

# Engineers and Engineering Sciences in Development: A Non-engineer's View

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## PUBLIC LECTURE



Bangladesh Economic Association  
Rajshahi Regional Seminar 2020

*Organized jointly by*

Rajshahi University of Engineering and Technology (RUET)-  
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## Background

The organizers of the 2020 *Rajshahi Regional Seminar of the Bangladesh Economic Association* have requested me – a student of economics – to deliver a *Public Lecture* which shall be of relevant interest to the Engineers. My colleague and friend Professor Dr. M. Moazzem Hossain Khan of Department of Economics, University of Rajshahi insisted me, almost every other day, to write a “thought provoking” paper. I gave much careful thought on the possible subject matter. Since this 2020 Rajshahi Regional Seminar of the Bangladesh Economic Association is an unusual joint venture with the Rajshahi University of Engineering and Technology’s Faculty of Applied Science and Humanities – I thought it to be appropriate to write and talk about the *possible role of Engineers and Engineering Sciences in facilitating development in the complex era of 4<sup>th</sup> & 5<sup>th</sup> industrial revolution within the orbit of globalization*.

The self-selecting idea of writing on the subject has been a difficult-to-accomplish task for me – a non-engineer. I tried to conceptualize, however, keeping the *science of causality* in mind.

After much thought into the logical links of the key issues encompassing the theme, I contemplated it to be appropriate to respond to the following self-posed questions:

1. Who is an engineer?
  - A designer and builder of an infrastructure?
  - A technology mover?
  - A development activist in a multidisciplinary team?
  - A pathfinder?
  - A thinker and doer of sustainable human well-being?
2. What is development and developmental cooperation?
  - Inter-country trade?
  - Sharing of knowledge and learning from each other (with people of other countries)?
  - Inter-country connectivity building?



- Exploring each member countries' comparative advantage?
  - Maximize mutual benefit based on mutual trust and reciprocity?
  - A mechanism (ways and means) for ensuring accelerated sustainable development?
3. What role engineers can play in expediting meaningful development?
- Can play role in isolation as technical personnel?
  - Can play role as a member of a multidisciplinary team?
  - Can play lead role?

The treatise under discussion has two distinct dimensions, namely *A. Development and Cooperation: Model, New Developmental State (NDS), and Developmental Regionalism*, and *B. Engineers as Prime Movers of Development and Cooperation*. The presentation of these two dimensions under the “umbrella theme” might seem apparently disjointed. This is so because, first, I wanted to put my thoughts on the essence of various dimensions of development and cooperation (irrespective of role of any specific discipline including the engineers) encompassing, among others, issues and concepts of development model, New Development State (NDS), and developmental regionalism (with relevant lessons learned). Second, after setting the conceptual stage for development and cooperation, I have made an attempt to place the engineers and engineering sciences as lead agents and prime movers of development and cooperation for a “second nature-based” new industrial revolution<sup>1</sup>.

Finally, I have come to the conclusion that an engineer is not just a technical person (expert) and engineers can be the leaders of development. However, to become the “leader of development cooperation” a paradigm shift in engineers' thought process is necessary.

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<sup>1</sup> A major part of this paper is drawn from author's keynote paper titled “Role of Engineers in Development and Regional Cooperation: Thoughts of a non-Engineer” presented at National Seminar of the 53<sup>rd</sup> Convention of The Institution of Engineers, Bangladesh (IEB) on 15 January 2012. However, in this paper, I have made some major revisions and included some new analyses.

**A. DEVELOPMENT AND COOPERATION:  
MODEL; NEW DEVELOPMENT STATE;  
DEVELOPMENTAL REGIONALISM**

**A.1. Development Model of Developing Countries: The Essence**

Traditionally economists are tempted to understand and/or define development in increased Gross Domestic Product (GDP) and/or in high economic growth rate and assume that the benefit of such growth will trickle down. Contemporary economists also suffer from a lot of "development myths": *"Today's wealthy countries achieved success through steadfast commitment to the free market"*. *"Neoliberalism works"*; *"Neoliberal globalization cannot and should not be stopped"*; *"The neoliberal American Model of capitalism represents the ideal that all developing countries should seek to replicate"*; *"The East Asian model is idiosyncratic, the Anglo-American model is universal"*, *"Developing countries need the discipline provided by international institutions and by politically independent domestic policymaking institutions"*. All these myths have been explored and logically refuted by Ha-Joon Chang and Ilene Grabel<sup>2</sup>. Therefore, as social thinker, the very first thing we need at least to clarify would be to understand the essence of 'development'. In this connection, I think the following would be the best guide to follow:

1. Development is not purely an economic phenomenon but rather a multi-dimensional process involving reorganization and reorientation of entire economic and social system (as proposed by Michael Paul Todaro).
2. Development is about transforming the lives of people, not just transforming economies (as proposed by Joseph E. Stiglitz).
2. Development is the process of expanding human freedom; freedom is the primary goal of development and freedom is also the principal means of development. Development is the

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<sup>2</sup> Chang, Ha-Joon & I. Gabriel (2005). *Reclaiming Development: An Alternative Economic Policy Manual*. London: Zed Books.



enhancement of freedoms that allow people to lead lives that they have reason to live (as proposed by Amartya Sen).

Since 2000, most developing countries (DCs) have pursued Poverty Reduction Strategy Papers (PRSPs) as a policy framework to ensure and attract official development assistance (ODA) and promote development. However, in general, their implicit development strategy has been a close integration with the global economy through removing trade barriers, the liberalization and deregulation of domestic financial markets, and increased aid-financed social expenditure to achieve the Millennium Development Goals (MDGs). The outcome was *growth in gross domestic product (GDP) with little structural transformation*. Poverty rates, measured using 'crude' and 'linear' definition, have been falling but only slowly, as insufficient productive and decent employment opportunities have been created for the rapidly growing population. As a result, the number of people in multidimensional poverty increased.

The global financial crisis and recession further exposed the weaknesses of this development model. It revealed the risks, uncertainties, and vulnerabilities of integration with the global economy dominated by so-called financialization of the real economy. Most of the developing countries (DCs) experienced a sharp slowdown, with decline in real per capita GDP. Although growth has subsequently recovered, it is clear that new development paths are now required for sustainable and more inclusive growth which meets the immense challenge of productively employing the millions of young people – new entrants to the labour market. New development paths are required to address the issue of rising inequality and destructive power of innovation.

Without any ambiguity, I am of the view that the opportunity for rapid poverty reduction through the development of productive capacities and associated expansion of productive employment is real and significant. It can emerge from (a) mobilizing underutilized resources, as well as the addition of new capacity through investment in agricultural productivity, plant and equipment; (b) the diffusion of available technologies; (c) public spending on infrastructure, skills and capabilities; (d) increasing public spending on education, health and social security; and (e) the creation of new 'useful' products and markets. There is, however, no

unique way to combine these elements into a single correct strategy for inclusive growth. Notwithstanding, there is ample historical evidence that a cohesive, strong, catalytic and effective State responsive to the needs of its constituents is one of the prerequisites for defining the content of a long-term development strategy suitable to discovering what works in a particular context of individual countries. Although finding out a single correct strategy may be futile it is absolutely a good guide to keep in mind that "*A good economic policy is the policy whose long-term social benefit is positive*".

The modalities, role and reach of the State in national economic management have tended to fluctuate over time. However, in all dynamic developing economies and in all countries now classified as developed market economies, the government has played an immense role in promoting and supporting economic development. From this standpoint it is time to talk about a **New Developmental State** (NDS). This NDS traces its intellectual origins in part, to the Structuralist school and in part to the East Asian developmental State. It focuses on creating new productive capacities rather than "re-allocating" given resources and putting given productive capacities to more efficient use.

*One-size-fits all* will not work. Each NDS will need to choose the trajectory of development suited for its own economy, ranging from the traditional path toward "modernity" through Rostow's well-established stages of growth, including, industrialization via textile and garments and other labor-intensive commodities, toward technological leapfrogging into services or skill-intensive capital goods. The NDSs must identify and promote the type of industrialization which is best suited for the particular country. This type of search makes up a key component of the new functions of the NDS, and requires policy space. Rather than taking industrialization as a given trajectory for all DCs, the NDS "searches" (tries, experiments pragmatically) for the optimal path of development in its own economy, including choosing the optimal form of productive and development trajectories.

The NDS approach is more holistic and integrated, encompassing both economic and social development, and needs to ensure that such development is served by finance rather than the other way around. Both



the internal and external conditions that existed in East Asia in the 1950s and 1960s no longer exist.

At early stages of development, the initiatives of the NDS will not rely solely on market forces to generate the desired structural change and economic transformation. In order to accelerate growth, the NDS will need to carry out significant shifting and reallocating of national and possibly international assets and resources to the growth-enhancing sectors. For this purpose, the new developmental State in DCs, should engage in a more strategic type of integration into the global economy that would enable these countries to integrate in a manner which is in their interest to do so, rather than pursuing rapid trade liberalization based on current and given comparative advantage.

