Delivering Impact through STEMS: The Imperative

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This is the critical phase for us and also for the planet as a whole. Those who concern might have already raised their eyebrows while reading the first sentence. And may be, instead of thinking a little, some of the readers have already started to judge me and consider me pessimist or sceptic. An issue such as **climate change** is really big and that calls for an immediate and immense change in societal behaviour and human attitude. This and other relevant matters have therefore forced themselves to the front of international attention in recent times.

Climate change impacts ecosystems; deterioration of environmental health is one of the vital issues associated with it, which we now face and no country is spared. Problems pertinent to the human-induced climate change mainly include water quality, food security, growing use of natural resources, and of course the popping-up of pathogenic or viral attacks, etc. Some of the indicators of climate change are global warming, changes in the timing of seasonal life-cycle events, heat or temperature change, shifting range, unknown diseases, food chain disruptions, ecological imbalance, extinction risks, etc. Now is the time to understand the scientific, technical and socio-economic impact of climate change and consequently the fleeting & evanescent Nature.

We know that climate is always under the influence of its internal dynamics, the earth's own natural processes and also under the external forcing(s) such as earth's orbital movement, its variable space journey, solar activities, radiations or magnetism. There is not much value in having indicators that tell us that the climate and ecosystem have already deteriorated. And, it is not wise if we blame external forcing(s) as the only cause for today's weather patterns. Energy from the sun is distributed by ocean currents, tides, winds and other such mechanisms affecting the local regions and their climatic system (e.g. thermohaline circulation). We - the human race might have ignored caring the planet's finite resources as much as we do care our infinite ambitions. Believe it or not, most of the problems are due to anthropogenic activities. Weather, in particular the Indian monsoon, is remarkably disturbed in a changing climate. Climate change increases flood risks for some areas whereas there is severe drought at other places. Due to the climate change, the mean sea-levels are increasing and the India's 7517 km long coastline, for example, is becoming vulnerable day-by-day. Another example is that of Mumbai (formerly Bombay) city where the coastal

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flooding is common. In 2005, single-day heavy rainfall in Mumbai claimed more than 1000 lives. And, may be due to such heavy rain, high tides and movement of earth's surface (plate tectonics), Mumbai – the city built on reclaimed land of seven islands – keeps crumbling in the rainy season every year. Another distinct example is that of the greenhouse gas emissions causing global warming. India which is set to become the world's most populous nation by 2030 reported more than 2000 deaths due to the summer heat of the year 2015.

Negligence to sustaining the earth and the human's greed for industrialization and economic development in pursuit of material wealth have already cost this planet a lot. Some concerns like me believe that research and scientific evidence are the keys to coping with these issues. Without that, it will not be possible for industrial enterprises, governments, society or individuals to think about the problems we face and to find a way out. In order for us to achieve that understanding, there is an urgent call for political-will and also to put in place various legislative frameworks for (i) integrative global approach in tackling such issues; (ii) adopting preventive measures locally to planet deterioration; and most importantly (iii) generating value from conserving the natural systems and their resource development. On the ground of the aforementioned considerations, scientific community and the local authorities or social councils should adopt a continuous or at least seasonal monitoring of causes or consequences and thereby frame local correctives to climate systems for supporting the habitat and also for sustaining the overall planet health. Their recommendations can directly shape the government's priorities, inter-governmental agencies and also the international agreements on climate change. It is good to know that off late the governments of India and Chile have sought for advice on sustainable technology transfer and implementing relevant policies.

Generally speaking, *sustainability* is the term describing *endurance of systems and processes*. Brundtland Commission (1987) - the United Nations' Commission on Environment and Development defined Sustainable Development as "*the development that meets the needs of the present without compromising the ability of future generations to meet their own needs*." The Earth Summit (1992) - the United Nations' Conference (in Brazil) on Environment and Development: *There is this urgent need to find a more sustainable way of life; reduce environmental emissions and use resources carefully*. The Earth Summit also advocated to move towards a model in which environmental enhancement is fully integrated with economic development. As a result of these efforts (and also the Johannesburg Declaration & Plan of Implementation, 2002), today (i) the environmental policy making process and (ii) scientific research in most of the developed nations rely heavily on the transition to sustainable production and consumption patterns. In September 2015, the world leaders / countries (will) discuss and establish a set

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of global goals to eradicate poverty, to progress and prosper by adopting those (proposed) sustainable development goals (SDG). The United Nations' SDG mainly emphasize the importance of health, prosperity and well-being of all people.

