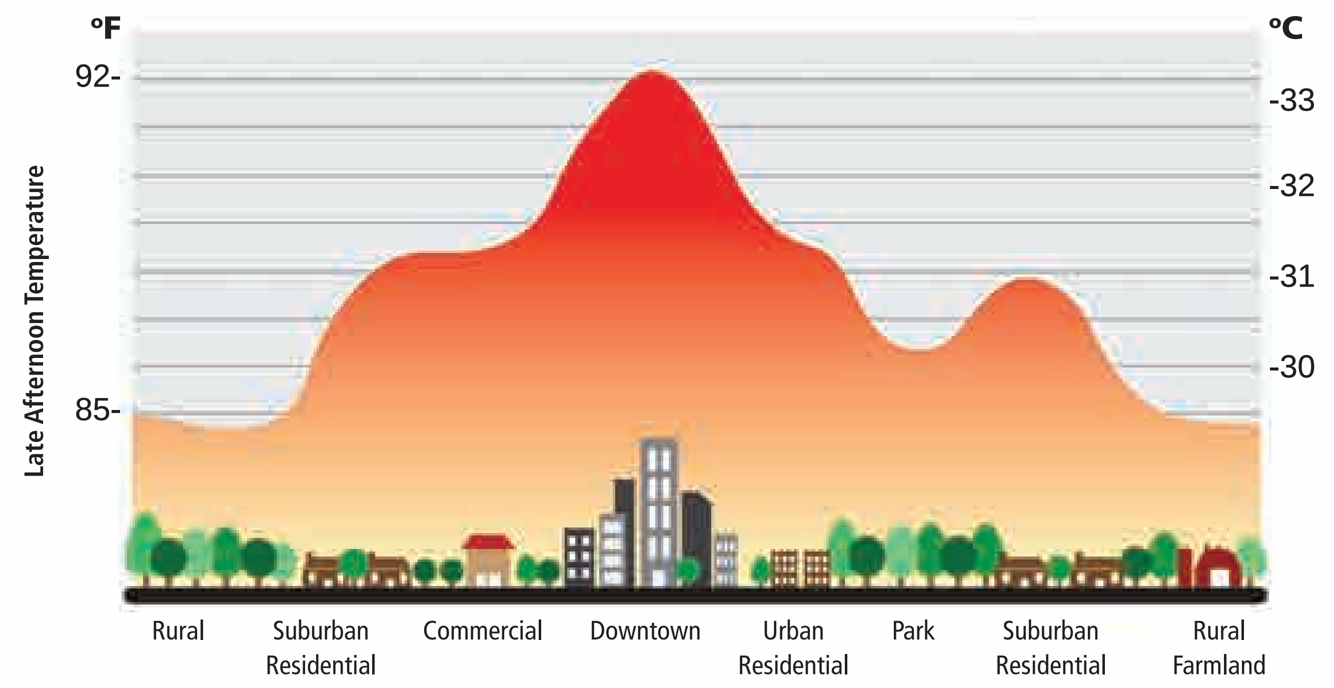
These all influence the design of a city (for example building styles) and behaviours and activities of inhabitants (demands for heating and cooling etc.) as well as the specific urban climates that result. Urban climate vary from place to place as the factors that cause them – building materials, morphology of the surface, emissions by humans – also vary.

In arid environments, cities surrounded by deserts may actually be cooler than the surrounding rural landscape (urban cool islands). This is because urban residents plant gardens and water those gardens. Energy is used in evapotranspiration rather than heating the ground or air and temperatures are cooler.

At even the smallest scale, within a city, temperatures from one side of a street to the other, from a park to an industrial neighbourhood, or one suburb to another may be significantly different. These patterns are a function of urban morphology, built materials, amounts of vegetation and human activity.

In most parts of the world the proportion between the above categories of land use is fixed by the land development authorities in accordance with resource availability and climate. In UAE fixing a proportion of land use between above categories has direct relation to scarce resource use. For instance fixing a certain percentage of total land area for greenery would lead to increase in quantity of water used.

Heat island effect



Bottom: Heat island effect (Courtesy: http://c3headlines.typepad.com/.a/6a010536b58035970c017744ad1afa970d-pi)

Stage 2: Impact of land use?

Use Table 2 to record changes brought by different types of land use on the campus. Handheld instrument that measures the parameters given in the table is provided. Otherwise, use a thermometer to record temperature; instruments available on your campus to measure humidity; and thin strips of paper or pieces of thread tied to a stick for determining wind direction. As a last resort seek help from local authorities to measure these parameters.

TABLE 2: Changes in climate brought by different types of land use

Land use		Temperature	Humidity	Windspeed/ Direction
Campus building	Before sunrise			
	Afternoon			
	After sunset			
Road surface	Before sunrise			
	Afternoon			
	After sunset			
Campus Garden / Lawn	Before sunrise			
	Afternoon			
	After sunset			
Open Desert	Before sunrise			
	Afternoon			
	After sunset			
Desert plantation (if close by)	Before sunrise			
	Afternoon			
	After sunset			
Sea (if close by)	Before sunrise			
	Afternoon			
	After sunset			

Community practices survey

It would be good if the group could conduct similar studies in different categories of urban settlement like the residential, industrial, shopping, office complexes and other categories (if any).

The findings should be discussed with local authorities to find ways in which the negative impact of built environment on local weather could be supressed. Efforts to implement change in practices or infrastructure should be lead by the community.

Stage 3: Biodiversity of your campus?

In this task the audit group will create a biodiversity register for their campus. The audit team will also try and estimate the quantity of fresh water and energy that is used in the process of maintaining this biodiversity. A comparison between quantity of carbon dioxide sequestered and produced in the process of creating the biodiversity will help them understand whether it is worth trading precious resources for exotic biodiversity. The group will also estimate whether the ideal return to sewer rate (RTS) of 20 per cent can enable them raise the same biodiversity on treated waste water. They can also look into energy and resource implications of raising biodiversity on treated waste water. These estimates will help the group understand the factors that make certain ways of sequestering carbon dioxide more economical.

Record the plant biodiversity (visible to the naked eye) available in your campus using table 3. The space provided in the Table might be inadequate to record all the species. Please copy the format of the Table to record additional species. The information about type of water used will be available with campus administration and BMS managers.

TABLE 3: Plant biodiversity register

Biodiversity type	Native/ Exotic	Type of water used for irrigation	Quantity of water used for irrigation	Quantity of energy used for irrigation
Grasses				
Shrubs				
Trees				
Creepers				
Others (specify)				

Role of the biodiversity

Plant and animal kingdoms functions regulate each other. It is true that the animal kingdom owes its existence to the plant kingdom but the animal kingdom's role in sustaining plant life on Earth is also very important. Together the biosphere ensures that Sun's energy can be trapped on Earth for longer periods of time.

The energy trapped by living organisms millions of years ago created oil reserves that power the human civilisation today. The biosphere is still toiling to harvest sun's energy using processes that regulate the climate and also creates future reserves of energy in one form or the other. While the current biodiversity in the emirates may not lead to the formation of large reserves of future fossil energy, nevertheless they play animportant role in maintaining the global ecological balance.

Magic in Plant – animal relationships

The plants perform the ingenious process of photosynthesis to provide energy for all other living organisms. With all the technology and intelligence, humans have not been unable to create such a process that could harvest similar quantities of energy especially with the limitations under which plants operate and function. Plants produce everything that any animal would ever require as a source of energy to sustain itself. In return in the web of life, animals would regulate the plants growth and dispersion.

Plants are able to performphotosynthesis using, the humidity provided by the hydrological cycle, gases made available in the ambient air, mineral and organic nutrients available in the soil at the ambient temperature, without moving from one's place and using renewable energy. As yet there is no known human technology mimicking such a process.

On the contrary, in all of the production processes/activities practiced by humans, rarely has any raw material been fully utilised and recycled.

Natural systems may not seem as efficient as some of the processes that humans have developed when considered in isolation. But the underlying factor in all natural systems is the concept of sustainability. While a solar panel can perhaps trap more solar energy than a leaf but one must admit that a solar panel is no match to the self-assembling capability of the leaves.

To cite an imaginary example, to mimic the natural photosynthetic process, we would have to develop a process wherein solar panels can self-assemble and reproduce at ambient temperature on any part of our planet using renewable energy. All materials are moved from one place to another using renewable energy. All materials used as raw materials for the solar panel is fed back to the resource loop after its de-commissioning. The electricity made available by such solar panels could definitely power human civilisation for ever!

Images courtesy – Anitha Saji, Salim Javed, Gary Brown, Karan Raghwa and EAD

Do you recognise us?

Measuring quantity of water and energy used

In case the green landscape is irrigated using water sprinklers and drip equipment then contact the landscape managers for the information required. Even if the landscape is irrigated using a garden hose that is left to flood the landscape, managers will be able to help.

There are ways of measuring the quantity of water being consumed directly. Diameter of the pipe, pressure and time will help determine quantity of water used. Turning of all water use for a small period of time and running the irrigation system will help determine the quantity of water consumed by monitoring the source tank.

The pumping equipment used indicates power consumption factors and the BMS managers can help you calculate power consumption for time the irrigation systems work.

Can treated water alone meet irrigation demand?

Ideal quantity of waste water that can be recovered for irrigation by the campus (based on 20% RTS target proposed by RSB):

$$\frac{\text{Total water consumption } \textit{per} \text{ day}}{100} \times 20$$

Total water used for irrigation *per* day (in litres or kilo litres) =

Percentage =

$$\frac{\text{Total water used for irrigation } \textit{per} \text{ day}}{\text{Ideal quantity of waste water that can be recovered}} \times 100$$

Comparing carbon produced and carbon sequestered!
Net primary production in a desert ecosystem is about 1 kilocalorie / square metre / *per* day under natural circumstances.

1 kilocalorie = 1.163 watt hours 1 calorie = 4.1868 watts *per* second
1 kilowatt hour = 3600000 watts *per* second

Now determine the amount of energy being consumed in irrigating the landscaped area on the campus. Remember, that the energy will be largely consumed to transport water for irrigating the greenery.

If the energy used to irrigate 1 square metre of green area is more than 1.163 watt hours then your campus is exceeding the carrying capacity of your region. This will lead to generation of more carbon than gets fixed in the biomass produced.

Buzzzzzzz....... of the bees

Bees feed on nectar of flowers to create honey. The plants use the bees to reproduce (pollination). Both cannot exist without each other and it would be hard to answer the question, did the angiosperms (flowering plants) evolve first or did bees? Probably they evolved together. There is an abundance of similar relationships in natural ecosystems.

From the systemic perspective every species in the ecosystem is doing some work. If a species is eliminated, then the work/function performed by that species in the ecosystem suffers. The ecosystem then begins to weaken. Accordingly, certain other species evolve or disappear to adjust to changes in the given system. Undisturbed, the physical environment and the living world both influence each other and evolve to adjust to any changes in their status. Human induced changes however are sudden, and do not provide the time required by species to evolve or adjust.

It would be perfect if the bee populations would start feeding on flowering plants grown by humans instead of flowering plants in natural ecosystems. The only issue in such a scenario would be the fact that the bees would also need to adapt themselves to the use of pesticides and fertilisers used by humans to grow such plants. Unfortunately, the physiology of the bees does not allow for such adaptations. Alternatively with the absence of bees, humans would not only have to find out ways of making artificial honey to meet their needs but also find new ways for pollinating the plants.

Record the animal biodiversity (visible to the naked eye) visiting or available in your campus using Table 4. The space provided in the Table might be inadequate to record all the species. Please copy the format of the Table to record additional species.

TABLE 4: Animal biodiversity register

Name of the species	Native/exotic	Vertebrates/ Invertebrates	Terrestrial

Column1 – The common name or scientific (Latin) name of the species, include local (Regionally appropriate language) name if known.

Column 2 – Mention whether the species is exotic or native.

Column 3 – Mention the type of animal.

Top right: Beehive (Courtesy: Anitha Saji)

After compilation the implications of the biodiversity registers should be discussed within the group and with campus administration. Together the group should try and answer the following questions:

Question	Reply (Tick the applicable)	What does it indicate? (Tick the applicable)	What needs to be done?
Is it more economical to irrigate plants on the campus using treated water?	Yes / No	• Social/cultural inhibitions to use of treated water • Lack of appropriate technology • Lack of will on part of water managers • Health and hygiene concerns	
Do native species of plants and animals help sequester more carbon dioxide?	Yes / No	• Native species consume less energy and resources • The native species have evolved to suit the environment over long periods of time	

How sustainable is our campus?

If the campus supports plant diversity which is not watered at all or is completely sustained by irrigation with treated wastewater its sustainability is 100 *per* cent.

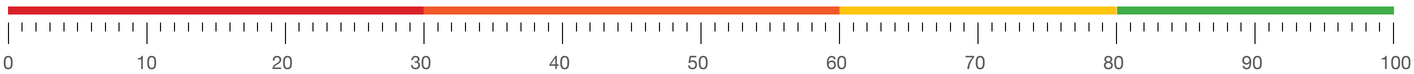
If the plant diversity is completely sustained using fresh water the sustainability *per* cent is 0.

If the plant diversity is partially sustained by irrigation with treated wastewater use the formula given below to calculate sustainability:

$$\frac{\text{Quantity of treated wastewater used for irrigation}}{\text{Total quantity of water used for irrigation}} \times 100$$

Note, for complete sustainability use only wastewater for irrigating greenery. In addition it is very important to manage doing so by using equal to or less than 1 kcal of energy *per* square metre (the net primary production rate in a desert ecosystem).

Depict the resource efficiency of your campus on the number line given below:



Community practices survey

It would be good to create a biodiversity register for few streets and households around the campus. The street and household registers should sample houses representing different standard of living and different sizes. This would help the team to identify a reasonable range of biodiversity in the region. Any remedial measures taken to improve the biodiversity and associated carbon dioxide sequestration should be spearheaded by the community.

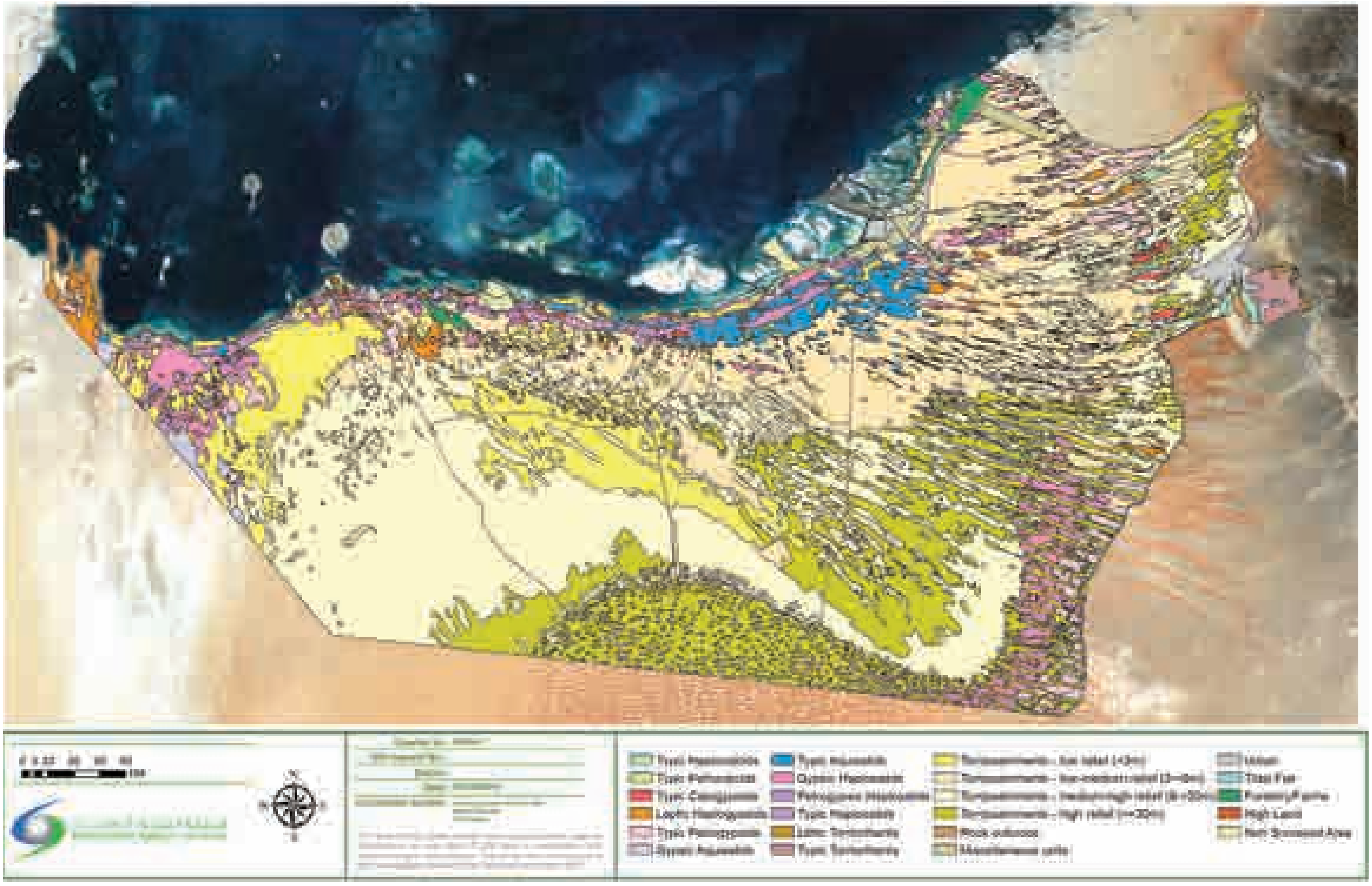
Bottom: Typical college campus garden (Courtesy: EAD, SCI college)

Stage 4: Pesticide and fertiliser use on campus?