Rather than arguing that DCs should integrate with the world economy and produce according to their static comparative advantage, the analytical foundation behind the NDS is associated with the classical economic perspective, which claims that productive structure is not endogenous to the countries' endowment structure (in terms of its relative abundance of labour, skills, capital or natural resources), but that comparative advantage is very much influenced and co-determined by interactions between internal and external environment in which it is operating. While the mainstream model of the State is underpinned by the paradigm of free trade and free capital movements as being the optimal strategy for the world economy, the analytical underpinnings of the NDS define their own optimal degree of openness, implying that structural changes arise from shifts in the world economy, over which most developing countries have not much influence.

The NDS model is thus underpinned by the theory of openness within a managed trade policy that may enable a country to concentrate its relatively scarce resources in areas of production where world demand is highly income and price-elastic; additionally from this analytical perspective, it needs to promote the diffusion of knowledge of the kind of learning needed for continuous upgrading of the quality of all of the local factors of production.

The success of the NDS will depend on good development governance or in particular, the capacity to achieve and sustain high rates of investment and to implement policies that encourage the acquisition and learning of new technologies. In all cases, the allocation of public investment is the primary function of the NDS, along with setting up of a pro-investment regulatory framework that would enable rapid catch-up growth that could accelerate economic development. Moreover, the State needs legitimacy and to be a truly representative State, which will largely depend on the State's legitimacy to ensure a consensus for the development drive. This is a question of political will that involves "development contracts" or a social consensus in support of the development drive. A further important governance capacity is the ability to absorb external shocks.

The nature of the relationship between growth strategies and governance capabilities varies widely amongst countries, including the composition and the nature of the State itself. While certain conditions may work very well in some countries, they may not work well in others.

In pursuing *real development* it is important to recognize the *capability traps* of many governments and organs of the state. Capability traps holding many governments back are related to *isomorphic mimicry* where governments copy best practice solutions from other countries that make them look more capable even if they are not more capable and *premature load bearing* where governments adopt new mechanisms that they cannot actually make work, given weak extant capacities. (Therefore) "Importing "best practices" and placing unrealistic expectations on the presumption that the level of performance and pace of change achieved elsewhere is possible everywhere, including "here", is a temptation".<sup>3</sup>

## **A.2. Development Cooperation towards Building New Developmental State**

The benefits of cooperation (regional, South-South, North-South) will be greatest when a dynamic relationship is established in which policies

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<sup>3</sup> Andrews, Matt., Lant Pritchett and Michael Woolcock (2017). Building State Capability: Evidence, Analysis, Action. UK: Oxford University Press (p.54).



carried out by NDSs and cooperation reinforce each other in a continual process of change and development. In such a dynamic relationship, regional cooperation supports both the building of the NDS and the successful achievement of its objectives. The NDS in DCs in turn enhances and shapes the benefits of cooperation.

Domestic ownership and leadership of policies is a *sine qua non* for enhancing the development benefits of any kind of development cooperation, whether North-South or South-South. Mainstreaming South-South cooperation, both interregional and intraregional, into the national development strategies is thus a necessary condition to ensure that South-South cooperation promotes rather than hinders the achievement of the development goals.

It is clear that, with current policies, globalization has not fostered the desirable kind of structural change in DCs that could pull labour from less to more productive activities. A NDS would seek to use development cooperation to re-shape its integration into the global economy in ways which would enable the structural transformations necessary for creating decent and productive employment opportunities and achieving substantial poverty reduction.

Two central objectives of the NDS should be to promote learning and enhance resilience. Openness works positively only if the phenomenon of learning is suitably institutionalized on the policy side, involving appropriate government interventions that would make the domestic economy more responsive to change. In general, managed development cooperation has the potential to facilitate openness and learning in a far more rational and efficient way than the unmanaged global market. Developing countries should seek to capitalize on this.

Intensifying integration is also likely to be a valuable strategy because the diversification of markets and investment sources enables greater resilience. The differential responses of DCs during global recessions in the past clearly demonstrated how strategic Southern integration can affect volatility. Those DCs which were relying more on regional markets were buffered somewhat from the sharp downturn in Northern markets.

There are a number of benefits which developing countries (DCs) can gain from regional cooperation. First, most of the DCs lack a sufficiently large and diverse **home market** (that could allow diversification of the industrial structure), and thus regional markets provide an important economic space within which learning over time can take place. Second, there are major opportunities for the achievement of economies of scale through the provision of various kinds of **regional public goods** which would benefit developing countries within regional groupings. Such regional public goods include various kinds of **physical infrastructure supporting transport, communications and energy**, as well as **regional science and technology infrastructure, and regional innovation systems**.