There are no doubts that sustainable development has become the buzzword of the century. Many refer this term (merely) to going "green" and caring for ecology and environment. The previous industrial outlook mocked the need of *sustainable development*. When the late entry of its burden was likely to become a hurdle to industrial development in economic point of view, the sustainability apathy grew in industries. The members of the World Business Council for Sustainable Development (WBCSD) have signified the business value of sustainable development and pinpointed social responsibility and liability on the part of corporate enterprises that use hazardous materials in their processes or products. The WBCSD coined the term "*eco-efficiency*" in its year 1992 publication "*Changing Course*" and this new business concept is meant for implementing the "*Agenda*-21" in the private sector. The *Triple Bottom Line for Industry* given by the WBCSD includes (i) economic prosperity and continuity for the business and its shareholders, (ii) social well-being and equity for both employees and affected communities, and (iii) environmental protection and resource efficiency or conservation, both global and local. Despite economic and environmental concerns, the sustainability efforts are rarely complemented on the social front which I think is essential to achieve a workable and well functioning system. This clearly hints to the social perspective tackling poverty, inequality and inclusive growth. In most cases, industrialists and politicians do everything (i) *for their own good* and (ii) *good to only their set of people* or *institutions* leaving disproportionateness around. Innovative ideas along with social responsibility should be recognized. People need to develop more practical approaches to sustainability. And, we need to look for more success stories like that of the solar energy.

Historical records show that scientific advancements accounted for substantial changes in our life-style and wellbeing. The Industrial Revolution took place in the western countries around 1700s when people first appreciated the terms 'science' and 'technology' and valued the applications of 'technological innovations' for their commercialization. During the World Wars, people experienced use of science and technology for destructive purposes. Though industrialization is considered as an essential feature of economic growth, it - at times - is infamous due to the adverse environmental health consequences caused by the release of pollutants. Human beings should express their gratitude to the planet. Policies are being placed to create a course of action, followed by enactment (of a law), and then rules & regulations that are designed to carry out that law successfully. Today, the environmental policymaking process in most of

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the developed nations relies heavily on the transition to sustainable production and consumption patterns. Public support is being generated through organized ways to educate all about the environmental issues and research. In the spirit of that, recent science has seen major advances in the ongoing endeavours directed towards diminishing the impact of anthropogenic and industrial activities on the environment. The time has come when we concern and care for our planet and heal its damage or deterioration that has happened due to our past activities. Some of the greatest benefits to public from science include medicine and energy. Though the 20th century science revolutionized the living standard of mankind, the major disadvantages of this progress are now being identified as significant pollution through green-house gases, heavy metal toxicity, eutrophication, persistent organic pollutants, etc. In India, for example, the measures adopted in the "Green Revolution" increased agricultural production and made India self-sufficient in food grains but unfortunately the excessive usage of chemical pesticides and fertilizers are now found to cause negative effects on the soil, land, water, our body and its metabolism.

The **S**cience, **T**echnology, **E**ngineering and **M**athematics (STEM) are considered as prudent and even strategically important subjects forming the basis for technocracy, skilled human resource in industries, innovation and knowledge based economy. The 20th century science and technology revolutionized the living standard of mankind and offered solutions to great socio-economic or strategic challenges of the time through knowledge transfer and commercialization. In other words, any country's engineering turnover and manufacturing sector today rely mostly on STEM economy. People think that mathematics requires a lot of wisdom and judgment, and they feel others are better in mathematics than they are. Rather than studying the world directly, the mathematicians actually create models of the world. Researchers look forward to demonstrating various phenomena mathematically. An ideal mathematical model is expected to be accurate enough to be useful, and also that it should be simple and elegant enough to generate realistic and interesting applications. Mathematics has applications in many branches of science including chemistry, green & industrial engineering, and even in total cost assessment and life-cycle assessment, etc. Mathematics finds its applications in quantum chemistry: single-variable calculus, muti-variable calculus, differential equations, complex functions, group theory, probability and statistics, linear algebra, etc. EATOS is an interesting and easy-to-use tool for environmental assessment of organic syntheses (www.metzger.chemie.uni-oldenburg.de/eatos/). Similarly, the concept of *E-factor* (http://www.sheldon.nl/roger/efactor.html) provides the impetus for developing sustainable processes in particular in the pharmaceutical industry and this focuses on the problem of waste generation in chemical manufacturing. A very strong STEM subject teaching, training and continuing professional development are required to produce top scientific research and