One is always mesmerised by the sprawling forests, grasslands and scrublands. While the plants seem to cover the surface of our planet in an effortless manner, like every other living being they too require ideal conditions in order to thrive. The right soil conditions, humidity, temperature and sunlight are basic essentials to plant life.

In the arid, desert landscape of Abu Dhabi, green plants line the streets and localities much like many other cities in the world. Having evaluated the cost of energy and water used for maintaining the campus greenery, it is useful to remember that the green areas in Abu Dhabi also come with a cost. One of the importantfactors also to be taken into consideration is the soil, the medium on which plants grow. Locate your campus on the map given below to find out the quality of the natural soil available and then compare it with the needs of plants that are grown in the campus.

Distribution of soil groups in Abu Dhabi



Bottom: Soil groups in Abu Dhabi (Courtesy: EAD)

Use Table 5 below to collect information about how many pesticides and fertilisers are used to maintain that lovely piece of greens on the campus?

TABLE 5: Pesticides and fertiliser use

Measurable	Pesticides	Fertilisers	Bio-pesticides	Bio-fertilisers
Quantity used *per* month				
Cost *per* month				

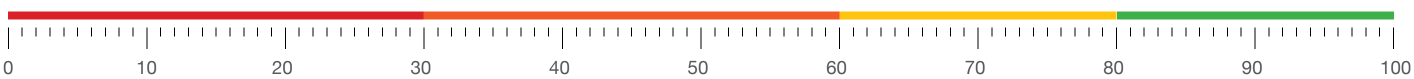
How sustainable are we?

In this regard, if the campus uses only bio-pesticides and bio-fertilisers then definitely the campus can give itself a rating of 100% on sustainability.

If the campus uses chemical pesticides and fertilisers, then the sustainability quotient is 0%.

The Sustainability quotient will vary between 0-100% depending on the proportion between the bio- pesticide and bio- fertiliser used vs. the chemical pesticides and fertilisers used.

Depict the resource efficiency of your campus on the number line given below:



Maintaining good soil conditions

While there are many ways of maintaining good soil conditions for plant growth, use of fertiliser to augment soil quality is an important landscaping practice. In this regard, compost prepared on the campus from food and horticultural waste can easily score better when compared with some of the chemical fertilisers available in the market. Composting at the campus will not only help save cost and provide means to manage some of the waste in the campus but is also very beneficial for the sustained enhancement of the soil conditions.

While there might be reservations regarding the health hazard in undertaking such anexercise due to the presence of microbial organisms, it would do well to remember that microbes are important and they play an important part in the ecosystem. Microbes are found almost everywhere including the human body. As long as sound method and proper precautions are undertaken, composting can be one of the best solutions towards soil enhancement for plant growth.

Community practices survey

It would be good to collate fertiliser and pesticide use practices for a few streets and households around the campus. The houses should represent different standards of living in the area. Any measures taken to switch to bio-pesticides and bio-fertilisers should be spearheaded by the community.

Microbial Diversity and Conservation

Microbes are organisms that one needs a microscope to see. The lower limit of the human eye's resolution is about 0.1 to 0.2 mm or 100 - 200 um. Most microbes range in size from about 0.2 um to the 200 um upper limits, although some fruiting bodies of fungi can become much larger. Microbes include the bacteria, algae, fungi, and protozoa.

It is obvious that the omission of microbial communities in management and conservation of ecosystems is due to a lack of understanding about the functioning and composition of environmental microbial communities leading to the assumption that microbial communities are insensitive, resilient, and redundant. However, getting microbial diversity under the attention of policy and management will require incorporation of microbial diversity into predictive ecosystem process models.

Ecosystems collectively determine biogeochemical processes that regulate the Earth System. Loss of biodiversity is generally regarded as detrimental to ecosystems and ecosystem functioning and therefore has been a central issue for environmental scientists during the last few decades (Hooper *et al.*).

Post audit analysis

The working group should organise a meeting with the core group to discuss its findings. Should the group think that the cause needs to be taken up at the policy level with campus administration or the government, a draft should be prepared and submitted for consideration through the proper channels.

Research and experimentation on new ways to improve land use at any level should be taken up as a project related to the discipline the students are studying at the campus. The same can also be taken up as an independent research or internship project with private parties with the due permission of competent authorities.

Community action

The working group should organise a meeting with the representatives of the community to discuss the findings of the community audit undertaken. Should the group feel that there is a need for the local administration to pitch in and take chargethen a draft should be prepared and submitted for consideration for the proper authorities to consider. Any action to improve land use practices should be taken up by the community independently.

INDIVIDUAL	INSTITUTION	COMMUNITY

Magical microbes

Ostracods

Ostracods, or ostracodes, are a class of the Crustacea (class **Ostracoda**), sometimes known as **seed shrimp**. Some 70,000 species (only 13,000 of which are extant) have been identified, grouped into several orders. They are small crustaceans, typically around 1 mm (0.039 in) in size, but varying from 0.2 to 30 mm (0.0079 to 1.1811 in) in the case of Gigantocypris. Their bodies are flattened from side to side and protected by a bivalve-like, chitinous or calcareous valve or shell. The hinge of the two valves is in the upper (dorsal) region of the body. Ostracods are grouped together based on gross morphology, but the group may not be monophyletic; their molecular phylogeny remains ambiguous.

Ecologically, marine ostracods can be part of the zooplankton or (most commonly) are part of the benthos, living on or inside the upper layer of the sea floor. Many ostracods, especially the Podocopida, are also found in fresh water, and terrestrial species of Mesocypris are known from humid forest soils of South Africa, Australia, New Zealand, and Tasmania. They have a wide range of diets, and the group includes carnivores, herbivores, scavengers and filter feeders.

The Importance of soil microbes

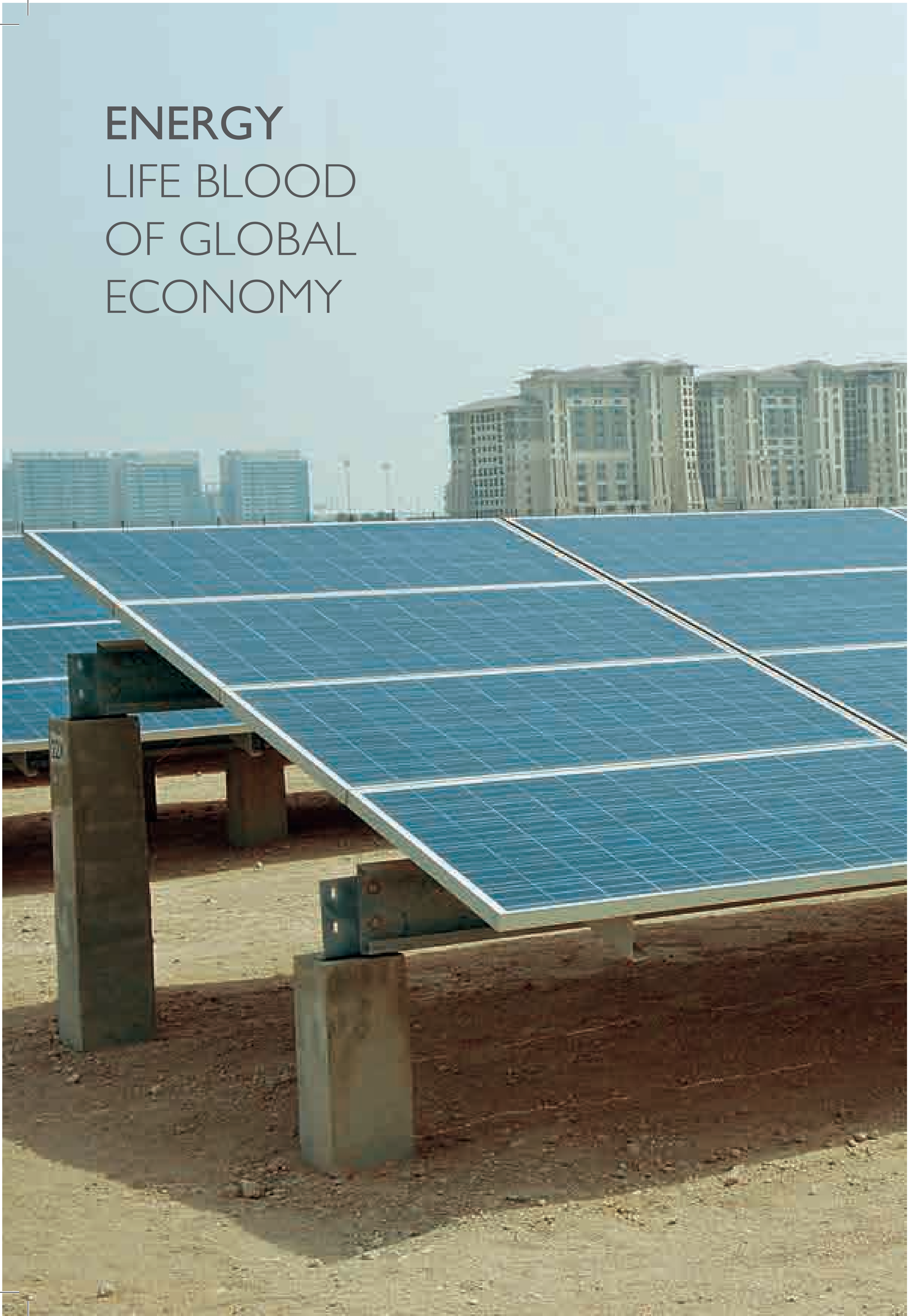
The soil is alive! Below our feet and invisible to the naked eye, tiny microbes—the great digesters of the earth—constantly break down organic material into a more usable forms that plant roots can identify, absorb, and ultimately incorporate for new growth. This material includes complex organic compounds, such as tannins, lignins, proteins, carbohydrate, cellulose, pectin, etc.

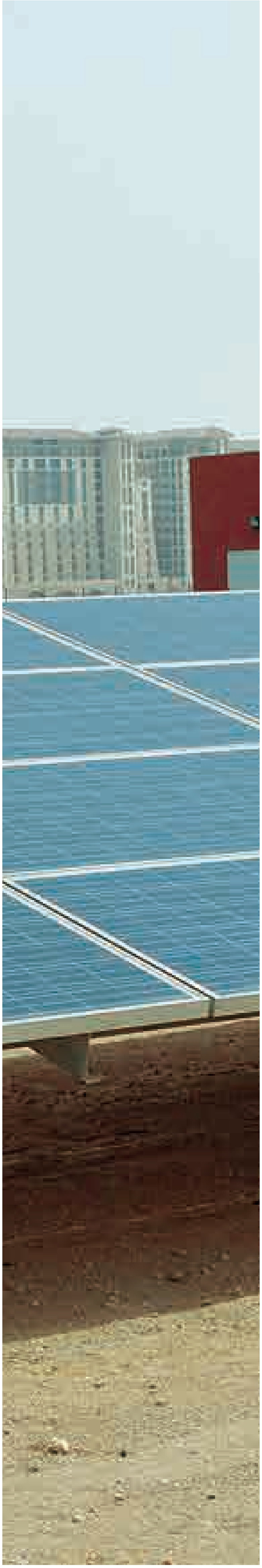
Healthy soil should contain no less than 10,000,000 bacteria *per* grame. The presence of microbes ensures that nutrients are made available to plants at a steady rate. While the plants are actively growing—and requiring more nutrients—so do the microbes in the soil. As the weather warms, both the plant and microbes respond at a similar rate. The microbes become increasingly active in their role of breaking down organic materials into forms more readily absorbed by the growing plants that need extra nutrition. As the weather cools—and plants require less nutrition—so do the microbes. The reduction in their activity means fewer nutrients in the soil are being released to the plants. In this way, the soil can rebuild food reserves. This self-regulating cycle has occurred for millions of years as part of the wisdom of nature.

Microbes also help to stabilize the soil by physically binding soil particles together; they release a by-product called glomalin that acts as a "glue," binding mineral particles and organisms to each other. This contributes greatly to soil aggregation. All of these processes happen naturally in a healthy, productive soil.

Top right: Soil bacteria, photo by Eric Erbe, digital colorization by Christopher Pooley, both of USDA, ARS, EMU (Courtesy: http://upload.wikimedia.org/wikipedia/commons/b/bc/E_coli_at_10000x,_original.jpg)
Top left: Ostracods (Courtesy: EAD)

ENERGY
LIFE BLOOD
OF GLOBAL
ECONOMY





"We must not rely on oil alone as the main source of our national income. We have to diversify the sources of our revenue and construct economic projects that will ensure a free, stable and dignified life for the people."

- Late H.H. Sheikh Zayed Bin Sultan Al Nahyan.

LEST WE FORGET!

Roadkill

Energy is connected to all aspects of human life and possesses the ability to transform people's lives. A country's economic welfare, growth and *per capita* income are directly related to energy availability. According to a report by the Global Economic Forum, 'Energy is the life blood of global economy,a crucial input for all the goods and services provided in the modern world'. It is a known fact that economic growth is connected closely with the standard or quality of life that people enjoy in a country. The millennium development goals (MDG), which is a blue print to meet the basic demands and standard of life for the world's poorest and to which all countries have agreed and committed to provide for, clearly state that the MDG goals may not be achievable without providing safe and affordable energy.

Bottom: Roadkill by Cman189 (Purchased from www.cartoonstock.com)
Top left: 10 MW Shams CSP (Courtesy: EAD)

Having understood the importance of, and need for, energy in the modern world, some key issues need to be comprehensively examined:

a) sources from where the energy (energy mix) is made available,
b) whether the current global demand is met by the supply and if so, at what cost? and
c) whether the current modes of supply are sustainable, especially given the fact that current economic growth models are heavily energy dependant.

Burning need for energy

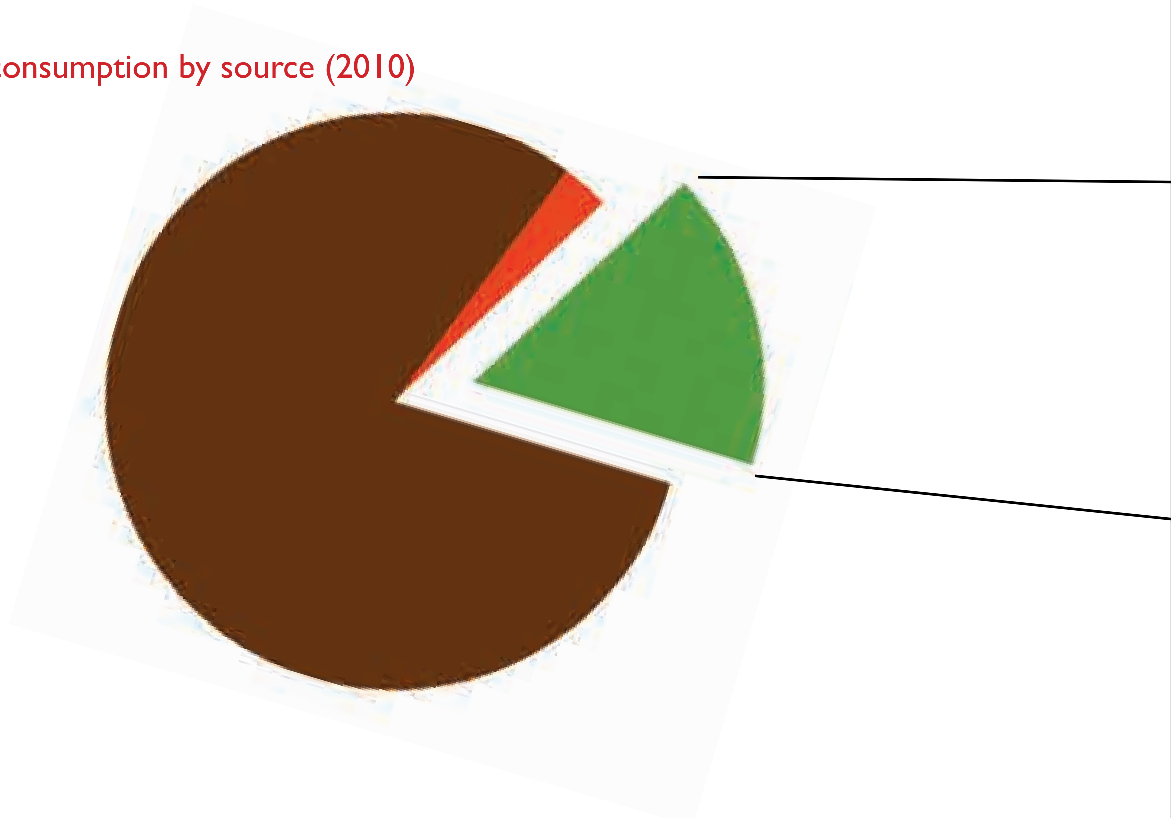
While Energy is important for the continued survival and well-being of people, it is unfortunately drawn mostly from finite and non-renewable fossil fuels. As *per* the International Energy Agency statistics, till as recently as 2011, oil, coal and natural gas constituted 81.6% of world's primary energy supply. This was followed by sources such as biofuels (10%), nuclear power (5.1%), hydro power(2.3%) and others (1%) such as solar, wind, geothermal and so on.