In addition, with regard to the *agricultural constraints* to development in DCs, reflected in their inability to generate surplus and to guarantee food security for all, joint adaptive research with neighboring countries, regional storage facilities and coordinated investment programmes at the regional level can all make a difference. And, '*financial deepening*' can also have a strong regional dimension.

It is possible to identify a number of reasons why Southern partners may be motivated to engage in cooperation and mutual advantages obtained with DCs.

*Firstly*, there is a potential to create mutually beneficial market gains and opportunities for both partners.

*Secondly*, DCs offer access to natural resources which their Southern partners need.

*Thirdly*, regional prosperity and regional stability cannot be achieved without the participation of all the countries in the region.

*Fourthly*, the DCs can work jointly with Southern partners to better articulate their common voice and exercise their collective influence in all forums.



### **A.3. Cooperation as Developmental Regionalism: Integration beyond Liberalization**

**Developmental regionalism** can be understood as a development-led regionalism that accepts globalization as a historical trend, but rejects the market-led approach to globalization. Developmental regionalism aims at maximizing the benefits of regional cooperation with the goal of achieving an advantageous insertion of the members' economies into world markets. This goal is not an end by itself, but only a means to accelerate economic, social and human development.

Developmental regionalism is concerned with both the (a) internal economic development and domestic integration, while at the same time, with (b) strategic integration of the regional trading blocs into the world economy. Developmental regionalism involves domains such as trade, variety of policy tools, and not only those traditionally associated to trade policies proper from tariff and non-tariff barriers, to subsidies, concessional loans, direct provision of infrastructure and other public goods, promotion of research and development and science and technology activities, State-owned enterprises and State-controlled mixed enterprises, and many others.

In tandem with its holistic vision of development, regional trade can also be promoted through coordination of investment in strategic areas such as regional transport and other ancillary infrastructure. Prioritizing investment in strategic areas of common interest and common constraints can help to overcome the pre-existing bias against regional cooperation (including trade). As many developing countries are better connected to other continents than to neighboring countries, they cannot fully benefit from the potential gains of regional integration. The promotion of developmental regionalism should go hand-in-hand with strengthening the structures, institutions, capabilities typical of the developmental State at the national level.

This kind of developmental regionalism aims at fostering industrialization and accelerating economic and social development of member countries both as goals per se, and as a means of successfully integrating their economies in the global web of market relations. In the

context of globalization, new developmental regionalism strives to exploit the maximum extent of the benefits that can stem from negotiating with other blocks and economic powers from a position of relative strength, such the one allowed by member States collective ability to act as a single player. The expanded regional market generated through inter-State cooperation, along with temporary protection policies for domestic capital, contributes to secure benefits for domestic firms over their foreign competitors. In fact, developmental regionalism assumes the need for gradual and sequenced trade liberalization together with conscious and planned policy actions enacted to build up productive capacities. The existence of such productive capacities is seen as a necessary condition that will eventually enable domestic businesses to participate in global market.

In most developing countries, the experience of developmental regionalism is still in its embryonic stage. African countries, supported by the AFDB and the NEPAD as well as other partners, are embarking into similar initiatives to promote the creation of development corridors, and redress long-standing infrastructural gaps. Although, in general, these initiatives are at a more incipient stage than those in the Asian region, notable examples are: the North South corridor, which connects Durban and Dar es Salaam, and the Maputo corridor linking South Africa's northern and eastern regions to the port of Maputo. So far, the most successful examples of its practical realization can be found in Asia. Indeed, the region where these processes are most advanced is East Asia, a region where a positive, proactive view of integration has been prevailing for a long time. Here are some examples:

First, the recent experience of trilateral economic cooperation between China, the Republic of Korea and Japan constitutes a successful example of development regionalism. Trilateral cooperation in North-east Asia began in 2000, and has been focusing particularly on environment protection, transport and logistics, and finance, and research and development. In the manufacturing area, particular attention was devoted to the IT sector. The latter covered several areas, from telecom service policy to network and information security. Yet, the main strategic goal was the joint development of new technologies such as next generation Internet, open source software, and radio frequency



identification (RFID) sensor network. The three North-east Asian countries were aware of the key role of IT for overall economic upgrading and industrial competitiveness. The countries representing this trilateral cooperation adopted proactive government commitments in order to generate synergy effects in technological development and, more broadly, to enhance their firms' international competitiveness.