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STEM skilled workforce. Governments of the so-called developed countries have long identified *STEM Education & Communication* as their top priority at school level and now at university level (higher education). The basic challenges for STEM teaching are (i) to help students successfully pass the examinations and get the certificates or degrees, and (ii) to help youngsters identify how these subjects are fascinating and could lead to more specialized, satisfying, varied and rich careers.

Off late, we at the *Razak Institution of Skills, Education and Research (RISER) – a registered charity in India* have identified *STEM for Sustainability* as our top priority at developing skills, educational programmes, research and also at the level of entrepreneurial business ventures in collaboration with *Isak's Consortium for Higher Education, Research and Entrepreneurial Sustainable Development*. The basic challenges for *STEMS Research & Enterprise* are (i) to help research bring multi-disciplinary or trans-disciplinary approaches in their application and (ii) to help youngsters identify how these subjects can develop economy and environment hand-in-hand and how this initiative could lead to more innovative, satisfying and sustainable entrepreneurship / enterprises. I believe that sustainability in itself is a multi-disciplinary field. Sustainability has emerged as the broadest and all-encompassing concept of all and it (sustainability) is one of the few significant words that will soon (and should) be carried over broadly outside the scientific language. The appeal and slogan on offer are: "concern and care" (for the planet). At present, because of the pollution, climate change and related environmental issues, science-technology-engineering-mathematics i.e. STEM appear to be even more important than before. Historically, these subjects offered one of the major sources of improvements in our planet. I believe that there is a need to move toward a model in which sustainability is integrated with STEM (Science, Technology, Engineering & Mathematics) as our approach and attitude for economic, environmental, strategic, and social development. Therefore, the acronym "**STEMS**" was firstly coined during the first Conference on **S**cience, **T**echnology, **E**ngineering, **M**athematics and **S**ustainability (C-STEMS 2014) at Nanded, India with the theme, "STEMS: Inspiration for Research and Applications." And, this new approach of STEMS is meant for implementing the model in which sustainability is integrated with STEM for overall sustainable development and care for the planet. This is the first and the one-and-only conference series of its kind where sustainability is considered as all encompassing phenomenon and almost the fundamental occupational concern.

The Second Indian (National) Conference on Science, Technology, Engineering, Mathematics and Sustainability (IC-STEMS 2015) calls upon staunch supporters for a sustainable society, industry, ecology and environment. The *Razak Institution of Skills, Education and Research* (RISER) on "No-Profit-No-Loss basis"

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brings together like-minded people on a common platform to discuss the importance of sustainability and also to reflect on "how ? and why ?" to make people give priority to STEM subjects in the planning and execution of their sustainable agenda. The IC-STEMS 2015 is only the second in a series of research conferences in which the RISER India uses the research it supports to illustrate the change that today's world (in particular India) faces, and this is also meant to point to evidence that might help the people to solve immediate sustainability problems and make the most of opportunities. Such initiative is supposed to inspire the consortium of higher education research, entrepreneurial and industrial interventions on the challenges of sustainable development fostering shared prosperity while protecting the planet through STEMS and relevant trans-disciplinary approach. And, this shall consequently groom researchers, philosophers, thinkers, entrepreneurs, stewards or leaders who consider sustainability as the development.