Sustainability of our energy stack!

In 2012, fossil fuel constituted 87% of the total energy use. Despite the increase in the world's consumption of fossil fuel, approximately 1.2 billion people or 20% of world's population, almost all of them from developing countries,are still without access to basic electricity. According to a UNEP report dated June 2014, energy prices have gone up by a whopping 260% since the beginning of the millennium (2000). It is no wonder that under these circumstances the MDG still seems like a distant dream.

In this scenario it is conclusive that neither the global demand for energy is being met, nor are the sources or energy mix in any way sustainable.

Total world energy consumption by source (2010)



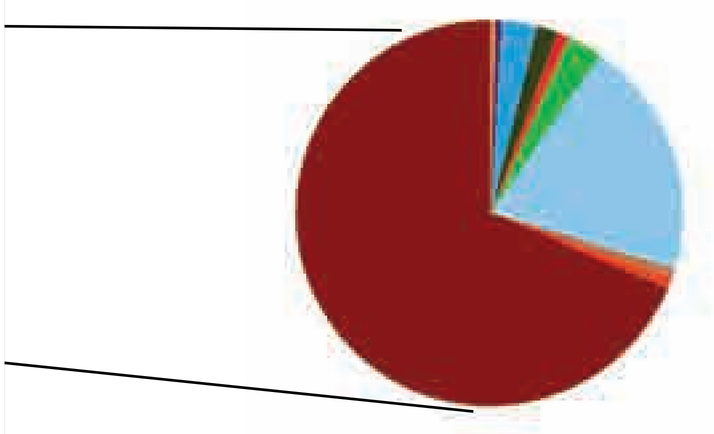
Where does the buck stop?

While it has been clearly established that fossil fuels consumed for electricity, transportation, heating or cooling are largely responsible for the increase in global greenhouse gas emission and the resultant climate change; the increased use of fossil fuels continues unabated. A case in point being the availability of data on the volume of carbon emissions from fossil fuel combustion-according to the Global Carbon Project, CO_2 emission reached an estimated 9.7gigatons (Metric system) in the year 2012, a good 58% higher than what it was during the year 1990. Incidentally, 1990 was the cut-off year for the volume of carbon emissions as *per* the Kyoto protocol (an international treaty that sets binding obligations on industrialised countries to reduce emissions of greenhouse gases). The increase happened despite the commitment from countries that ratified the protocol and pledged that they would steady the carbon emission to 1990 levels by the year 2012.

While the linkage between high energy use and greenhouse gas emission is well documented, an issue that is presently being explored is the nexus between high energy use and water consumption. Water is essential to energy production: in power generation; in the extraction, transport and processing of oil, gas and coal; and, increasingly, in irrigation for crops used to produce biofuels. Currently 780 million people lack access to potable water. According to a World Bank report, by 2035, the Global energy consumption is slated to increase by 35% and the extent of water use by the energy sector is estimated to grow by 85%.

Climate change is further expected to exacerbate water issues through adverse weather patterns which will cause increased flooding and droughts. With the use of fossil fuels also comes the deterioration in air quality, in addition to hydrocarbon emissions, combustion of fossil fuels are also responsible for increasing carbon monoxide, nitrogen oxides, sulphur oxides and particulate matter in air. All of these pollutants in addition to impacting climate, also impact human health.

The global population is expected to be reaching 12 billion in 2100. The need of the hour is to wean our population off fossil fuel dependence and develop alternative means to meet our energy demands, and also to minimise environmental impact.



Renewables

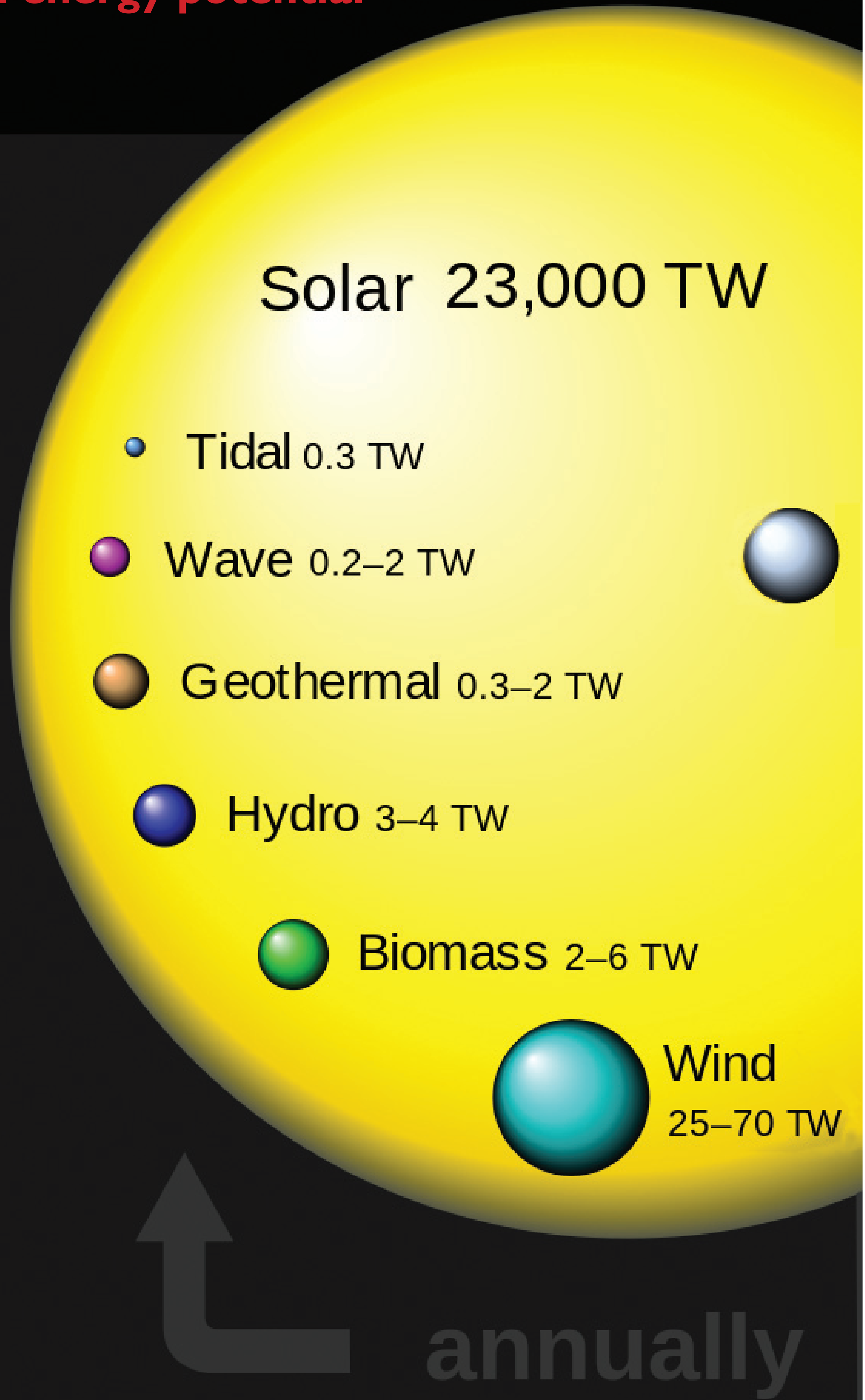
Biomass heat	11.44%
Solar hotwater	0.17%
Geothermal heat	0.12%
Hydropower	3.34%
Ethanol	0.50%
Biodiesel	0.17%
Biomass electricity	0.28%
Wind power	0.51%
Geothermal electricity	0.07%
Solar PV power	0.06%
Solar CSP	0.002%
Ocean power	0.001%

Total

Fossil fuels	80.6%
Renewables	16.7%
Nuclear	2.7%

Bottom: Total world energy consumption 2010 by Delphi234 (Courtesy: http://upload.wikimedia.org/wikipedia/commons/6/67/Total_World_Energy_Consumption_by_Source_2010.png)

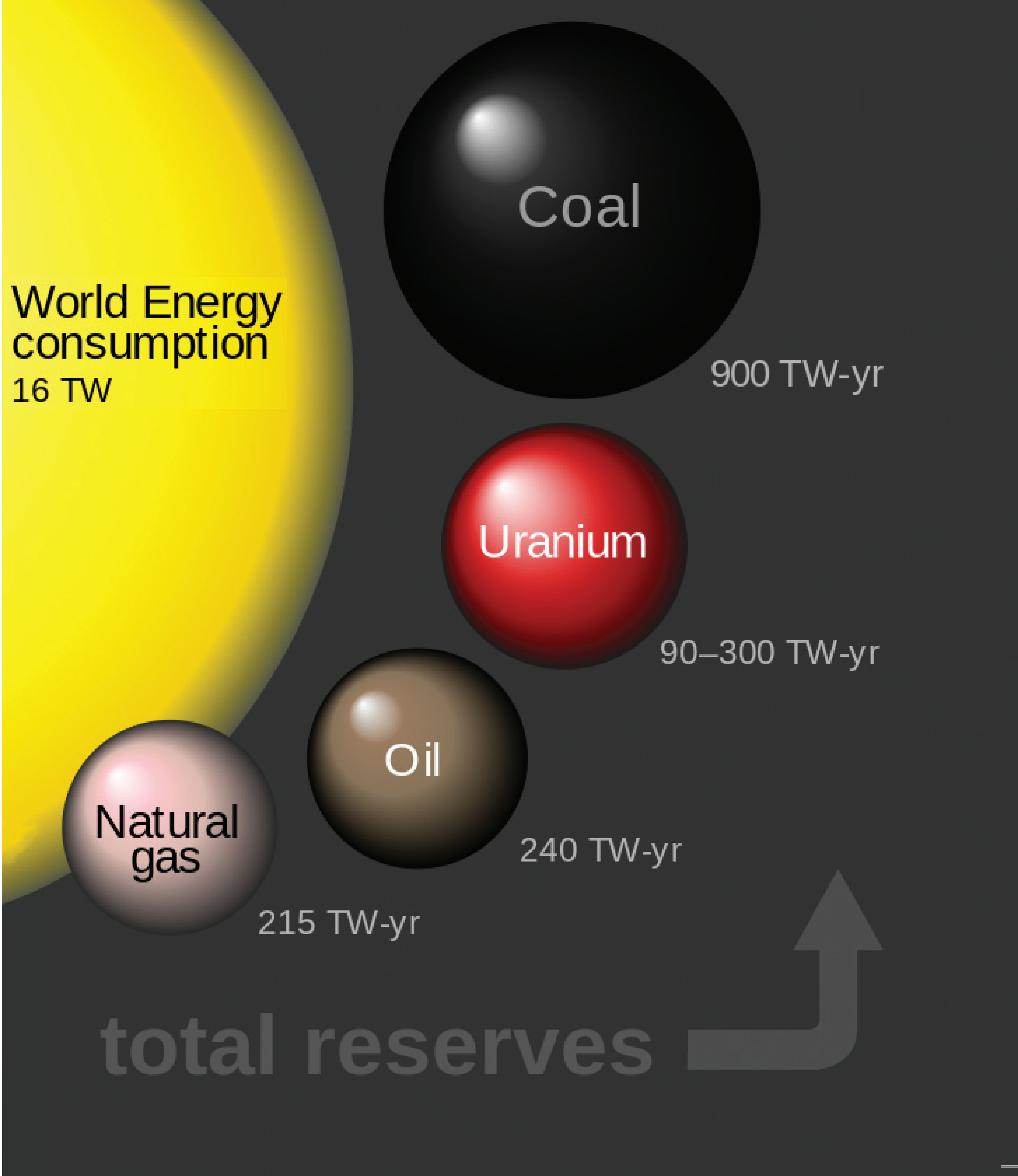
Global energy potential



Bottom: Global energy potential (Courtesy: http://commons.wikimedia.org/wiki/File:Global_energy_potential_perez_2009_en.svg)

Global Energy Potential. Comparison of renewable and conventional planetary energy reserves. While for renewables the yearly potential is shown in terawatts (TW), conventional sources display their total recoverable reserves in terawatt-years (TW-yr). The volume of the spheres is proportional to the amount of energy they represent. Global solar power of 23,000 TW refers to the earth's total land mass with atmospheric losses taken into account, and corresponds to 200 million TWh *per* year. Worldwide energy consumption of 16 TW during year 2009 translates into 140,000 TWh.

1 TW of electrical output (TWe) makes the Terawatt-year (TWyr) a natural unit to use in discussions of total electricity production.



Misty solutions!

Energy security, social equity and environmental impact mitigation are key players in the global stage today. Three major goals, namely the development of stable, affordable, and environmentally-sensitive energy systems have been defying simple solutions. The World Energy Council refers to the three goals as a major 'Trillema'.

UNEP's Green Economy initiative launched in 2008, states that the way forward for the world is to adopt an economic path that results in improved human well-being and social equity while significantly reducing environmental risks and ecological scarcities.

One of the ways to pursue green growth is to reduce carbon emission by enhancing energy efficiency and by investing in and developing renewable energy. A good energy strategy would definitely go a long way in enhancing social equity and reducing environmental risk, particularly climate change.

Energy derived from natural processes (e.g. sunlight and wind) that are replenished at a faster rate than they are consumed are referred to as renewable. Solar, wind, geothermal, hydro, and some forms of biomass are common sources of renewable energy.

Bottom: CNG (Courtesy: EAD)

Sipping energy

Energy efficiency measures are a proven means to reduce dependence on traditional energy resources, by using them more efficiently. With respect to electricity supply, for example, the typical power plant uses only 30% of its fuel for producing electricity; the remaining 70% of the fuel produces heat that generally is exhausted through tall stacks into the atmosphere. If the waste heat is used instead for additional power production, for industrial processes or for heating buildings, the efficiency of fuel use can be more than doubled, often to as much as 70%. Similarly, an industry that uses large amounts of heat in its processing often can produce very low cost electricity in conjunction therewith. The technology for achieving these savings is called "combined heat and power" or "co-generation". Building efficiency and appliance efficiency measures can save a large percentage of the fuel required for these large-consuming applications.

Energy efficient buildings would need:

- Ceiling insulation,
- to seal all gaps in doors, windows and so on,
- LED – avoid halogen,
- to install stand by power controller- automatically shuts off power,
- to educate building occupant that screen savers do not save energy and it is important to conduct energy audit,
- energy efficient equipment's – energy star labels,
- to match HVAC system and lighting output to occupancy – if the system is already programmed then check and retune the schedule if need be to suit occupancy period,
- to maximise lighting efficiency – would use less energy and generate less heat, and
- to use daylight to reduce artificial lighting.

Some future energy uncertainties

- Volatility in the prices and availability of rare-earth minerals (Dysprosium, Terbium, Europium, Neodymium and Yttrium) found in limited quantities in limited locations can hamper development of clean energy solutions such as wind turbines and solar power,
- carbon Capture use and Storage (CCS), an environmental technology to prevent large quantities of CO_2 from being released into the atmosphere from the use of fossil fuel in power generation and other industries, is as yet to be adopted in a significant manner. CCS, is currently the only way to significantly reduce the greenhouse gases from escaping into the atmosphere due to the burning of fossil fuels,
- increased need for consumption of meat and agricultural commodities will severely hamper the development of bio-fuels, and
- even with increasing focus on renewable energy carbon emissions continue to grow.