Second, the Brunei-Indonesia-Malaysia-Philippines East ASEAN Growth Area (BIMP-EAGA) is one of the sub-regional "growth polygons" that were established since the early 1990s to foster the process of regional integration among the member States of the Association of Southeast Asian Nations (ASEAN). As these sub-regional zones include very poor countries, they face significant challenges. The BIMP-EAGA has tried to overcome these challenges by adopting the principles of developmental regionalism, promoting activities aimed at enhancing the economic capacity and prospects of lesser-developed countries in order to foster their integration into the regional economy.

Third, The Greater Mekong Sub-region (GMS) Program (ADB coordinated) can be considered as successful example of developmental regionalism. The GMS, started in 1992, involves all the major actors around the Greater Mekong area, such as Thailand, China, and all the LDCs in the region, ASEAN and ASEAN's development partners including Japan. It is the only regional cooperation programme specifically targeting all LDCs in the region. The core of GMS is to enhance the infrastructure of industrial development in the region by implementing programmes in areas of transport, telecommunications, energy, tourism, trade facilitation, investment, human resource development and agriculture. The basic strategy is to attract private investment to the region and facilitate cross-border trade, investment and tourism by strengthening infrastructure linkages. To enhance transportation linkage over the region covering three East Asian LDCs, Thailand, Viet Nam and Yunnan Province as well as Guangxi Zhuang Autonomous Region of the PRC, the GMS programme introduced three economic corridor projects: (a) the East-West Economic Corridor (Myanmar, Thailand, the Lao PDR, and Viet Nam); (b) the North-South Economic Corridor (China -Yunan, Guangxi, the Lao PDR, Thailand,

Viet Nam and Myanmar); and (c) the Southern Economic Corridor (Cambodia, Thailand and Viet Nam).

Fourth, The China's *One Belt One Road (OBOR or yi dai yi lu)* initiative is the most talked about mega scale example of developmental regionalism having geo-economics and geo-strategic implications. OBOR intends to connect more than two-thirds of the world population and opening up the windows for revival of global business and infrastructural development across countries. Arguably, OBOR is one of the largest development plans in modern history. Under OBOR initiative China intends to build massive amounts of infrastructure with pipelines and port in Pakistan, bridges in Bangladesh and railways to Russia aiming at re-creating "Modern Silk Road" trading route that may kick start a new era of globalization. OBOR has implications for the expansion of internationalization of the renmibi (RMB), both in the real economies of Belt and Road host countries and in the London offshore financial market. OBOR initiative intends to connect two ends of Eurasia, as well as Africa and Oceania along two routes – one overland corridors (the "belt") and one maritime shipping lanes (the "road"). Under OBOR, China plans to construct projects in more than 70 countries along these routes. The Belt and Road initiative is expected to cost more than one trillion US dollar. Globally, a lot of debates are already in place about the possible causes and consequences of China's Belt and Road initiative: Is it to resolve the issue of managing China's excess surplus? Is it to promote China's hinterland? Is it a state-backed campaign for China's global dominance? Is it an aggressive stimulus package for a slowing economy? Is it a massive campaign for Chinese investment around the world? Is it to ensure China's dominance in the construction sector at the expense of local contractors in partner countries? Will this initiative increase the risk of debt distress in many countries? Will this make China the biggest foreign creditor? Is this a part of "*debt-trap diplomacy*"? Will this initiative block sea trade or monopolize sea trade by China? Will this act as dual-use for commercial and military purposes? Will this be used by China as a vehicle to write new rules, establish institutions which will reflect Chinese interests, and reshape 'soft' infrastructure? The argument I have raised quite is simple: Economic dominance accompanied by huge moral hazards can be dangerous!



## **B. ENGINEERS AS PRIME MOVERS OF DEVELOPMENT AND COOPERATION**

Now, before I enter into the complex domain of “Role of Engineers and Engineering Sciences in Development” let me – in order to make meaningful link between what has been said above and what I want to say now – recapitulate the first broad dimension on “development and cooperation”. First, I tried to argue that the one-size fits all type of traditional development model has failed to respond to the needs of sustainable human(e) development through meeting the challenge of productive employment of millions of young people and addressing the risks and vulnerabilities of integration with the global economy dominated by so-called financialization of the real economy. This traditional model has generated slow growth in GDP without any structural transformation. Second, in addressing the first issue a new model termed as “New Development State” (NDS) has been proposed. The development under NDS must be able to reorganize and reorient entire economic and social system, transform not just economies but lives of people, and expand human freedom. The NDS, based on knowledge economy, focuses on creating new productive capacities (in which engineers/engineering science has a key role to play) rather than “re-allocating” given resources and putting given productive capacities to more efficient use. This model encompasses openness with managed development policy, diffusion of knowledge and learning needed to upgrade quality of all local factors of production, good development governance, ‘search’ for optimal path of development in specific economy, and alike. Third, Development regionalism is important which accepts globalization as a historical trend, but rejects the market-led approach to globalization.