This year, the conference provides a national forum for high-level discussions to researchers, academicians, industrial personnel, professionals and policy makers interested in the latest developments in science, technology, engineering, mathematics and sustainability (STEMS). Though "STEMS" is not a widely accepted acronym, many foreign researchers are attracted to the cause and are willing to contribute to the proposed international conference on STEMS in the future. I reiterate: The IC-STEMS 2015 conference theme, in principle, focuses on the state of the art theoretical and methodological developments as well as on recent applications of STEM in fields as diverse as climate, environment, ecology, chemistry, health, medicine, physics, construction, materials science, polymers, etc for overall sustainable development or sustainability. It strives to inculcate a new sustainability approach of looking at things around us. It offers interdisciplinary, scholarly and brain-storming discussions on environmental, relevant socio-economic and STEM based sustainability endeavours of researchers, professionals and policy makers. Objectives of this conference are (i) to develop the interest of amateur or young students for undertaking studies and research in the frontiers of science, technology, engineering, mathematics for sustainability; (ii) to give an opportunity to participants for understanding the new developments through invited talks by eminent scientists and technologists; (iii) to provide a platform for multidisciplinary communication, networking and intensify collaborations among scientists, policy makers and industries; and (iv) to deliberate on the recent developments and trends in "Sustainability and the use of STEM for Sustainability." Activities that we advocate mainly involve co-evolution of knowledge & entrepreneurship by identifying local problems and linking human beings to the (global) sustainability system and also to the protection of the planet from degradation or deterioration. There is a lot to learn from each other. The take-home message of

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this conference should, in principle, sound like: “It is the moral obligation of the intelligent beings to care for our planet through STEMS research and enterprise.”

The presentations, research abstracts and papers that the scientific community shares here illuminate many of the country’s most pressing issues. Accepted research papers from plenary lectures, oral/poster presentations, key notes, invited talks and industrial presentations is being published in the form of proceedings (with International Standard Book Number) and is made available to all the delegates / participants. This also shows how researchers are using innovative methods to undertake systematic investigation and study of pressing problems associated with the society and enterprise in order to establish facts and reach new knowledge or conclusions. And, they do this in their own unique way. But while the research we support shows that adapting to sustainable development and mitigating climate change are big challenges, we also find an opportunity for industries to commercialize environmentally benign products and processes such as smart materials, low carbon technology, utilization of biomass, solar / renewable energy and relevant clean fuel technologies that the planet will not get adverse impact from. Alternatives to the detached and centralized energy model should be considered. A crucial part of tackling climate change is to help people develop and deploy industrial technologies at lowest possible or zero environmental cost. We believe that the insights such conferences offer are valuable, and we know that they are fascinating.

Research has shown us ways to respond to diseases. There is still a lot to learn from ancient knowledge. The *Ayurveda*, a system of traditional medicine originated in India, considers food not only as nourishment but also as medicine and proposes that there are healing properties in plants and their products. For example, the scientists working in the field of natural products learnt to extract, isolate and identify medicinally important entities from plant and marine life. Anything, be it unani medicine, homeopathy, *ayurveda* or meditation like yoga or salat, all that are useful for sustaining human health and well-being have been learnt across borders and brought in life when needed. Similarly natural calamities, pollution and changing climate has engendered deep thinking among scientists and policy makers about what went wrong and what could happen next. In addition, the burdens of industrial growth and human desire for a lavish life-style have irreversibly consumed the resources. It is not wise to overrate consistency. There still a lot to learn from each other. No thinking person can now deny our global responsibility to protect the planet and its inhabitants. This is a challenge of society, policymakers, investors and social enterprise to provide the knowledge we need to renovate and or reshape institutions to cope with the deterioration that we know is becoming inevitable.

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Our work is to bring young people close to the planet and make their education, skills and research activities actually benefit sustainable development and also make the use of sustainable agenda economically and socially acceptable. This shall include, for example, how solar, wind, micro-generation or nuclear power might be revived as an energy option for peaceful and pollution-free applications. We should address the issue of climate change aggressively as we do for the issue of poverty. Not all change in the world is for the worse; STEMS are advancing at an ever growing pace, and can produce solutions to many of the biggest problems that we face today. But the social aspect is also vital if we are to research and apply STEMS' discoveries and innovations wisely. We need to do more to protect our offspring against future global warming. On a bright side, many environmentally significant practices are being routinised and ingrained.