Energy sustainability options in the Arab region

The situation in Middle East and North Africa, also known as the MENA region, is considered unique in more ways than one. The region is home to 52% of proven oil reserves and 42% of the gas reserves (World Energy Scenarios: Composing energy futures to 2050 World Energy Council 2013) and having been located in hot and arid regions also has immense potential to generate renewable energy, especially solar and wind. While China and India have increasingly begun to dominate the energy demand and trade, the middle east will continue to play a very central role in any long term outlook.

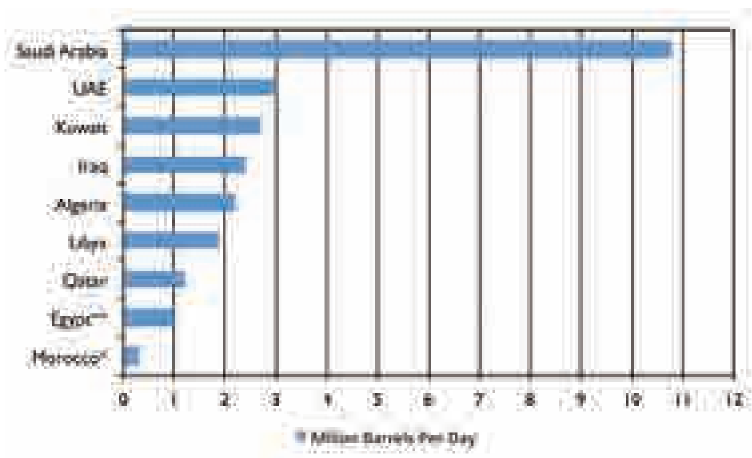
With substantial oil reserves, the cost of energy in most of the Arab world is heavily subsidised, and in most places energy is made available at the cost price. Cheap energy is perceived as a public good and hence most of the population takes cheap availability of energy as granted. In comparison with many developing countries in Africa and Asia, only 9% of (WHO and IEA database) the population in the middle east is without proper access to electricity. Yet, the fact-sheet of WEO (World energy Outlook 2013) clearly states that production and demand for oil will continue to grow in Middle East. This growth in regional energy consumption comes with an able economic and environmental cost.

The Arab Forum for Environment and Development (AFED) in its 5th report 'Survival Option', sums up the energy scenario in the region:

Since the early 1980s, the consumption of energy has grown faster in the Arab region than in any other region in the world, reflecting the proliferation of energy-intensive industries, and growing demand for electricity and transport by growing populations.

Against a backdrop of rising demand for electricity, increased oil price volatility, gradual depletion of fossil fuel resources, and growing climate change concerns, policy makers in Arab countries must address the lack of energy diversification, disparity in per capita energy use within countries and across the region, and the region's high carbon footprint, associated with high energy inefficiency.

Proven oil reserves in Arab countries



Thus, the need for shifting away from and economy based on finite fossil fuel extraction to one based on investments in diversified energy sources is more urgent than ever. Any consideration of meeting the region's growing demand for energy must include a focus on energy efficiency and renewable energy. Arab countries have a great potential for renewable energy, including solar and wind, as well as hydro and geothermal in specific locations, all of which are underutilised.

*Morocco, Somalia, Jordan, Lebanon and Djibouti
**Egypt, Mauritania, Yemen, Tunisia, Sudan, Syria, Oman and Bahrain

Bottom: Proven oil reserves in Arab countries (Courtesy: Arab Region Atlas of the Changing World)

UAE Energy scenario

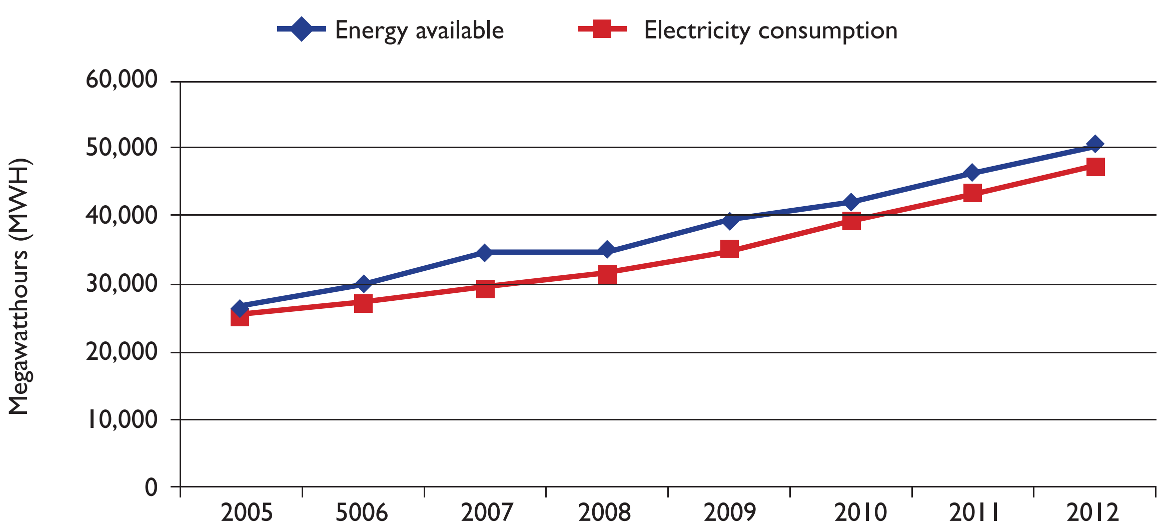
Hydrocarbon forms an integral part of UAE's economy. This is natural, with UAE possessing the world's 7th largest proven reserves of both crude oil and natural gas. During the 1930's global oil companies came for exploring oil reserves in the country. Since then there has been no turning back, and right since its inception in 1971, the country has relied on its large oil and natural gas reserves to support its economy. Even with the plan of strong economic diversification that the country has embarked on, oil still accounts for 42% of GDP (2013- UAE year book).

71% of all energy requirements in the UAE are met by natural gas and 29% is met by Oil. UAE currently lags in the diversification of the fuel mix for its energy needs. Major domestic sectors which consume energy are the power and water sector, transportation, the oil and gas sector and some heavy industries.

According to World Bank statistics (2012), UAE is rated as one of the World's highest *per capita* energy consumers in the World. Brunei, Luxembourg, Kuwait, Qatar, Trinidad and Tobago and Iceland are the 6 countries that precede UAE in energy consumption. Each person in the UAE consumes 8,271.5 of oil equivalent each year in comparison to 90 in Afghanistan, 1,806.8 in China and 7,164.5 in USA. Temperature and aridity are the two factors which dominate energy use in the UAE. With most of the potable water use met through desalination, the nexus between energy, water and food is very apparent in the UAE. Water and energy have a direct relationship in the UAE. Being a desert, the availability of renewable fresh water is very less with non-conventional sources of water such as desalination supplies water used to meet the scarcity and that is very energy intensive. Managing the energy footprint of water and water footprint of energy is indeed a daunting task in the UAE.

Despite being a hydrocarbon country, UAE's success in positioning itself as a leading green economy and a celebrated centre for research on alternative energy is quite laudable. The initiation of Masdar green community free zone in 2009, a location close to Abu Dhabi airport is an example of government led initiative that succeeded in both galvanizing the private sector and profoundly influencing public policy.

Energy available and energy consumed in Abu Dhabi



Bottom: Energy available and energy consumed (Courtesy: Energy and Environment Statistics 2012, Statistics Centre, SCAD)

The Abu Dhabi energy story

Abu Dhabi Emirate is the key player in the UAE's energy scenario with 95% of total reserves of crude and 92% of gas in the country. The jurisdiction of oil and gas falls under two authorities in the Emirate, the supreme petroleum council headed by H.H. The President of the UAE and the ADNOC group of companies (Abu Dhabi National Group of Oil Companies - www.adnoc.ae).

It is to be noted that, 51% of natural gas is used by the energy intensive power and water sector, chemical and other industrial uses are the second highest consumer of natural gas. The transportation sector is also energy intensive but as yet is largely dependent on oil. With an effort to reduce energy emission with cleaner natural gas, Abu Dhabi has initiated a law for using CNG (Compressed Natural Gas) in all Government and public transport systems, a fact that is likely to exert pressure on the production of natural gas especially, as much of the quality of Emirate's natural gas needs high investment to be made usable. These factors have led the Emirate to look towards importing natural gas.

Hence the major energy strategy of Abu Dhabi involves creating the right energy mix, which in addition to nuclear energy entails development of renewable energy such as the solar, wind and so on. Abu Dhabi aims to achieve a target of 7% of renewable energy by the year 2020.

The regulation and supervision bureau (RSB), an independent regulatory body for water and electricity in Abu Dhabi and the Emirates authority for standardisation and metrology are putting in great efforts to ensure there are systems in place for enhancing energy efficiency in the Emirate.

Bottom: Sun for lighting (Courtesy: EAD, SCI college)

The issues of energy consumption, climate change, water and sustainability are deeply intertwined. Sustainability in the context of energy consumption can mean different things:

- Finding ways of making current energy consumption levels sustainable, finding new sources,
- determining the right mix of energy sources to meet sustainability standards,
- reducing energy consumption and at the same time maintaining or enhancing quality of life, and
- inventing ways for equitable distribution of energy.

A WORD OF CAUTION!

It is very clear that technological advancement has neither been successful in reducing use of energy, nor has it resulted in reduction in size of our cities, or use of fossil fuels/resources. So we seriously need to question conventional technology based solutions to manage energy consumption.

When it comes to energy consumption four things are very important to establish:

- Our current energy sourcing pattern,
- current *per capita* energy consumption,
- potential to reduce energy consumption, and
- shifting sourcing of energy to renewables.

The solution is simple, either we need to produce more energy forever to meet demand and improve our quality of life, or we need to fit our energy demands within the potential of the present energy sources. Either way it is imperative to shift to renewable, clean energy sources and more efficient use.

Examples of college campus using the sun for lighting

ENERGY AUDIT

Stage 1: **Sourcing of energy**
Stage 2: ***Per capita* energy consumption**
Stage 3: **Potential for shifting to renewable**

Note: Energy consumption and climate change issues have a cause and effect relationship. The group of people handling these audits should work closely since information sourced can be shared by both groups.

Stage 1: Sourcing of energy

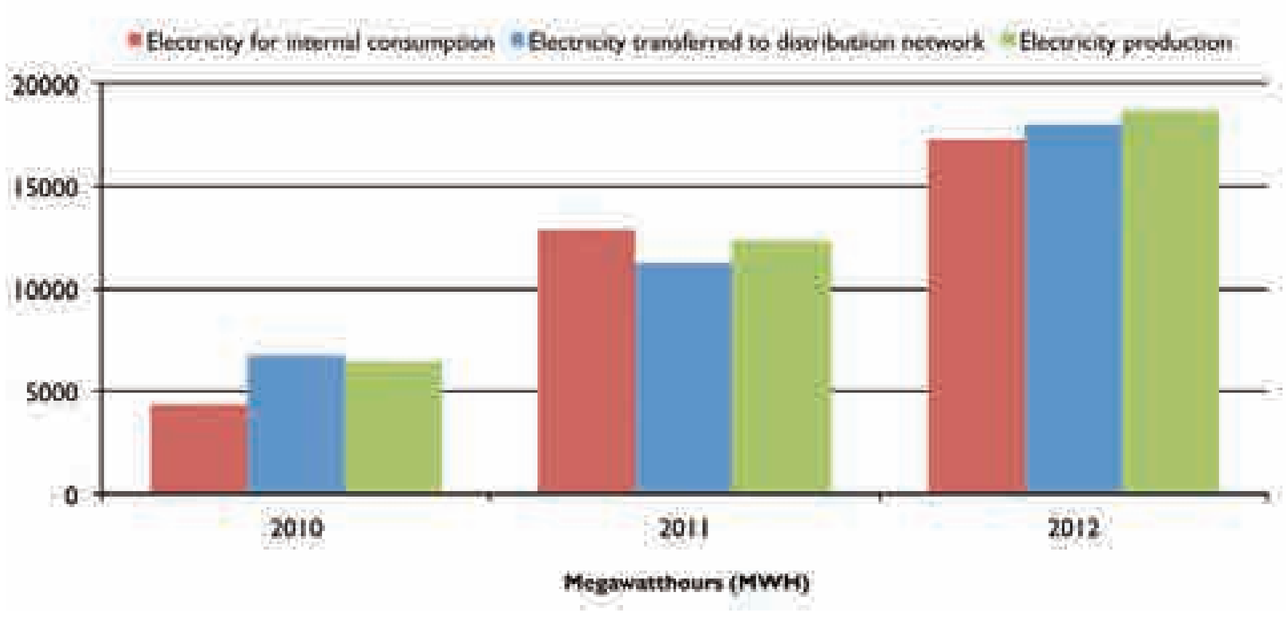
The campus administration and building management staff will have the information you need to determine the sources of energy on your campus. Organise a meeting with the representatives from the two agencies and explain to them the work you are planning to do. Adopt a participatory approach and do not indict anyone or any authority. The building management system (BMS) has accurate information on consumption of electricity.

Natural systems

Natural systems seem to have realised long ago that to be sustainable it is important to source energy available at the point of use. If energy needs to be distributed, it has to be distributed using material produced with renewable energy only. Today in most places on Earth (other than around rare volcanic vents) the primary source of energy is the Sun. Our entire biosphere is powered by the Sun. In hydrocarbons, nature found a way of storing Sun's energy for long periods of time.

Use table 2 to estimate monthly sourcing of energy on your campus. To convert fuel quantity to energy in Mega Joule (common unit), use table 1 on the next page.

Production and internal consumption of solar energy plants in Abu Dhabi



Bottom: Production and internal consumption of solar energy plants (Courtesy: Energy and Environment Statistics 2012, Statistics Centre, SCAD)

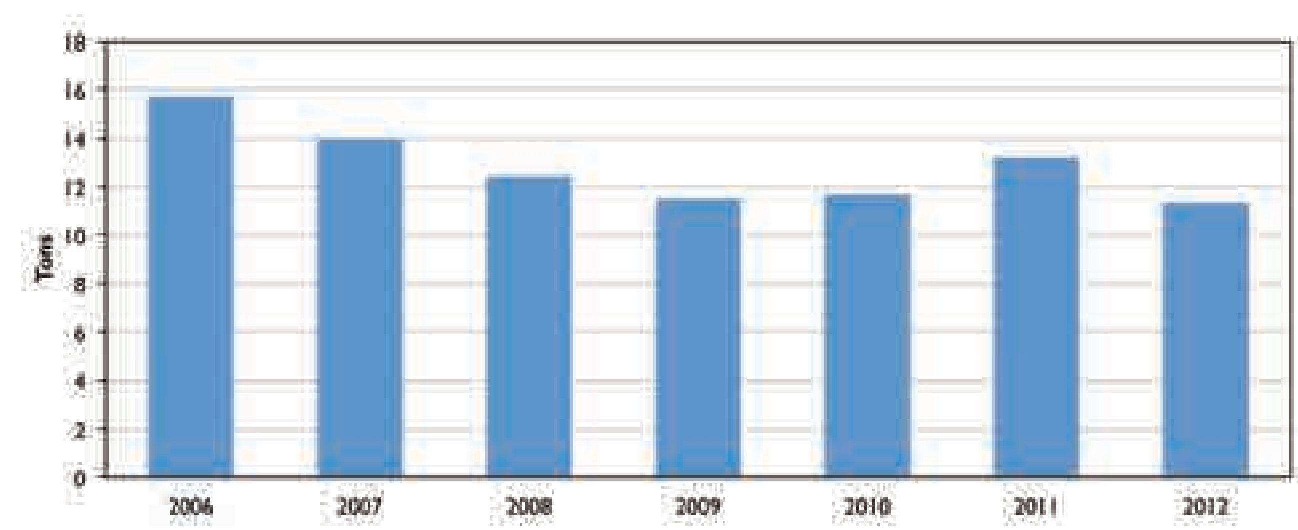
TABLE 1: Energy equivalents for various fuels

FUEL	ENERGY EQUIVALENT
Hydrogen	121 MJ/kg
Petrol/gasoline	*44-46 MJ/kg
	32 MJ/l
Diesel fuel	45 MJ/kg
	39 MJ/l
Crude oil	*42-44 MJ/kg
	*37-39 MJ/l
Methanol	20 MJ/kg
	18 MJ/l
Liquefied Petroleum Gas (LPG)	49 MJ/kg
Natural gas (UK, USA, Australia)	*38-39MJ/m3, 52.2MJ/kg
Natural uranium, in LWR (normal reactor)	500,000 MJ/kg (=500 GJ/kg)
Natural uranium, in LWR with U &Pu recycle	650,000 MJ/kg (=650 GJ/kg)
Natural uranium, in FNR	28,000,000 MJ/kg (=28,000 GJ/kg)
Uranium enriched to 3.5%, in LWR	3,900,000 MJ/kg (=3,900 GJ/kg)

**In case where a range for energy equivalent is given take the mean.*

MJ = Megajoule; GJ = Gigajoule; kg = Kilogramme; l = Litre
Energy equivalents = Multiple the amount of fuel x the appropriate energy equivalent.
E.g. 1,000 litres of diesel fuel x 39 MJ/l = 39,000 MJ

Per capita carbon dioxide emissions from oil and gas sector in Abu Dhabi



Bottom: *Per capita* CO_2 emissions from oil and gas sector (Courtesy: Energy and Environment Statistics 2012, Statistics Centre, SCAD)

The formation of hydrocarbons

Only a tiny proportion of organic matter – about 0.1% – escapes being consumed by bacteria or broken down into nutrients by physio-chemical processes. Transported by currents, this matter sometimes sinks to the bottom of the sea or great continental lakes. It is partly preserved in these poorly oxygenated environments, well away from tidal currents. It mixes with mineral matter (clay particles and very fine sand) and with dead marine plankton (microscopic animals and plants). This mixture is transformed into dark, foul-smelling mud by anaerobic bacteria.