### **B.1. What is the Contribution of Engineering Science to Modern Life?**

Engineering science has played a critical role in improving human quality of life in the last 50 years by developing better water supplies, sewer systems, waste-water treatment plants, designing buildings to protect us from natural hazards and provide health care, improving

agriculture through water resource development and distribution projects, dramatically improving transportation systems and so on.

It is the engineers whose work has helped to reduce the death rate dramatically which is one of the principal reasons that population has been able to grow so dramatically in the last 150 years. For example, improvements in transportation alone have enabled rapid migration of large numbers of people all over the world and increased the volume of raw materials and finished products in international trade 1000 times in the last century. Economic output has increased over 30 times, fossil fuel 40 times and industrial production 150 times in the last century. Along with this growth has come some undesirable environmental, health and social impacts, particularly in the last half century.

## **B.2. A New Human Perspective is needed**

In the last five decades, the world population has been more than doubled to 7.7 billion people and the world's economic output has increased fivefold. This unprecedented growth is altering the face of the earth and the composition of the atmosphere. Pollution of air and water, accumulation of wastes, destruction of forests, erosion of soils, depletion of fisheries, and damage to the stratospheric ozone layer threaten the survival of humans and thousands of other living species. Humans are conducting an uncontrolled experiment unprecedented in scope and scale that represents the reversal of natural evolution which produced clean air and water and increasingly complex and diverse ecosystems -- systems which made human evolution possible.

These changes – a result of unsustainable and inequitable patterns of production and consumption – are likely to accelerate with the addition of 80 million people to the planet each year. We are – a society living off its natural capital, not its income. We are acting like a planet in liquidation – a bad business. Recognizing that these trends placed humankind at a crucial crossroads, scientists around the globe, including 102 Nobel laureates, signed the World Scientists' *Warning to Humanity* (in 1992). The warning reads as follows:



*WARNING. We the undersigned, senior members of the world's scientific community, hereby warn all humanity of what lies ahead. A great change in our stewardship of the earth and the life on it is required, if vast human misery is to be avoided and our global home on this planet is not to be irretrievably mutilated.*

Despite these warnings, entire Earth's living systems have continued to decline. Moreover, the degradation of natural systems is likely to accelerate with the addition of 80 million people to the planet each year unless strategies to meet human needs are made more sustainable and just. The fact is simple that the current strategies to meet human needs are not sustainable.

It is really appalling that eighty percent of the world's resources are being consumed by 20% of the world's population. The world's poorest 20% earn 1.2 percent of the world's income. The income ratio of the richest 20% to the poorest 20% was 28:1 in 1960; it was 192:1 in 2018. For 40% of the world's population, poor sanitation, malnutrition, and air pollution are still the major causes of illness and death. The rural poor will increasingly migrate and be transformed into an urban poor, and environmental health and social problems will multiply. **For the first time in history, more people are now living in urban than in rural areas.** And this **urbanization** is nothing but **slumization** in the absence of concomitant industrialization.

In USA, air pollution is believed to kill more people than automobile accidents -- more than 70,000 premature deaths per year according to the EPA. By the time population growth stabilizes in this century, a five- to sevenfold increase in consumption of energy and goods will be needed just to raise the consumption level in the developing world to that in the industrialized world. Agricultural production must increase threefold in the next forty years for all humans to have adequate nutrition -- we are already appropriating the most productive 40% of the land-based biomass for human purposes. **Simply to maintain the current unhealthy levels of pollution and waste loadings will require an 80-90% reduction in pollution generated per unit of**

**economic output.** This cannot be achieved by building more waste treatment plants or air pollution control devices.

The world will need an unprecedented two billion jobs in the next twenty to thirty years to employ the current 1 billion underemployed and unemployed people and the new job seekers who will enter the market. This cannot be done with economic activity that substitute capital for labor, consumes large amounts of materials and energy and creates large volumes of pollution and waste. Paul Hawken points out that with a sextupling of population and increasing economic output over 100-fold we have the reverse of the situation at the start of the industrial revolution which was an abundance of natural resources and the ability of the biosphere to assimilate wastes. "Our thinking is backward: we should not use more of what we have less of (natural capital) to use less of what we have more of (people)."