Policy makers, environmentalists and the public in general assume that the chemical industry disregard the environmental consequences. This makes us understand that now the impact of being represented in the society as 'industrialisation for pollution' can be severe for both enterprise and communities. The challenge for the present-day chemical industry is to continue providing applications and socio-economic benefits in an environmentally friendly manner. The concept of *green chemistry* can certainly help achieve *sustainability* in *chemistry point of view*; or rather stand as a component of *sustainable development*. Having said that, *sustainability* not only offers the choice to conserve or consume resources sensibly but it also encompasses the societal attitude towards the environmental change. Eco-efficiency has been recognized as an important tool in transforming unsustainable development to sustainable development. There is a need to achieve various (actually twelve) principles of *green chemistry* including the *atom-economy*. A new concept of elemental sustainability should also be added to such chemistry by which one may conserve the rare metals and or their supply by way of encouraging the careful resource utilization and recycling. Utilization of a single metal atom as functional entity or catalyst instead of its nanoparticles or bulk usage could also save precious elements or rare chemical matter.

I don't condemn people for being chemical vigilantes but chemistry's role in human life must always be appreciated. The greatest boons of chemical industries are medicines and petrochemicals but we need to focus more on environmentally benign chemical products and processes for the industries now. The subject's role in waste management, converting waste to wealth, organic recycling, biodegradable materials and also in the pollution control must be recognized. Allen and Rosselot (in Pollution Prevention for Chemical Processes, John Wiley & Sons, Inc., USA) presented the following hierarchy for pollution prevention and waste management, in decreasing order of preference: (i) source reduction, (ii) in-process recycling; (iii) on-site recycling, (iv) off-site recycling,

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(v) waste treatment to render it (the waste) less hazardous, (vi) secure disposal, and (vii) direct release to the environment. Chemistry does also play a vital role in tackling the issue of "*energy trilemma.*" To the best of my knowledge, the term was coined by the World Energy Council and this "trilemma" refers to the difficulties associated with (i) cost, (ii) accessibility and (iii) the environment. The environmental aspect will be in the spotlight again over 30 November to 11 December 2015 during the 21st session of the Conference of the Parties and the 11th session of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (COP21/CMP11) in Paris, France.

Recently, the United Kingdom (UK) Committee on Climate Change (CCC) has called on their government to dispel policy uncertainty and take urgent action to avoid the increasing costs and impacts of climate change. Other studies over a period of 1990 – 2012 show that the UK has annual greenhouse gas emissions fallen by 25% (by 2012). The 2008 Climate Change Act in the UK and the 2015 Clean Power Plan of USA are some of the other important steps. Back in 2010, the USA government set a limit on greenhouse gas emissions and allowed companies trade *pollution permit* (on purchase). Some efforts to check emissions have already been made internationally. In September 2015 came an announcement where China, moving away from heavy industries, has decided to curb emissions by implementing this *cap-and-trade* system under the China-USA climate agreement which the heads of these countries reached earlier this year. USA and China could reduce emissions by adding renewable capacities. The Indian nation, the world's second largest populous country and fourth largest economy, aims to improve living standard of all of its citizens and reduce poverty by doubling per capita income. India backs clean energy and by the year 2022, its government seeks a target of 175 Giga Watts (GW) renewable energy capacity which is about 20 per cent of country's total energy mix. India, in its most awaited and intended Nationally Determined Contribution submitted on 01st October 2015 to the United Nations' Framework Convention on Climate Change (UNFCCC) committed to achieve around 40 per cent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030. However, India's stand will most probably be declared in detail during the upcoming December 2015 conference (COP21/CMP11) in Paris, France. India's role is very important because reports suggest that India's developmental agenda with a viewpoint of food, energy, and economic security of all has increased greenhouse gases 65 per cent in the last decade and minimum 40 per cent share belongs to its industries. India is a rich source of untapped energy deposits but that would require massive deforestation and mining. There are already incidents of violent revolt by the so-called marginalized tribal population across Indian states with coal and mineral deposits. Emission-free and carbon-free growth path will be vital to India's sustainability. India, being already an agro-based economy, is well poised to reduce emissions and adopt sustainable

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growth gradually over the next decade as a natural consequence of its growing agro-based industries, renewable and solar energy sector.