Over time, this mud accumulates and hardens. Mud that contains at least 1-2% of organic matter can be transformed into source rock which eventually produces oil and gas deposits. The weight of accumulating sediment pushes the source rock further under the earth's crust from a few metres to a few hundred metres every million years or so. This gradual sinking, which can reach up to 8,000 metres, is called subsidence and leads to the formation of a sedimentary basin.

1 km underground, the temperature is already at 50°C and the pressure is at 250 bars. Under these physical conditions, the organic matter gradually changes and is converted into kerogen, an intermediate material made up of water, CO_2, carbon, and hydrogen, which is then converted into oil or gas. At depths of 2,000 metres, when the temperature underground reaches 100°C, kerogen starts to generate hydrocarbons:

- At between 2,000 and 3,800 meters, it turns into oil. This depth interval is known as the oil window.
- When the source rock sinks further, to depths of between 3,800 and 5,000 metres, the liquids produced become increasingly lighter and gradually turn into methane gas, the lightest hydrocarbon. This depth interval is known as the gas window.

With estimated average sedimentation of 50 metres every million years, 60 million years are required to change dead animals into liquid hydrocarbons, now located 3,000 metres underground. It is hardly surprising; therefore, that oil is classified as a non-renewable energy source.

Relation between renewable and non-renewable energy

Bottom: Relation between renewable and non-renewable energy by dpin350 (Purchased from www.cartoonstock.com)

TABLE 2: Monthly sourcing of energy

Source of energy	Uses	Quantity	%	In Mega Joules
Electricity	Lighting			
	Cooling			
	Heating			
	Equipment /Appliances			
	Transportation			
	Others			
Diesel	Lighting			
	Cooling			
	Heating			
	Equipment / Appliances			
	Transportation			
	Others			
Petrol	Transportation			
	Others			
*Gas	Equipment / Appliances			
	Transportation			
	Others			
**Aviation fuel	Transportation			
	Others			
Renewables (Specify)	Lighting			
	Cooling			
	Heating			
	Equipment / Appliances			
	Transportation			
	Others			
Total				

**The energy equivalents for CNG, LNG and LPG should be added together.*

Use information provided in table 2 to compile table 3.

TABLE 3: Energy consumption *per* month by source

Source	Electricity	*Gas	Petrol	Diesel	Aviation fuel	Renewable	Others
Lighting							
Cooling							
Heating							
Equipment / Appliances							
Transportation							
Others							
Total							

**The energy equivalents for CNG, LNG and LPG should be added together.*

Add the total of all the sources to get total energy consumption *per* month. Contact ADWEA office in the region to find out the mix of fuels used to generate electricity.

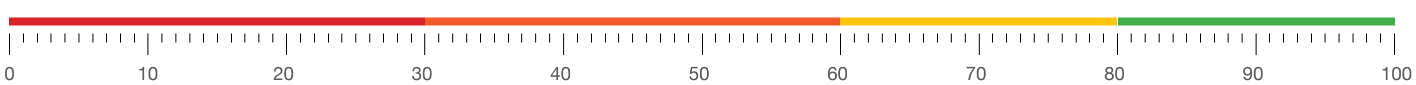
TABLE 4: Fuels used for electricity generation

Fuel type	Percentage of electricity generated
Gas	
Diesel	
Petrol	
Renewables	
Others	
Total	

Estimating sustainability:

Percentage of energy coming from renewable sources is sustainability percentage of the campus.

Depict the resource efficiency of your campus on the number line given below:



Community practices survey

It would be good to conduct energy sourcing audits for few households around the college. The household audits should sample houses representing different standard of living and different sizes. This would help the team to arrive at a reasonable average for the community. Any measures taken to improve sourcing of energy should be spearheaded by the community.

Stage 2: *Per capita* energy consumption?

The energy consumption being worked on here is routine energy consumption. There are no set standards for energy consumption. The general rule we seem to follow is how much we can get out of the total available. We strive to increase energy consumption, since it is synonymous with economic progress. Simply put, the more energy we can procure, the more we can use and the better off we are. Energy consumption can be reduced by use of energy efficient equipment. The campus must have been installed by energy efficient fixtures. Fill the table given below with information from the campus administration:

TABLE 5: Energy efficient fixtures/initiatives

Purpose	Energy savings	Cost savings
Lighting		
Cooling		
Heating		
Equipment / Appliances		
Transportation		

A word of caution here that reducing routine consumption of energy could come at a cost. It is equally important to be aware of the energy intensity of material efficiency fixtures and associated waste disposal issues.

Changing habits and compromising with a little comfort would go a long way in saving energy. Take the campus cooling system for example; raising the temperature of the thermostat a few degrees could save a lot of energy while at the same time be good for the health of the people who travel in and out of the airconditioned environment.

Energy and natural systems

It is not surprising that natural systems source energy from solar radiation and in rare instances heat from deep ocean volcanic vents. The energy source in case of the Sun is renewable in relation to Earth's geological timescale. The energy is transferred from one place to another on our planet using means that run on renewable energy. The wind and water currents carry energy from one place to another. Living organisms store and transfer renewable energy of the Sun from one trophic level to another. Material is created, assembled and transported at ambient temperature across the globe using renewable energy.

In Abu Dhabi the annual solar radiation averages out to 6.03 $kWh/m^2/day$. This is a substantial amount of energy. Say a family were to source solar radiation from 500 square metres of land area:

Energy available = 500 x 6.03 = 3015 kWh *per* day

Solar photovoltaic cells that convert 15% of sunlight to electricity are easily available.
3015/100 x 15 = electricity produced

Determine the *per capita*, *per* day electricity consumption of your campus.

To determine whether the electricity produced is enough compare *per capita per* day energy consumption with electricity produced at 15% effeciency by solar PV.

The efficiency we need to tap solar radiation = per capita *per* day energy consumption / 15% of solar PV potential of the campus

All we need is a more sustainable way of storing energy!

Per capita/per day **energy consumption on your campus**

Take total monthly energy consumption of your campus from Table 3.

Per day energy consumption =
Total monthly energy consumption of your campus / Number of days in that month

Per capita / *per* day energy consumption =
Per day energy consumption of your campus / *Total strength of your campus

*Include all employees, faculty, students, maintenance staff that comes to the campus every day.

To convert *per capita, per* day energy consumption from Mega Joule of energy to kWh.
Per capita, per day energy consumption in Mega Joule / 3.6 (1 kWh = 3.6 Mega Joule)

It is important that the *per capita, per* day energy consumption figure be displayed at appropriate places on the campus. It will help enhance awareness among the campus population, and encourage discussion between all stakeholders. In addition, it would also encourage management and authorities to consider the issue and be open to suggestions from the audit team to reduce energy use.

Unfortunately, CO_2 generated as a result of the consumption of non-renewable energy is the main cause of the phenomenon - 'Climate Change'.

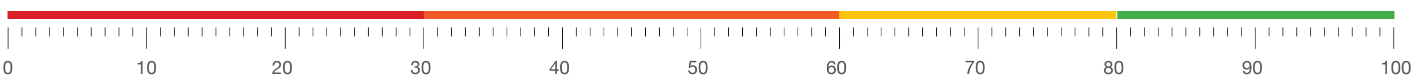
Estimating sustainability

If all the energy consumed on the campus comes from renewable energy sources and the audit group believes that there is no room for reducing energy consumption, then the sustainability in terms of energy consumption is 100%.

If the audit group decides that energy consumption needs to be reduced but fails to act on reducing energy consumption then sustainability is 0%.

Otherwise the annual target for reduction in energy consumption has to be set by the audit group as representative of the campus population. The percentage to which the campus population achieves the set target will be the sustainability % of the campus. Remember, to assess the impact of steps taken to reduce energy consumption.

Depict the resource efficiency of your campus on the number line given below:



Community practices survey

It would be good to conduct energy consumption audits for few households around the college. The household audits should sample houses representing different standard of living and different sizes. This would help the team to arrive at a reasonable average for the community. Any measures to reduce energy consumption should be spearheaded by the community.

Stage 3: Potential for shifting to renewables?

If we continue to heat, beat, and treat (the process we use to manufacture everything including solar cells and wind mills) to harvest renewable energy then we actually have not learnt from our mistakes. The challenge is not only to shift human civilisation to renewable energy but also to harvest renewable energy using material put together at ambient temperature. The primary criteria to assess whether our needs or wants are legitimate or not is to gauge whether the process used to meet them creates conditions that are conducive to life.

Young, enterprising people with out of the box thinking can reinvent responsible ways of sourcing energy required to run human civilisation. The intelligence used for reaching where we are today needs to be invested to discover ways of living sustainably on this planet. Let the campus be the laboratory to discover these new ways.

Renewable energy here means energy that is replenished faster than it is consumed. Like solar, wind and hydro-electric to some extent. Renewable source of energy means a source that can sustain itself on geological timescale. Like our Sun (Fossil fuels are a renewable source of energy if we use them slower than the rate it gets produced).

Setting an annual target

The audit group after consulting with all the stakeholders on campus would decide on the target for switching to renewable sources of energy. The target has to be at least 5% of the total energy consumed by the campus population in 1 year. For larger campuses this could be less but in such cases the audit group will have to justify setting a lower target.

Total energy consumption *per* annum / 100 x 5
(The target could be set in kWh or Mega Joules)

Discussions and debates with all the stakeholders should be encouraged, to arrive at practical options for achieving the target. The audit group could also invite experts from government and non-government renewable energy agencies to help them with setting a target and achieving it. The only option for not shifting to renewables would be reduction in energy use.

Estimating sustainability

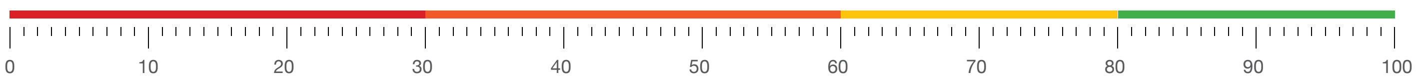
If the campus already runs on 100% renewable energy or it achieves the target set by the campus community or shifts to renewables by a minimum of 5% of its total energy consumption, its sustainability is 100%.

In case the campus does not run on 100% renewable energy or/and the campus community fails to make a measurable shift towards renewable energy the sustainability score is 0%.

Otherwise the percentage of switch to renewable energy sources in relation to the annual target will be the sustainability percentage of the campus.

Remember, to assess the impact of steps taken for moving towards renewables, a similar audit will have to be conducted once again at appropriate time.

Depict the resource efficiency of your campus on the number line given below:



Community practices survey

It would be good to conduct renewable energy scoping studies for few households around the college. The household audits should sample houses representing different standard of living and different sizes. This would help the team to arrive at a reasonable average for the community. Any measures to shift towards renewable energy sources should be spearheaded by the community.

Community action

The working group should organise a meeting with the representatives of the community and the energy management authorities to discuss the findings. If the group thinks there is something that needs to be taken up at the policy level with local administration, a draft should be prepared and submitted for consideration through proper channel. Any action to improve energy use practices should be taken up by the community independently.

List down the steps that need to be taken to ensure overall sustainability of energy use in the region:

INDIVIDUAL	INSTITUTION	COMMUNITY

Analysis of the audit

The working group should organise a meeting with the core group to discuss its findings. If the group thinks there is something that needs to be taken up at the policy level with campus administration or government, a draft should be prepared and submitted for consideration through proper channel.

Research and experimentation

Research and experimentation on new ways to improve energy management at any level should be taken up as a project related to the discipline students are studying on campus. The same can also be taken up as an independent research or internship project with private parties with the due permission of competent authorities.

WASTE
A WASTED RESOURCE

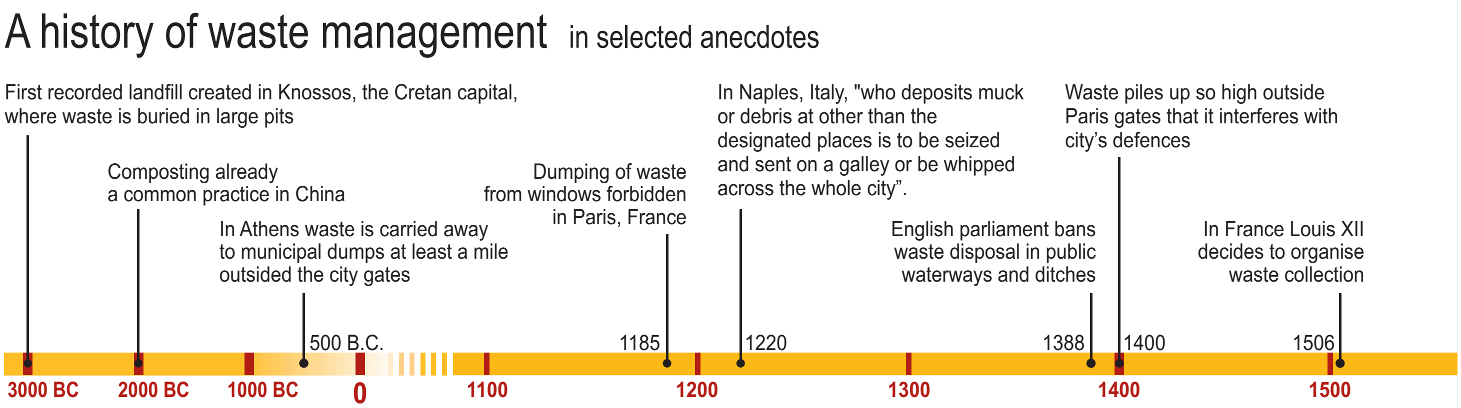
Globally, waste is a very complex and a controversial issue. Waste, or trash as we know it, is not a 20th century phenomena. According to the GRID-Arendal, a centre collaborating with UNEP, the first recorded landfill was created in Knossos in around 3000 B.C.E.

WHAT IS WASTE?

Although the word, waste, has many definitions, one of which refers to by-product of most processes in nature. Usually, natural systems have the capacity to absorb the generated waste and convert it back to a resource at a point in its lifecycle. Natural systems, thus, are self-regulated and can scale up or decrease the capacity to absorb waste depending upon the requirement. Microbes control recovery and absorption of nutrients for all living organisms–the fungi on bread, termites on wooden furniture, decaying leaves are all evidence of the natural waste recovery mechanism at work.

Waste, for the purpose of this manual, signifies the flow of materials or by-products that are discarded by humans (with no more primary or secondary use for them) and produced as a result of their manufacturing processes, transportation, distribution of goods, materials and as a result of their consumption patterns. Even though such processes produce liquid, solid and gaseous waste, the current discourse in this chapter mainly deals with the category of solid waste. One of the main causes of this waste is due to the fact that there is no felt or perceived need for the use of the material so discarded. Most perceptions about waste are related to human behaviour.

Left: Waste (Courtesy: EAD)



Sources: US Environmental Protection Agency; National Energy Education Development Project, Museum of Solid Waste, 2006; Ecollect, 2006; Waste online, 2006; Environment Switzerland 2000; Stadtreiningung Hamburg.

How big is the global garbage bin?