There is increasing social and political instability worldwide despite the end of the Cold War and the increased globalization of the economy (which the globaphobes argue contributes to the instability). According to UNCHR there are 71 million refugees, 47 million environmental refugees, unprecedented migration of people from East to West and South to North, 74 regional military conflicts, the UN has seen its influence erode and there is increased isolationism on the part of major powerhouses.

The astronauts in Apollo 13 said, "Houston, we have a problem!" – a societal problem caused by the "design" of an economic and social system which lives off its support system in a degrading, unhealthy and unsustainable manner. We will need a paradigm shift in the relationship of humans to the environment and each other – one in which humans live in harmony with both natural systems and each other. We cannot achieve these results with our current thinking.

As Einstein observed, "the significant problems we face cannot be solved at the same level of thinking we were at when we created them." In the next twenty to forty years, society must adopt new strategies that allow the needs of an expanding population to be met in an environmentally sustainable and equitable manner. But our response



to the situation so far has been irresponsible and dangerously inadequate. For example, based on so called *cost-benefit analysis* of carbon emission we recommend taxing carbon and give a message to firms that emitting carbon and contributing to climate change is OK as long as you pay a fee: This is simply immoral; simply legitimizes pollution.

The current *ideology of growth* has captured our imagination to the degree that we continue to believe that more of the same resource intensive and pollution creating economic growth remains the best way to serve the common good. Economist's idea of *growth at any cost* is primarily an outcome of their intellectual failure in *valuing values of things* having high value or having lots of intrinsic values. Examples include failure in putting appropriate economic, social, cultural, political and intergenerational values of consequences of climate change, of (rising) inequality, of inadequate sanitation, of non-portable water, of work absenteeism, of school dropout, of not immunizing a child, of deaths and disabilities due to preventable causes, of crime prevention, of not getting fair price (by the farmers), of construction of dams or irrigation system ignoring the value of social capital (ultimately a "lose-lose" scenario), of indiscriminate use of energy and fuel, of unjust trade in the era of globalization, and so on.

For quite some time we know that a healthy environment is essential to human existence, health and well-being. Humans can live for about four minutes without air, four days without water, and four weeks without food. Plants, animals, and the habitats they occupy provide the food that sustains human life. The earth and all its living organisms supply all raw materials for human activities. All economic, social, and community systems derive resources from, and are a part of, the biophysical system we call the biosphere. There is no inherent conflict between protecting the environment and a strong human economy since the environment is the support system for all human activity.

### **B.3. Engineers towards a Just and Sustainable Future**

How do we create a life that allows all present and future humans to be healthy, have their basic needs met, have fair and equitable access to the earth's resources, have a decent quality of life and preserve the

biologically diverse ecosystems on which we all depend? **Future scientists, engineers, and business people must design technology and economic activities that sustain rather than degrade the natural environment, enhance human health and well-being, and mirror and live within the limits of natural systems.** We must dramatically reduce the resource and energy throughput of our economy and minimize our ecological footprint to maintain the life support system that will make a sustainable future possible. This calls for a **New Industrial Revolution** that builds upon the information and biotechnology revolutions of the past half century. This is to note here that the world population will be stabilized at a level which should be within the short and long term carrying capacity of the earth's finite resources. This level is of great debate and is probably between ten and twelve billion people, a level we will reach within the next fifty years.

Now let me come to a serious point about our science of economics, which is caught into the trap of *model-blind science*<sup>4</sup>. Some of us even try to propose 'the' model and not 'a' model. This *blindness* originates from not recognizing the fact that: *Correlation failing to establish causality is the death of causation*. This is not to say that models are useless. But models are never true; but there is truth in models. Also, it is not unfounded that most economists (most model builders) have adopted a fragmentalist and reductionist approach to social phenomenon, making unfounded universal claims, ignoring the social, cultural, and political context, reifying markets and material incentives, and having a conservative bias. More so, many assumptions that go into economic models – perfect competition, perfect information, and perfect foresights – are patently untrue. Also, economists' obsession with choices made by individual households or individual investors – hides the fact that preferences and behavioral patterns are "socially constructed", or imposed by the structure of society.<sup>5</sup> Here it should be noted that Economics provides many of the stepping-stones and

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<sup>4</sup> To learn more about "Model-blind Science" which based on data-centric vocabulary fails to understand causal links and suffer from pretensions see, Pearl, J. & D. Mackenzie. (2019). *The Book of Why. The New Science of Cause and Effect*. UK: Penguin Books.