In 2014, the World Health Organization (WHO) reported that in 2012 around 7 million people died - one in eight of total global deaths – as a result of exposure to polluted air. One example of women cooking in rural areas of India was shown where these cooks were the first victims of smoke-related respiratory problems, chronic obstructive pulmonary disease, lung cancer, stroke and cardiovascular illness. The fuel pellet they made from a mixture of wood, agricultural waste, coal and cow-dung produces fine particulates and carbon monoxide. More broadly, there are risks associated with particulates, gaseous and bio-aerosols. Delhi is considered among the most polluted cities in the world now. A 300 per cent rise in respiratory problems is seen between years 2007-2008 and 2013-2014. Chemistry researchers are working on mitigating air pollution and on ways to improve overall air quality indoor and outdoor. Other hazards related to asbestos, silica, and flammables, etc must also be understood. Exposure to harmful emissions, volatile organic compounds, particulates or bio-aerosols should be minimized by personal protective equipment and or by completely avoiding them. In India, for example in view of the age-old philosophy of "cleanliness is godliness," the Government launched a national campaign namely the *Swachh Bharat Abhiyan* (Clean India Mission) to clean the country. This mission should become more than sweeping the streets and initiatives to improve safety, health and environment must also be launched across various occupations or workplaces. It is essential to avoid pouring municipal or industrial effluents to water bodies without treatment. And, people should be made aware of the dangers of water pollution due to fluoride / arsenic and also due to the endocrine disruptors found in fumigants, fungicides, herbicides and insecticides. Biodegradable materials should be preferred over the plastics that take years to degrade in the landfills. We should reduce waste production and increase recycling or waste treatment. Risk assessment and rescue services to check poisonous gas leakage, chemical explosions, fire-fighting at chemical or renewable energy plants, biogas and waste management sites must always be in-place. We are in need of entrepreneurial activities and enterprises in pollution-free fuel, biodegradable polymers, bio-based materials, bio-degradable drug-delivery materials, disposable sanitary napkins, handkerchief, towels in the medical or beauty trades, *green* packaging materials, compostable plant packaging materials, etc and other cost-effective and eco-friendly products manufactured from non-fossil starting materials. The hot topics of strategic as well as environmental importance are: the energy storage materials, adsorption including the zeolitic adsorbents in automotive engine exhaust, catalysis, sensors, pollution free energy generation or clean fuel technology, hydrogen, renewable energy, high-energy materials, aviation fuel, reduction in emission,

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and also the interfaces between chemistry and engineering, ecology, biology, materials and environmental science.

Research can play vital roles in generating new knowledge about sustainability through STEM. And, conferences and dialogue can provoke this thought in academia. Research laboratories around the academia benefit from operating in collaboration with industries – both in sending researchers to industries and in bringing-in challenges from technology transfer or knowledge commercialization. We must always be interested in researchers' view on the interplay between innovative products or processes, knowledge transfer, green engineering, and overall sustainability coupled with investors' or industrialists' view on industrial viability, economy and technocracy. Our new inspirational STEMS approach for a modern knowledge based economy and society includes intellectual investment, philanthropic enterprise and planet-loving industrialization. An example could be transport which comprises of on-board energy generation, supercapacitor electrodes, electricity, hydrogen or solar-based fuel. Other important studies include shift from fossil fuel to sustainable nuclear fuel, radiation effects on graphite moderating nuclear reactors, perovskite solar cells, lithium ion batteries, etc. A greater use of biomass, its conversion to value added chemicals or fuel, renewable chemicals from waste (such as the municipal solid waste, food waste, agricultural residue) along with an interdisciplinary approach from engineers, chemists and biologists would create numerous opportunities for innovations. Carbon capture, storage and conversion of carbon dioxide to valuable feedstock are other such potential avenues. Though there are concerns regarding the fracking to extract shale gas, some countries are still engaged in using the technique disregarding the plausible environmental impacts. In view of the burden for energy supplies and other valuables, a strategic shift to oceans and marine resource is noteworthy. Irrespective of chemistry's contribution to the development, pollution has given the critics undue advantage, and in response to that, the modern chemists have learnt from the experience and are now set to appear perfectly poised to help tackle sustainability issues for future generations. As governments and public in general strive to look for resource-efficient economy, the modern basic and applied researches at academic institutions and their transfer to industries are required to play important roles.