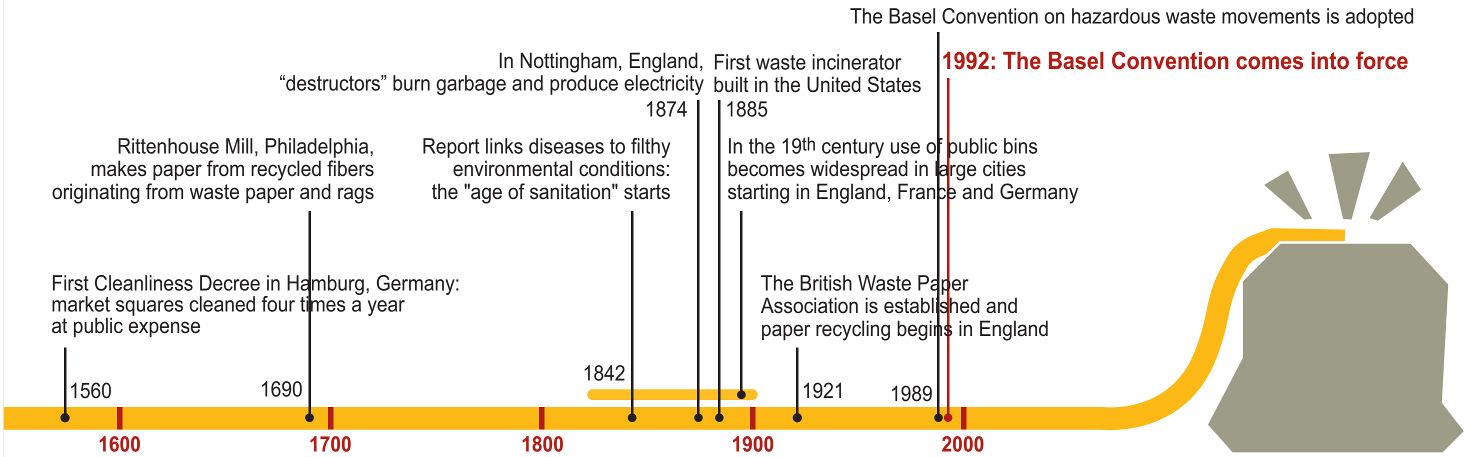
Globally, data on waste is most difficult to estimate. According to a review undertaken by World Bank on global solid waste management in 2012, solid waste generation is inextricably linked to urbanisation and economic development. Currently three billion people live in urban areas. As countries urbanise and their economic wealth increases, there is a corresponding increase in the standards of living and disposable income amongst people. This automatically results in the increased consumption of goods and services. There is a direct correlation between this and increasing amounts of waste. The report estimates that at present almost 1.3 billion tonnes of, or 1.2 kg/capita/day of MSW (Municipal Solid Waste) is generated globally every year. The actual *per capita* rates of waste, however, are highly variable, as there are considerable differences in waste generation rates across countries, between cities, and even within cities.

Even though the process of urbanisation and the growth of cities has a long history, past cities were essentially small settlements with low populations and a large rural hinterland, and hence produced less quantities of waste. Resource use was limited, and waste was largely organic in nature. Initially, waste used to be thrown on to streets and roads, later with increased urbanisation, it was taken out of the city gates and thrown in open pits. Despite growing mounds of waste and an unplanned waste management system, environmental impact was minimal as most of the waste was organic in nature and therefore easily decomposed. Wood is organic too but deomposes less easily and metal wastes used to get passed on to the next generation.

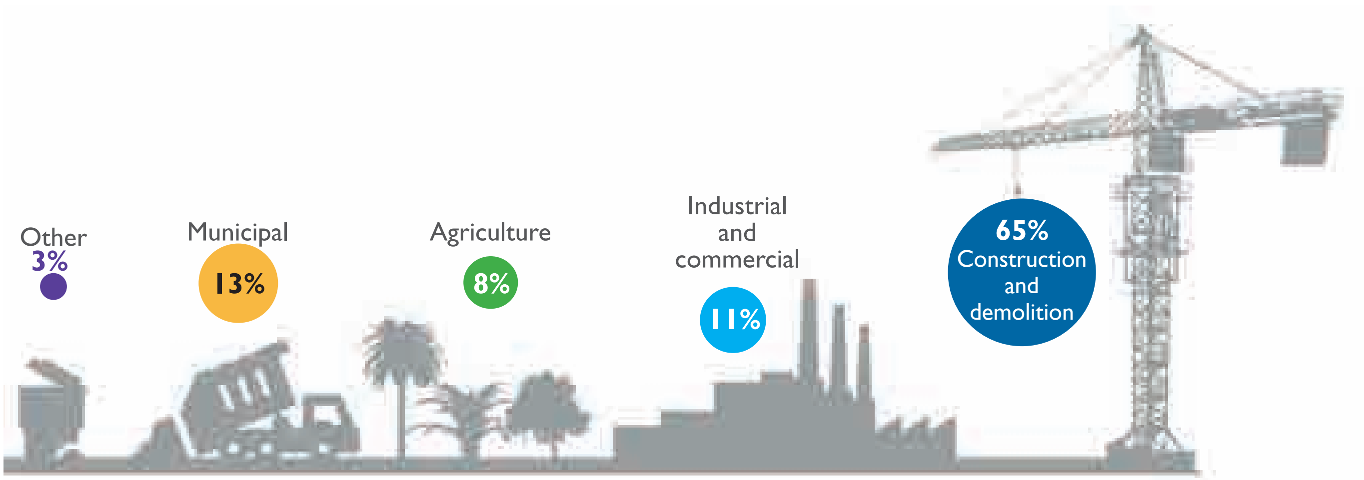
The waste scenario changed drastically during the 19th and the 20th century as not only the quantities but also the variety of waste increased multi-fold. The non-biodegradable waste increased many times over. The composition of waste seems to be influenced by culture, economic development, climate and energy sources. In general, low-income countries have more organic waste and high income countries have more paper, plastic and inorganic material in their waste stream. With a wide variety and increasing volumes, nature can no longer manage waste.

In the absence of a sound integrated waste management strategy, most recoverable materials end up in the landfill. The problem gets compounded by the fact that with increasing population and ever growing consumption, continued resources are drawn for the production of newer manufactured items.

Top: History of solid waste (Courtesy: http://www.grida.no/graphicslib/detail/a-history-of-waste-management_118d)



Abu Dhabi solid waste by type



Top: Solid waste in Abu Dhabi by type (Courtesy: Environment in figures 2013, Statistic centre, SCAD)
Bottom: Waste recycling by cgon369 (Purchased from www.cartoonstock.com)

Why is waste a problem?

The root cause of the problem is the fact that, our material use right from inception to disposal is linear (from cradle to grave – from mining to discarding of the manufactured item). One must admit that it is almost impossible to run unsustainable linear resource use cycle on a planet which has finite sets of resources.

Reaffirming the argument that resource use is directly proportional to waste generation is the fact that developed countries with only 22% of the world population, consume more than 60% of the industrial raw materials. These countries are also responsible for maximum waste generation. While the ecological footprint, the measure of the amount of productive land area needed to support a nation's consumption and waste, clearly indicates that the capacity of the planet to supply resources to meet the demands and aspirations of growing population is already creating a resource deficit, the excessive use of resources is still rampant.

Non-biodegradable solid waste is easy to recycle

Mixed solid waste is difficult to manage

Bottom centre: Non-biodegradable solid waste (Courtesy: EAD)
Bottom: Mixed solid waste (Courtesy: EAD)

Top: Recycle it (Courtesy: https://c2.staticflickr.com/8/7257/7699041718_8bc640fba7_h.jpg)

Where to keep waste?

Managing waste has always been a cost-intensive public service rendered by the government. While the *per capita* waste generation is less in the developing countries, with low budgets for managing waste they are also the ones facing the biggest waste challenge with their current rate of waste collection being lower than 50%. In these countries, waste in most cities is collected and dumped in arbitrary dump sites with no appropriate controls, thus posing a major environmental risk. Another daunting task for the developing countries is also the fact that, many among them are emerging economies and hence their contributions to total global waste is expected to increase steeply, with no proper waste management systems currently in place.

However, in the high income or developed countries with high *per capita* waste, landfilling and thermal treatment of waste are the most common methods of MSW disposal. With no reliable data, on the range and diversity of waste generated from the mining, manufacturing, agricultural, medical and household sector, it is difficult to plan effective management of waste.

While many developing countries have a good waste segregation and recycling systems, it should not be forgotten that recycling is energy intensive. From the energy used in transportation of recyclable material to the recycling facility to the energy used in actual recycling process. The best option is to prevent the generation of waste in the first instance.

Dumping waste in the desert

Bottom: Dumping waste in the desert (Courtesy: EAD)

Future waste!

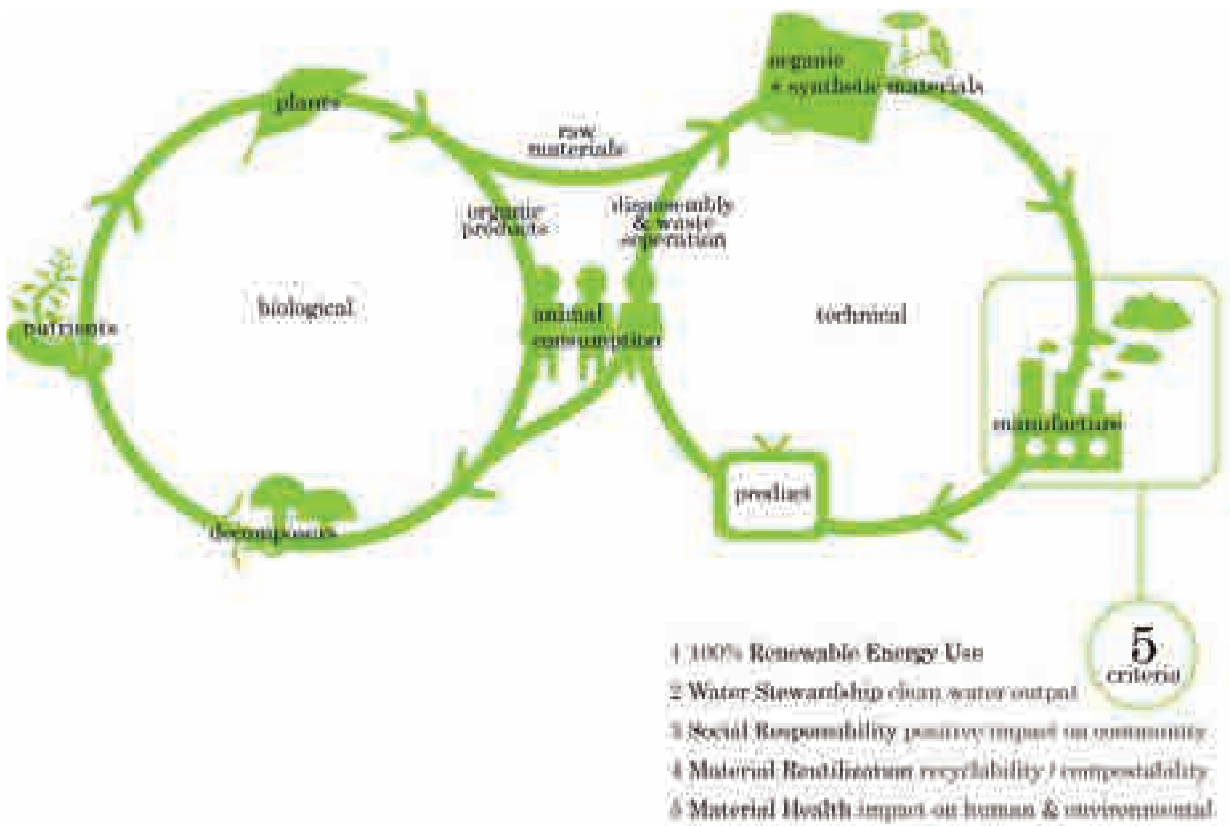
In the future, with increasing population and urbanisation, urban waste is set to increase globally-this means more waste shall be directed towards landfills. Electronic waste is the fastest growing waste stream in the world, currently at 20-50 Million tonnes each year, (GEO-Outlook 5) and is set to increase multi-fold in the future. This is one of the most complex wastes as it contains not only hazardous materials such as lead, mercury, BFR (brominated flame retardants), also strategic metals such as gold, palladium and rare earth minerals. Global debate among the waste regulators is also centred around nano-materials or particle wastes about which there is very little data and knowledge.

Waste effect?

Improperly managed waste poses risk to human health and the environment. Uncontrolled dumping and poor waste handling can lead to contamination of water, land and air. This can pose an increasing hazard to human health. Hazardous waste, in addition to being chemically damaging to the environment and human health, also brings with it increased risk of fire and explosion.

An increasingly alarming concern is the contribution of waste to climate change. Around 3-5 % of greenhouse gas emission comes from the waste sector. While this emission is only from the waste that has been disposed, it is more important to consider the impact of goods that have been used and disposed, from the life cycle perspective. Right from the production to disposal/recycling stage there is the issue of energy use which directly leads to climate change.

Cradle to cradle



Bottom: Cradle to cradle by Zhying.lim (Courtsey: http://en.wikipedia.org/wiki/Cradle-to-cradle_design)

Waste in the Arab Region

Despite having similar cultures, countries in the Arab world vary widely with respect to economic standards, purchasing power, consumption patterns, population and energy availability. All these factors have a direct correlation to waste generation. Data on solid waste is available only from few countries in the Arab region. In general, as *per* AFED (Arab Forum for Development), 2008 report, the Arab world contributes to 81.3 million tonnes of waste annually. Each person contributes to about 0.7kg of waste on a daily basis. GCC countries are listed as among the top 10 in the world in terms of *per capita* waste generation. Only 20% of waste gets adequately treated while recycling accounts for less than 5%.

In terms of composition of waste, organic waste constitutes the largest part. In some countries such as Jordan, Syria, Iraq, Lebanon and Yemen, the percentage of organic to other waste is more than 50%. GCC countries as expected of countries with higher income groups, have more of paper, plastic, metal and construction waste.

Challenges in the Arab world

Some countries, notably the GCC countries, have established waste management systems that have some monitoring mechanisms that ensure safety procedures are observed while dealing with handling of solid waste. While some Arab countries have developed an integrated waste management strategy most of them do not have a clear cut waste management system.

The main challenges that affect the waste management system in the Arab world are:

- Lack of surveys, data, statistics on waste,
- lack of sound environmental legislations on waste management,
- limited infrastructure, lack of funds,
- low level of awareness, and
- limited institutional framework to deal with soaring waste volume.

Solid waste from the transportation sector

Bottom: Waste tyres area at Al Dhafra dump site (Courtesy: EAD)

Changing nature of waste!

While the estimates of hazardous wastes range between 1.6%-3.2% of the total waste in the Arab Region, the inadequate processes related to handling of the hazardous waste in the Arab world is of special concern. According to the UNEP's Basel convention regional project report, there is adverse impact of hazardous waste on humans and the environment.

Even though e-waste contributes a very small percentage of the total waste in the Arab world, there is now increased concern on the same with increasing mobile phone penetration and internet net connectivity. This poses yet another dimension to the existing challenges of waste management, given the already weak system that exists currently for managing MSW.

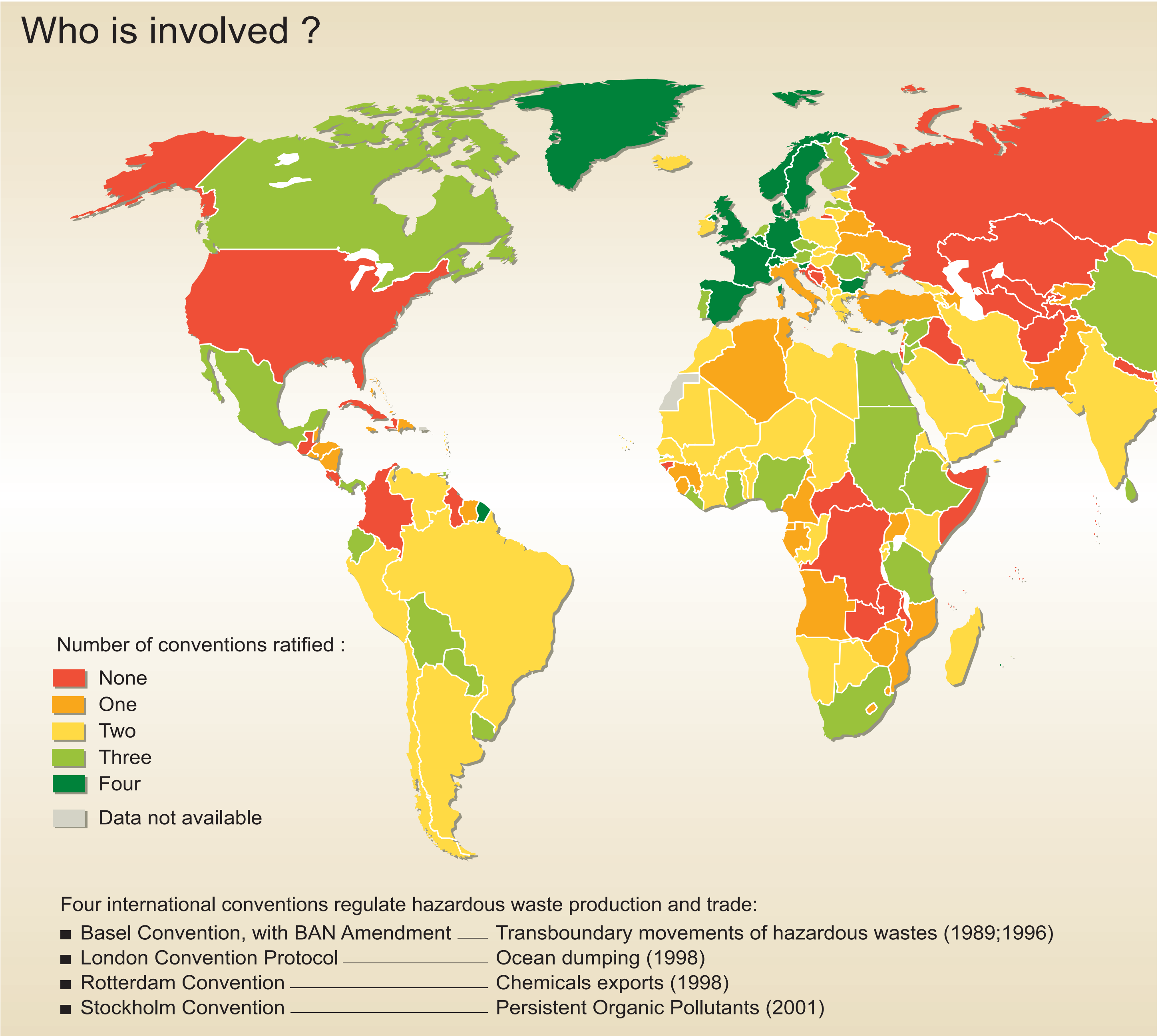
The issues of solid waste speak volumes of the way we value our environment today. We have an endless thirst for developing technologies that will enable us use more and more resources to improve our quality of life. We expect our environment to endlessly provide raw materials/resources for us, and also absorb all the waste we generate.

Waste in the UAE

With high GDP, *per capita* income and purchasing power, *per capita* waste in the UAE is quite high, between 1.8-2Kg. The waste generated by the residents of UAE is almost 6 times more than that generated by a French resident. While at the country level, law number 4 issued in 1999, articulates how waste should be managed. Variations exist at the operational level among different Emirates. This is due to the varied local needs, technology available and institutional frameworks.

Construction solid waste

Bottom: Construction solid waste (Courtesy: EAD)



BASEL CONVENTION

Currently while 66% (2012) of the waste stream ends up at landfills, Sharjah is striving to be the first Arab city to divert 100% of its waste from landfills. More than 20% of all waste sent to landfill in the UAE is recyclable. UAE also hopes to realise its dream of establishing the first waste to energy plant by 2016.

In the context of contribution to total waste, Abu Dhabi tops the list followed by Dubai and Sharjah. The percentage share of the other Emirates are low. 98.7% of the waste is non-hazardous and 1.3 % is hazardous. In terms of recycling of waste, Sharjah tops the list followed by Abu Dhabi and Dubai.

Top: Basel convention countries (Courtesy: http://www.grida.no/graphicslib/detail/who-is-involved-the-making-of-international-legislation_d19c)
Bottom: Basel convention logo (Courtesy: http://www.toxicswatch.org/2013/09/cop11-of-basel-convention-report.html)

Sources: Basel Action Network, November 2005; Secretariats of each convention, October 2006.

Basel convention

National definition of waste used for the purpose of trans-boundary movements of waste exists in United Arab Emirates. All hazardous and non-hazardous remnants and wastes, including nuclear wastes, disposed of or need to be disposed of, in accordance with the provisions of the law and include:

Solid Wastes: such as domestic, industrial, agricultural, medical, construction and demolition wastes.

Liquid Wastes: produced by domestic, commercial, industrial and other premises.

Gaseous (smoke, vapour and dust) Wastes: produced by domestic premises, bakeries, incinerators, factories, crushing plants, stone quarries, power stations, oil works and means of transportation and communication.

Hazardous Wastes: residues or ash of different activities and operations containing properties of hazardous substances.

Medical Wastes: Wastes constituted wholly or partially of human or animal tissues, blood or other body fluids or excretions or drugs or other pharmaceutical products or bandages, needles, syringes, sharp medical objects or any other contagious, chemical or radioactive wastes produced by medical or nursing activities, treatment or health care, dentistry or veterinary and pharmaceutical practices or manufacturing, research, teaching, sample taking or storage.

Abu Dhabi is striving to implement an integrated waste management plan in accordance with 'Vision 2030'. Currently the *per capita* waste in Abu Dhabi is about 1.5 kg *per* day. The responsibility for managing waste in Abu Dhabi is split between Center for Waste Management (www.cwm.ae) which takes care of most of the waste generated (MSW, green waste, medical waste, construction waste and so on). ADNOC (Abu Dhabi National Oil Company) is responsible for Oil and Gas waste, and the Federal Authority for Nuclear Regulation (FANR) handles radioactive waste, which is currently at minuscule quantities as the nuclear plant is not yet functioning.

Major issues with waste in the Emirate of Abu Dhabi are:

- High rates of waste generation,
- systems for waste collection and transportation are not yet fully streamlined,
- limited recycling and waste treatment,
- nearly 60% of the waste is disposed at dumpsites, (Add graph Chart (4) SCAD: Percentage distribution of municipal solid waste by method of disposal – 2012),
- some of the waste disposal sites are not sustainable and need to be strengthened with proper environmental safeguards,
- land filling currently emits methane which is a more potent greenhouse gas than carbon dioxide. This could be easily avoided through a sound waste recovery process,
- currently waste contributes to approximately 3% of carbon emissions most of which is in the form of methane emissions, and
- while the percentage of hazardous waste as a proportion to total waste is less, only 27% of it receives special treatment (SCAD 2012). There is a need to build more specialised hazardous waste management facilities.

As *per* the integrated solid waste management hierarchy, *per capita* waste generation needs to be reduced, and this can only be done with sound awareness and education programmes.

While EAD is responsible for policy and regulations, the Center for Waste Management (CWM) set up for operational management of waste in the Emirate has developed an integrated waste management strategy to establish a world class sustainable waste management system, that aims to divert polluting waste away

Wooden flooring recycled from construction wood waste

Bottom: Recycled wooden flooring (Courtesy: EAD) from landfills and maximises resource recovery. Optimising recycling, promoting re-use, as well as limiting production, form a core part of the centre's efforts to protect the environment.

CWM has so far established a number of waste treatment plants, and has introduced a commercial tariff system for collection and transportation of waste. They plan on installing solar powered recycling bins on all the main streets of the Abu Dhabi city to encourage recycling among residents.

Sustainability in the context of solid waste production and management means that:

- We learn material recovery from natural systems,
- reduce material use in our life styles, and
- develop technologies that will enable us to recover material after use.

A WORD OF CAUTION!

A word of caution before you set out. Technological advancement has not resulted in reduction in quantity of solid waste we generate. We seriously need to question the ability of conventional technology based solutions to manage solid waste. The simple solution is to use less material in the first place, for as long as possible, and ensure complete, energy efficient material recovery from what we dispose.

When it comes to solid waste the management on your campus the following are very important:

- Quantity and types of solid waste produced,
- material recovery processes in place, and
- types and quantities of solid waste that are sent to the landfill.

Composting is the best way to restore soil fertility

Bottom: Compost (Courtesy: http://upload.wikimedia.org/wikipedia/commons/5/53/Compost-dirt.jpg)

WASTE AUDIT

Stage 1: **Types and quantities of solid waste produced.**
Stage 2: **Solid waste segregation?**
Stage 3: **Types and quantities of solid waste from which materials are recovered.**

Stage 1: Types and quantities of solid waste produced.

On one hand packaging enables distribution of material goods around the world, while on the other, once the material goods reach the consumer, the package is the first thing that is disposed of as solid waste. Some part of the material good also soon finds itself in the disposal bin. Either it is no longer usable or it is replaced by an upgraded product. The same applies to edible stuff, disposed first is the package and some of the edible stuff also soon follows. The moment the material good leaves your hand, it is transformed from a resource to solid waste. Most of the solid waste on the campus is generated in this fashion.

There are people on the campus already managing solid waste. The campus administration would know about these people and it is suggested that a meeting be organised with them. The audit group would brief them about the work being done and spell out the help needed from them. Table 1 will help the audit group spell out the information required from the house keeping staff. The collected information will help the audit group arrive at types and quantities of solid waste generated on the campus.

Describe the audit requirements to the house keeping staff. To arrive at any quantity of solid waste they must segregate and weigh the waste. Calculate average from the quantity of solid waste they find on different working days of the week. Therefore, determining quantities for different types of solid waste will take a minimum of one week.

Waste collection bins

Bottom: Waste collection bins on college campus (Courtesy: EAD, SCI college)

Table 1 below determines types and quantities of solid waste produced on the campus.

TABLE 1: Types and quantities of solid waste

Type of Space	Quantity							*Average
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	
Paper								
Organic								
Plastic								
Wood								
Metal								
Glass								
E-Waste								
Chemicals								
Others								

**Calculate the average by adding the quantities of waste on different days for a type and divide by the number of days.*

Hazardous chemicals will be dealt separately. Check labels for the nature of chemicals. The chemicals in the above table should be non-hazardous in nature. Some types of waste will be generated only once or twice a year. Their quantity should be divided by the number of months to get monthly generation. These quantities should also reflect in calculation of *per capita* waste generation for the campus.

To determine the *per capita* solid waste generation on the campus:

$$\frac{\text{Total solid waste generated } per \text{ day}}{\text{Total number of people on your campus}}$$

Reducing the quantity of solid waste

Display the quantity of solid waste produced on the campus in different places where people assemble. Establish a target for reducing the quantity of solid waste produced. Start a campaign and seek participation of as many people as possible. Assess the quantity of solid waste produced on the campus with the help of housekeeping staff to determine the reduction in quantity of solid waste. Display the reduction in quantity of solid waste achieved every now and then to encourage people to put in more effort.

Keep the solid waste management authorities of the region in the loop and seek their help as and when required.

Community practices survey

It would be good to conduct solid waste generation audits for few households around the college premises. The household audits should sample houses representing different standard of living and different sizes. This would help the team to arrive at a reasonable average for the community. Any measures taken to reduce generation of solid waste should be spearheaded by the community.

Stage 2: Solid waste segregation?

The first step towards appropriate solid waste management is segregation of solid waste preferably at the source by producers of solid waste. This would mean that the people who are producing solid waste need to dispose it separately. We can broadly divide solid waste into two categories biodegradable and non-biodegradable.

The primary responsibility of segregating solid waste, at least in two categories of biodegradable and non-biodegradable, lies with the producer of solid waste at the point of disposal. The segregation of solid waste could also be handled by the housekeeping staff after collection from primary dustbins. This practice can be thought of being as effective as segregation at source, while in reality this does not help as much in proper management of solid waste.

Biodegradable and Non-biodegradable waste

As the terms indicates any type of solid waste that is a product of a biological process and can be degraded using biological processes is known as biodegradable waste or organic waste. The other, non-biodegradable type of solid waste would require physical, chemical processes to degrade, inorganic waste. Waste water will be considered as bio-degradable. Wet waste and dry are other common terms used for indicating these categories.

Segregation of solid waste, at least in these two categories increases the potential for material recovery manifolds. People will realise the importance of segregation if they try to manage the solid waste produced on the campus themselves for a few days.

The housekeeping staff on campus has already helped in determining the total quantity of each type of solid waste produced on the campus. As a second step to that seek the cooperation of the house keeping staff in determining the percentage of solid waste segregated on the campus. In table 2 mention the quantity produced by type, weekly average and mention who segregates solid waste, the producers at source or the housekeeping staff.

To calculate percentage of solid waste segregated:

$$\frac{\text{Quantity of solid waste segregated}}{\text{Total quantity of solid waste produced for the type}} \times 100$$

TABLE 2: Segregation of solid waste

Type of Waste	Quantity							*Average	Segregated by
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7		
Paper									
% segregation									
Organic									
% segregation									
Plastic									
% segregation									
Wood									
% segregation									
Metal									
% segregation									
Glass									
% segregation									
E-Waste									
% segregation									
Chemicals									
% segregation									
Others									
% segregation									

Continue to share the data collected with regional solid waste management authority.

Five R's

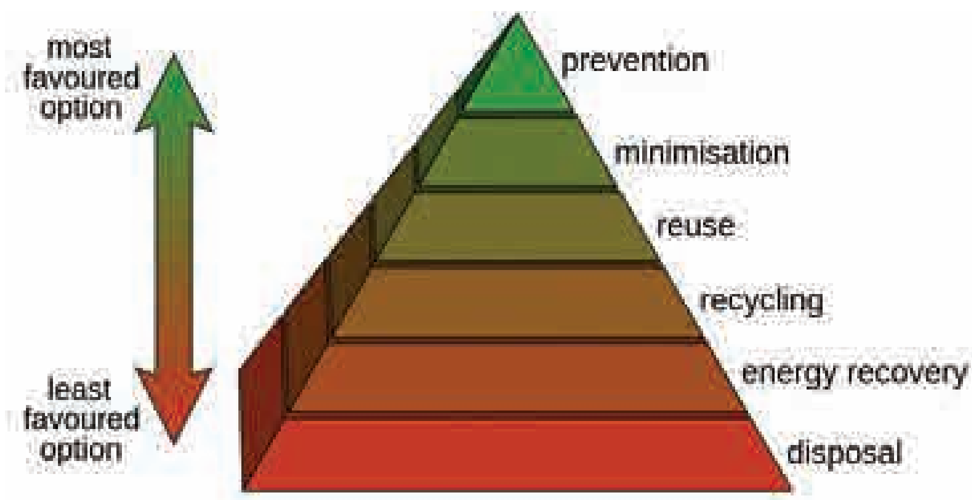
Reduce

Repair

Reuse

Recycle

Rot



Bottom: Five R's (Courtesy: http://hr.wikipedia.org/wiki/Odr%C5%BEivost)

Estimating efficiency

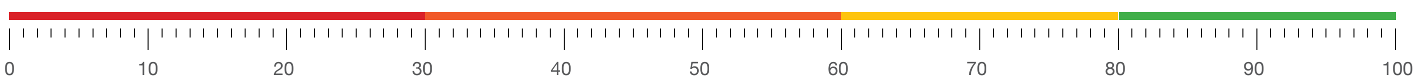
If all the solid waste produced on campus is segregated the sustainability is 100%.

If the campus does not segregate any solid waste its sustainability is 0%.

If otherwise the sustainability % =

$$\frac{\text{Sum of average for each type of solid waste}}{\text{Total number of types of solid waste}}$$

Depict the sustainability of the campus on the graph given below:



Community practices survey

It would be good to conduct solid waste segregation audits for few households around the college. The household audits should sample houses representing different standard of living and different sizes. This would help the team to arrive at a reasonable average for the community. Any measures taken for segregation of solid waste should be spearheaded by the community.

Stage 3: Types and quantities of solid waste from which materials are recovered

The next stage of investigation requires the housekeeping staff to work in collaboration with the waste disposal company. The data for what is recovered from the solid waste by housekeeping staff and waste disposal company needs to be collected. Table 3 below gives an idea of what kind of data is required.

The time frame in which certain types of solid waste is produced and its quantities will vary. Some types of waste will have monthly quantities while some like e-waste can have quantity *per* year. Please mention the time frame of the quantity in table 3 to avoid confusion. The waste disposal company should be able to give an estimate of quantity that can be recovered for each type of solid waste. This assessment will be done by the disposal company on the basis of disposal practices on the campus and recovery facilities available within the country.

TABLE 3: Solid waste recovery

Type of waste	Quantity generated	Quantity that can be recovered	Quantity recovered	Means used	Time Frame	% recovered
Paper						
Organic						
Plastic						
Wood						
Metal						
Glass						
E-Waste						
Chemicals						
Others						
Total						

Segregation of solid waste is the first step towards material recovery

Bottom: Waste bins for segregation (Courtesy: EAD)

Solid waste in natural systems

It is strange that natural processes manage to reuse all the waste they generate. Coming to think of it after this audit, it is not hard to imagine why nature goes all the way to manage the waste it generates? And like everything that natural processes make, waste is also managed:

- at ambient temperature,
- using renewable energy only, and
- using processes that can replicate themselves and are self-regulated.

Imagine if we could manage solid waste we produce in similar fashion! Take for example, if plastic could be created within the restrictions posed by the three principles mentioned above? Or more importantly if it could be disintegrated within the restrictions posed by the above three principles. No wonder then, that natural processes go all the way for putting together stuff at ambient temperature that to using materials sourced using renewable energy only because temperature is a property of light and heat (energy) and nature works very hard to tap both from the Sun.

Estimating sustainability

Solid waste that is used again or is recycled to make similar or new material would be considered as recovered. Solid waste quantity recovered by an external agency will also be considered in the recovery estimates of the campus. The only criteria for consideration of solid waste as recovered are facilitation of recovery process by people on the campus.

If the campus recovers 100% of recoverable solid waste of each type then its sustainability is 100%.