Universities are central to knowledge based human resource development. The higher education in India is still evolving where the huge youth population is crippled and only facing inequality, burden of fees or student loan. India has a huge youth population with an enormous hunger for degrees and jobs thereafter. For some people, the universities are only degree awarding factories and they do not involve themselves in research and extension activities. Amidst all this, the

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contribution of university as a knowledge source for public and private sector innovation is overrated. Most of the academics still remain too isolated from the problems the society is facing. University knowledge is useless if it is not responsive to the public and their immediate concerns. In fact, the university is supposed to be the *community of teachers and scholars for the community at large* (means public). This should also involve their interactions with outside world for training, consultancy on contractual basis, basic and applied research, collaboration and all types of formal and informal knowledge exchanges. The universities and the affiliates including students could bring a system of innovation through STEMS. But most of the times, this is too easily understood to mean a narrow focus on promoting commercialization of ideas through spin-outs and licensing for wealth-creating aspect only. Let's face it: Most of us are living in a materialistic world where most individuals cling to the myth of economic growth. Questioning growth is deemed the act of lunatics – but question it we must. Such myth must be turned into economy and development for a finite planet. And, the universities or even the lower level educational institutions are the places to inculcate this culture. University is seeking industrial research grants or funding from contract research; spin-outs and licensing could generate jobs and revenues. There is nothing wrong if government or society aim at skilled, well-educated and money-making workforce but there should be a provision for human resource with roles and responsibility for research, innovation and entrepreneurship having sustainability high on their agenda. While meeting any business objectives, an economically viable and possibly a holistic approach to outputs from the STEM base should go alongside a formal process rather than a commercial one by which potentially sustainable interests and business benefits are identified and satisfied together. Let me rephrase it this way: There is this need to groom philosophers, thinkers, entrepreneurs or industrialists and leaders who consider sustainability as the moral obligation and a business ethics with a development-for-all slogan and not as a tenacious tool to keep the corporate subservient. The importance of sustainability lies in industries recognizing it as part of a distributed system of innovation mediated by public and planet-inspired basic research for meeting human aspirations without irreversibly damaging the resources upon which the ecosystems on the planet depends.

At times, the business growth and sustainability fails to materialize together. For example, how to get industries to sort their waste? And, the industrialists should be responsible for their actions. The local government authorities can enforce the waste treatment, utilization or re-cycle. This is a heterogeneous sector; all the local groups, be they small or big, and the relevant major international agencies have their own aspirations, needs and goals. The best way to a *win-win* situation is to have an integrated approach to development and sustenance for all the stakeholders. For example, who should get the blame for an oil-spillage in

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the oceans killing marine lives? And, who should undertake the pain of cleaning up? Similarly, the nations of the world failed to set forth a comprehensive treaty to cut carbon emissions during the 2009 U.N. global warming summit in Copenhagen. These discouraged industrialists invest in clean technologies. Despite that, China has emerged as a leader in industries of renewable energy. Notwithstanding all the political problems, the Department of Energy in United States of America invested a lot in the basic energy research and supported various innovative clean tech ventures under the leadership of Nobel Laureate Steven Chu. Research must be undertaken to trace the direct links between the actions and their impact on environmental health and quality of life at a local level. It is good to know that off late some governments of the nations of the world are joining hands to curb emissions internationally and many are seeking for advice on implementing relevant policies locally.

The society is bit passive and dependent on scientists, politicians and local policy makers when it comes to discussing science and its advancements. Though some people appreciate the 'knowledge of science and technology' and recognize that scientific advancements could account for changes in life-style and overall well-being by overcoming great challenges including socio-economic and strategic ones, the public, in general, do not understand how science works; what its implications are, what to choose in science, etc. We practise science for some centuries now; but the importance of sustainability science was understood only in the recent years. Understanding the nature of science and the translation of the science research for the public and or the non-expert audience is a challenging task. Science educators can achieve science literacy in the public through regular dialogues and the science communicators and public conferences should motivate the people and awaken public's interest in recent sciences including the multi-disciplinary STEMS. Good education and its applications offer something new to the society: new information or just a new way of looking at well-known facts.

The US Green Building Council has instituted a green building certification programme namely Leadership in Energy & Environmental Design that helps building owners, constructors and operators be environmentally responsible and use resources efficiently and also recognizes best-in-class building strategies and practices. The concept of *micro-generation* involving on-site energy production for the home should be adopted and the technologies such as solar photovoltaic panel, wind turbine, fuel cell and other micro-CHP systems must be considered. Governments around the globe are not investing in sustainable development as much as they are doing in politicizing energy or politicizing strategically important areas. Instead, they are busy in introducing the self-declared war on terror, building one-religion nation or the so-called deterrence or counter-terrorism framework. The rich countries which could actually

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conserve the planet are pushing the people and planet to vulnerability, pollution and destruction. Very less attention is being paid to the impact for sustainability and relevant policies. I believe that sustainability should be considered as the fundamental occupational concern or criteria of living and now also be added to the basic human needs like the bread, clothes and house.