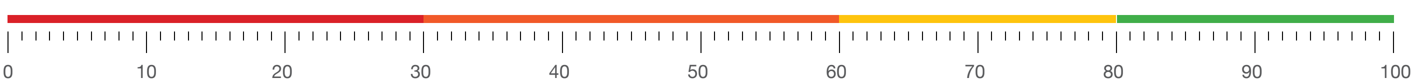
If the campus recovers 50% or less of the total recoverable solid waste of each type then its sustainability is 0%.

If the campus recovers more than 50% but less than 100% of total recoverable solid waste of each calculate sustainability using the following formula:

% of solid waste recovered by type – 50 x 2

$$\text{Total sustainability \%} = \frac{\text{Sum of sustainability \% by type}}{\text{Number of types}}$$

Depict the sustainability of the campus on the number line given below:



Community practices survey

It would be good to conduct solid waste recovery audits for few households around the college premises. The household audits should sample houses representing different standard of living and different sizes. This would help the team to arrive at a reasonable average for the community. Any measures taken to recover solid waste should be spearheaded by the community.

List down the steps that need to be taken to ensure overall sustainability of managing solid waste in the region:

INDIVIDUAL	INSTITUTION	COMMUNITY

Solid waste and Climate change

Biodegradable solid waste releases methane (CH_4) when it degrades. Methane happens to be green house gas (GHG) which is 23 times more potent than carbon dioxide (CO_2). Most methane is generated when biodegradable solid waste is buried in the landfill. Composting of biodegradable solid waste is desirable because the process produces less Methane and also results in production of fertiliser for plants.

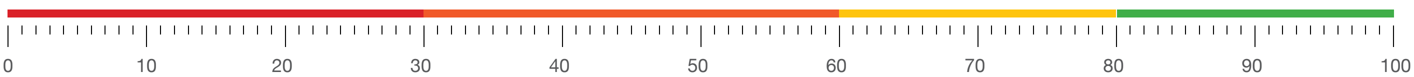
Recovering material from non-biodegradable waste in most cases is an energy intensive process. The use of energy contributes to production of Carbon Dioxide and other green house gases. If incinerated (burnt at high temperatures) this type of solid waste also produces dioxins and other toxic gases. Transporting solid waste from one place to other also adds green house gases to the atmosphere.

THE CAMPUS AT A GLANCE

Water audit

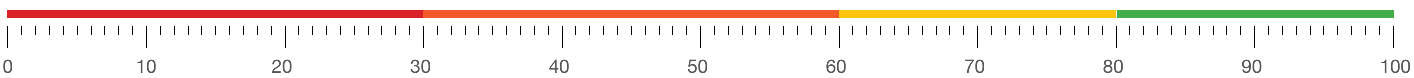
Stage 2: Current consumption of water?

Depict the resource efficiency of your campus on the number line given below:



Stage 3: Wastewater management?

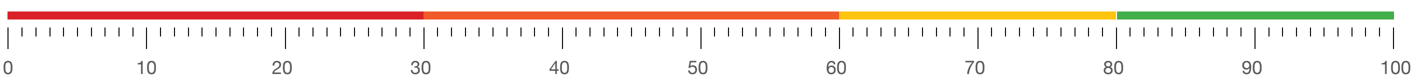
Depict the resource efficiency of your campus on the number line given below:



Climate audit

Stage 3: Reduction in emission of carbon dioxide?

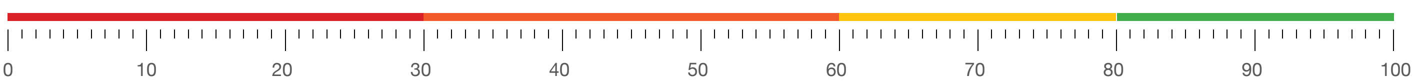
Depict the resource efficiency of your campus on the number line given below:



Land audit

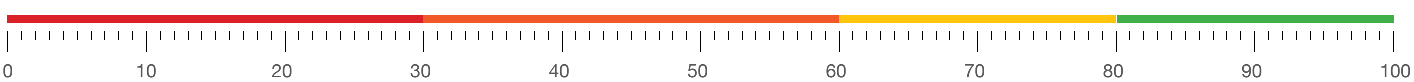
Stage 3: Biodiversity of your campus?

Depict the resource efficiency of your campus on the number line given below:



Stage 4: Pesticide and fertiliser use on campus?

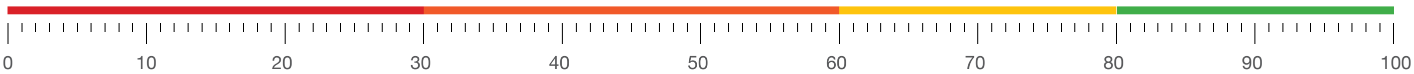
Depict the resource efficiency of your campus on the number line given below:



Energy audit

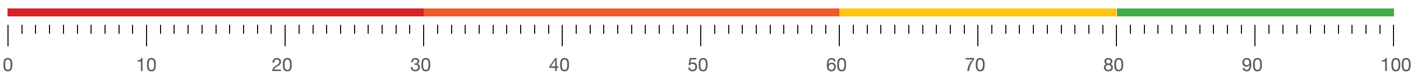
Stage 1: Sourcing of energy

Depict the resource efficiency of your campus on the number line given below:



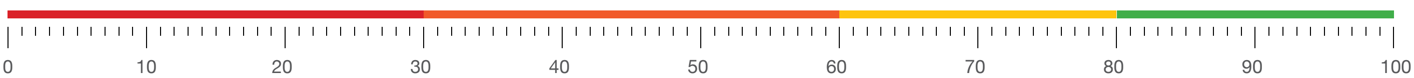
Stage 2: *Per capita* energy consumption

Depict the resource efficiency of your campus on the number line given below:



Stage 3: Potential for shifting to renewable

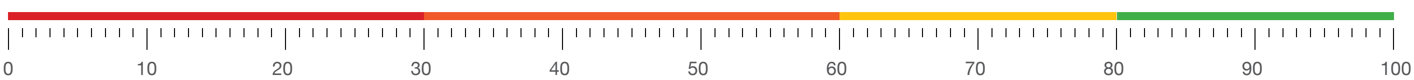
Depict the resource efficiency of your campus on the number line given below:



Waste audit

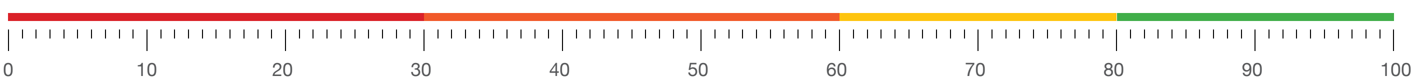
Stage 2: Solid waste segregation?

Depict the resource efficiency of your campus on the number line given below:



Stage 3: Types and quantities of solid waste from which materials are recovered

Depict the resource efficiency of your campus on the number line given below:



Bibliography

Introduction

Articles and books

Phillip Sutton, April 2004

Arnim Wiek, Lauren Withycombe & Charles L. Redman, March 2011

Executive summary, Arab Environment: Future challenges 2009

Mostafa K. Tolba and Najib W Saab

Executive summary, Arab Environment 5, Survival options

2012 report of the Arab forum for Environment and Development (AFED)

Key competencies in sustainability: a reference framework for academic program development by Arnim Wiek • Lauren Withycombe Charles L. Redman, 30 March 2011

Websites

http://www.un.org/en/sustainablefuture/pdf/rio20%20concludes_press%20release.pdf, 10 November, 2013

http://www.un.org/en/sustainablefuture/sustainability.shtml, 10 November, 2013

http://www.unep.org/Documents.Multilingual/Default.aspDocumentID=52&ArticleID=73, 11 November, 2013

Water chapter

Authorities, books and articles

2012 SCAD

Websties and Power point presentations

http://www.adwea.ae, 4 January, 2014

http://www.addc.ae, 4 January, 2014

http://www.aadc.ae, 4 January, 2014

http://www.adsse.ae, 4 January, 2014

http://www.rsb.gov.ae, 4 January, 2014

http://www.aaas.org/international/ehn/waterpop/acreman.html, 5 January, 2014

http://www.waterworld.com/articles/2012/10/new-thermal-desalination-process-claims-1kwh-m3-energy-use.html, 5 January, 2014

http://en.wikipedia.org/wiki/Desalination, 5 January, 2014 *http://www.unwater.org/downloads/water_for_food.pdf*, 6 January, 2014

http://www.unep.org/dewa/vitalwater/jpg/0211-withdrawcons-sector-EN.jpg, 6 January, 2014

http://www.worldwater.org/datav7/data_table_19_per_capita_bottled_water_by_country.pdf, 6 January, 2014

http://www.rsb.gov.ae/en/PrimaryMenu/index.aspx?PriMenu_ID=203&PriMenu_Name=, 7 January, 2014

Adapted from power point presentation: Dr. Mohamed A Dawoud, Adviser – *Water Resources, Environment Agency, Abu Dhabi*, 10 January, 2014

http://www.waterexhibitionadach.ae/downloads/3.pdf, 18 April, 2014

http://www.uaeinteract.com/spanish/news/default.asp?ID=365, 18 April, 2014

Climate chapter

Articles and books

Mustafa K Tolba and Najib Saab,2009

U.S. Forest Service and International Society of Arboriculture joint publication, 2011

'Inventory of Carbon & Energy (ICE)' V2.0, was compiled and written by Prof. Geoff Hammond & Craig Jones, 2011

Websites

http://slipr.com/2009/10/02/how-much-oil-does-the-world-use-in-a-day/, 12 January, 2014

http://numero57.net/2008/03/20/carbon-dioxide-emissions-per-barrel-of-crude/, 12 January, 2014

http://www.iea.org/co2highlights/co2highlights.pdf, 12 January, 2014

http://people.exeter.ac.uk/TWDavies/energy_conversion/Calculation%20of%20CO2%20emissions%20from%20fuels.htm, 12 January, 2014

http://www.ecoscore.be/en/how-calculate-co2-emission-level-fuel-consumption, 12 January, 2014

http://www.bath.ac.uk/mech-eng/sert/embodied/, 14 January, 2014

http://www.constructionstudies.ie/modules/wt4106-materials-tech-/inventory-of-carbon-and.pdf, 14 January, 2014

http://cdiac.ornl.gov/pns/faq.html, 14 January, 2014

http://chemistry.about.com/b/2011/04/26/how-much-oxygen-does-one-tree-produce.htm, 14 January, 2014

http://www.globalccsinstitute.com/insights/authors/derektaylor/2011/11/11/how-much-carbon-dioxide, 14 January, 2014

http://www.climatechange2013.org/images/uploads/WGI_AR5_SPM_brochure.pdf, 14 January, 2014

http://unfccc.int/essential_background/items/6031.php, 14 January, 2014

http://www.mofa.gov.ae/mofa_english/portal/2666c727-3cea-4483-9791-56462f752166.aspx, 10 April, 2014 *http://climate.ku.dk/green_campus/*, 10 April, 2014

http://bit.ly/biRxxM, 10 April, 2014

http://www.barari.ae/, 10 April, 2014

http://edition.cnn.com/2013/10/29/world/climate-change-vulnerability-index/, 10 April, 2014

http://www.greenlime.com.au/Coccos%3A-Global-Coolers.php, 15 January, 2014

http://bluecarbonportal.org/, 15 January, 2014

http://www.treehugger.com/clean-technology/wetland-restoration-the-best-alternative-to-carbon-capture-and-sequestration-technologies.html, 15 January, 2014

Land chapter

Articles and books

Colwell, 1997

Whitman et al., 1998

Cockell, 2005

Millennium Ecosystem Assessment, 2005

Hooper et al., 2005; Balvanera et al., 2006; Cardinale et al., 2006

Gans et al., 2005; Sogin et al., 2006; Rusch et al., 2007

Verstraete et al., 2007

Arab Region – Atlas of Our Changing Environment (AGEDI, UNEP), December, 2013

IUCN, 2008

Lund,2008

Falkowski et al., 2008

Cockell and Jones, 2009

Sutherland et al., 2010

Eisenhauer et al., 2010

Abu Dhabi development statistics 1960-2010 SCAD

Abu Dhabi Environment Strategy 2008 – 2012

Websites

http://www.unep.org, 16 January, 2014

http://unchronicle.un.org/article/interaction-climate-change-and-land-degradation-experience-arab-region/, 16 January, 2014

http://www.unep.org/GEO/geo2000/aps-africa-arab/index.htm, 16 January, 2014

http://www.afedonline.org/afedreport09/english/Char8.pdf, 20 January, 2014

http://www.geohive.com/earth/his_ history1.aspx, 20 January, 2014

http://www.world-builders.org/lessons/less/biomes/primaryP.html, 20 January, 2014

http://www.world-builders.org/lessons/less/biomes/primaryP.html, 20 January, 2014

http://www.rgs.org/OurWork/Schools/Geography+in+the+News/Ask+the+experts/Urban+ climatology.htm, 21 January, 2014

http://www.rgs.org/OurWork/Schools/Geography+in+the+News/Ask+the+experts/Urban+ climatology.htm, 21 January, 2014

http://www.globalchange.umich.edu/globalchange1/current/lectures/kling/microbes/microbes.html 21 January 2014

*http://www.ecomena.org/tag/land-degradation-in-middle-east/,*14 April, 2014

https://www.cbd.int/doc/meetings/sbstta/sbstta-17/information/sbstta-17-inf-16-en.pdf, 14 April, 2014

http://www.afedonline.org/afedreport09/english/Char8.pdf, 14 April, 2014

https://www.cbd.int/doc/meetings/sbstta/sbstta-17/information/sbstta-17-inf-16-en.pdf, 14 April, 2014

Energy chapter

Articles and books

http://www.iea.org/publications/freepublications/publication/KeyWorld2013.pdf, 18 April, 2014

The Arab Forum for Environment and Development (AFED) in its 5th report 'Survival Option', 2012

http://www.unep.org/climatechange/mitigation/Portals/93/documents/EnergyEfficiency/UNEP_Energy_Handbook.pdf, 18 April, 2014

http://www.ren21.net/Portals/0/documents/Resources/GSR/2014/GSR2014_KeyFindings_low%20res.pdf, 18 April, 2014

Websites

http://science.howstuffworks.com/transport/flight/modern/question192.htm, 25 January, 2014

http://www.iea.org/publications/worldenergyoutlook/resources/energydevelopment/, 25 January, 2014

http://www.ren21.net/REN21Activities/GlobalStatusReport.aspx, 25 January, 2014

http://www.bp.com/statisticalreview, 25 January, 2014 *http://www.adced.ae/en/economicreview/Article.aspx?Article_ID=69*, 25 January, 2014

http://www.planete-energies.com/en/energy-sources-/oil-and-gas/oil-and-gas-deposits/the-formation-of-hydrocarbons-8.html, 25 January, 2014

http://world-nuclear.org/info/Facts-and-Figures/Heat-values-of-various-fuels/, 25 January, 2014

http://www.solarteksystemsusa.com/10-fun-facts-about-solar.html, 25 Janauary, 2014

http://reports.weforum.org/energy-for-economic-growth-energy-vision-update-2012/, 16 April, 2014

http://www.resilience.org/stories/2011-10-20/role-energy-economic-growth, 16 April, 2014

http://www.un.org/millenniumgoals/poverty.shtml, 16 April, 2014

http://www.unep.org/newscentre/Default.aspx?DocumentID=2791&ArticleID=10885&l=en, 16 April, 2014

http://www.worldbank.org/en/topic/sustainabledevelopment/brief/water-energy-nexus, 16 April, 2014

http://vitalsigns.worldwatch.org/vs-trend/record-high-global-greenhouse-gas-emissions, 16 April, 2014

http://www.wrenuk.co.uk/, 16 April, 2014

https://www.bchydro.com/powersmart/business/power_smart_tips.html, 18 April, 2014

http://www.iea.org/aboutus/faqs/renewableenergy/, 18 April, 2014

Waste chapter

Articles and books

What a Waste! A global review of solid waste management by World Bank March, 2012

Websites

http://www.waste-management-world.com/articles/print/volume-12/issue-4/temp/arabian-blights.html, 27 January, 2014

http://www.intechopen.com/books/integrated-waste-management-volume-ii/municipal-solid-waste-management-in-developing-countries-future-challenges-and-possible-opportunities, 27 January, 2014

http://www.green-middleeast.com/Solid_waste.html, 28, January, 2014

http://www.cwm.ae, 28 January, 2014

http://www.grida.no/graphicslib/detail/a-history-of-waste-management_118d, 02 February, 2014

http://www.grida.no/publications/vg/waste/page/2857.aspx, 02 February, 2014

http://www.grida.no/graphicslib/detail/waste-management-hierarchy_5dc9, 02 February, 2014

http://www.bgreen.ae/analysis/1524/waste-and-recycling-in-the-uae/, 20 April, 2014

http://www.basel.int/, 20 April,2014

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