Most people tend to incline towards the causes that benefit the locality. People think that there are too many charities propagating their own agenda. But the rise in good causes should not undermine their aims. Top-down support from governments should meet bottom-up initiatives of the volunteers and institutions with a pace that is quick and timely enough to traction the notion that this planet is finite. Apart from food, drinking water, air, soil, clothes and healthy public, there are other issues needing actions on. There is a need to change the monopoly mindset of uncontrolled utilization of resources. There is a need to confront various pollutions, deforestation leading to poor air quality, emissions, greenhouse gases, carbon footprint, global warming and thereby the climate change. Our world has come closer in the face of globalization and that is why I believe that it has become easier to make ourselves feel as one family and achieve sustainability together.

Improved quality of life puts a strain on resources. Despite a hunger for economy, I believe that the human values are still strong. Key elements of happiness include food, clothes, home, workable educational system, job satisfaction, and strong relationship with family and the society. As one can see, many have recognised the value of happiness in exploring the relationship between wealth and well-being. But this is not enough. The world is becoming increasingly virtual day by day. There is a need for public engagement to policy making for STEMS. You will hear a large majority of people saying, “I am amazed by the achievements of science.” But when it comes to discussing and governing science, they flunk. I do not know why they do not take interest when the science plays such a big part of people’s lives. There are certain research areas in sustainable development where science, society and economic growth do need to be better understood by the public, policymakers, and even by researchers themselves. Our greed for the so-called development is all set to exhaust all we have got from the mother earth. Now, there is this urgent need to be responsible for our actions and be the caretaker of our resources. This means that the human race and the humanity must eventually check the rate with which they are consuming resources. It is easier to preach than to practise. Mahatma (Mohandas Karamchand) Gandhi wrote: “Be the change you want to see in the world.” How might such quotes be told differently? He also said, “The world has enough for everyone's need, but not enough for everyone's greed.” The society should answer today’s sustainability challenges.

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People get ideas from the surrounding and it is therefore essential to engage people, and then only the people will talk about these constructive ideas in the same way as they discuss information from the news, sports or entertainment world. I believe that researchers and their researches can have an immense impact on the societies that they observe. Let's introspect on how the role of modern science is evolving. It is high time we reform our science and the scientific approach to reinvent the mother earth. Ways of doing this may include space exploration for understanding our world, studying the earth's relationship with other (identified and un-identified) flying objects in the space, developing defence mechanism for planet protection, studies on astro-biological phenomena, panspermia, plausible colonization of moon or mars, answering big questions of how and when was matter created? teleportation, etc.

USA's National Aeronautics and Space Administration (NASA) announced, in the last week of September 2015, the definitive evidence of salt water flows on Mars. This should be an occasion for rejoicing. Let us, at the same time, not forget to spend our lives celebrating and conserving our planet and its resources that we have already got. When environmental history is written, our era could be seen as the dawn of global warming and the disaster for the planet due to heavy industrialization and pollution. Sustainable development is a very resilient model of growth; one that can adapt to changes in planet. It is the moral obligation of our generation to bring about more interdisciplinary and integrative approaches and engage socially and scientifically diverse researchers in a range of issues to invent long-term settings intended to develop mechanisms for quality of life and living. A truly global networking for the forthcoming era of sustainability researchers and entrepreneurs is essential if we are to conserve ecosystems on the earth and develop civilization for the future. We hope you live the revolution of sustainable development and enjoy it. I welcome your response via the convener at **stemsconference@gmail.com**

Let us care about entrepreneurial sustainable development, and get on with some more mature conversations with the public and industries about how we can sustain the planet better. By now, you know that the issues we as a species on this planet is facing are so big that scientists, policymakers, all people and all nations on this one planet need to listen to each other, collaborate and work together better – or we will have no science - no economy, nor indeed a planet (able) to live on.

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