<sup>5</sup> To understand more about what went wrong with economic models and assumptions behind, what's wrong with scientific pretensions of economists, why a model (or theory) is at best contextually valid and alike, please see, Rodrik, D. (2016). *Economic Rules. The Rights and Wrongs of the Dismal Science*. NY: W.W. Norton & Company.



analytic tools to address the big public issues of our time. What economic science doesn't provide is definitive, universal answers. The results obtained from economics proper must be combined with values, judgments, and evaluations of a moral, ethical, political, or practical nature. These last have very little to do with the discipline of economics, but everything to do with reality. Here comes the potential role and responsibility of Engineering Science (and all other natural sciences) because they ought to deal with reality in a holistic manner.

Based on the above stated arguments and realities, it's time to raise issues of our common interest: What should be our vision towards sustainable future development? Let me forward *Eleven Commandments* which need to be internalize by the Engineering Sciences to accelerate the process of sustainable future development. The *Eleven Commandments* are as follows:

1. *We will use resources efficiently.* Leading scientists have been calling for a huge increase in resource productivity -- by a factor of 4-10 in order to increase wealth for 4/5 of the world's population and to decrease environmental impact. This is critical because the industrialized economy is incredibly wasteful in use of resources while the planet has a finite amount of resources and a finite ability to absorb and process wastes. In their thought provoking book Factor Four: Doubling Wealth, Halving Resource Use, by Ernst von Weizsacker and Amory and Hunter Lovins call for a revolution in energy and resource productivity and provide over 50 demonstrated examples of factor 4 increases in energy, material and transportation productivity from a variety of institutions around the world. With a few exceptions they all cost less than conventional means of doing business and increased social and economic as well as environmental sustainability.
2. *We will learn from and live within natural systems.* Humans are the only species on earth that produce waste which is not a raw material or nutrient for another species. Also, we are the only species to produce wastes that can be broadly toxic and build up for long periods of time. Truly speaking, a sustainable

society should eliminate the concept of waste. Waste is not simply an unwanted and sometimes harmful byproduct of life; it is a raw material out of place. Waste and pollution demonstrate gross inefficiency in the economic system since they represent resources that are no longer available for use and/or create harm in humans and other species.

A sustainable economy would mirror nature's "circular" method of using matter and employ the concepts of design through which all waste would be the "food" (**waste = food**) for another activity. This idea is integral to **industrial ecology**. Metal extraction and conversion would be replaced by strategies to continuously cycle existing metals through the economy. For example, recycling aluminum rather than using virgin bauxite ore cuts energy use by 95% and pollution by 99%.

3. ***We will use renewable resources at a rate less than or equal to the natural environment's ability to regenerate the resource.*** This means **living off the income, not the capital** -- e.g., practicing sustainable forestry, sustainable fishing and sustainable agriculture. To cite an example, every ton of paper made of recycled fiber saves seventeen trees and cuts air and water pollution 30-50%. Organic farming and agricultural production which minimize the use of pesticides and fertilizers while conserving soil and water are safer and more sustainable.
4. ***We will rely less on non-renewable energy.*** Over 85% of the world's energy comes from fossil fuels. This form of energy use causes major environmental and health problems such as black lung disease, air pollution, acid rain, oil spills and global climate change, to name a few. The desire for a continuing "cheap" supply of fossil fuels has had enormous military and economic costs to keep the oil and gas flowing around the world, especially from the Middle East. Moreover, this fossil fuel dependence is economically unsustainable for more than a few decades -- it took 10,000 days for nature to create the fossil fuels that society consumes in one day!



5. *We will increase production of durable, repairable goods and eliminate persistent, toxic and bio-accumulative substances.*  
At the same time, we will eliminate disposable goods as much as possible and detoxify the production process by minimizing the use and discharge of toxic substances. Products would be designed for disassembly so that the materials could be utilized in making new products. For example, several manufacturers (Volkswagen, Volvo, BMW) are redesigning automobiles so that 90% or more of the materials can be recycled into new automobiles.
6. *We will focus on providing the ultimate ends of products or services not the products or services themselves.* A key to resource efficiency is to understand products as a means to deliver a service to a customer. For example, people do not want energy, they want the service it provides such as heat or light. Similarly, people want access to people, places, things and experiences not necessarily increased transportation. An example of a company that has adopted this idea is Interface, the largest commercial carpet tile company in the world which now leases carpet. The lessee gets the service of the product -- warmth, softness, acoustic value, and aesthetics for a fee. When the carpet is worn out, Interface takes it back and recycles it into new carpet.
7. *We will create low energy consuming transportation systems.*  
We must accelerate the development of alternative fuel vehicles that minimize and eventually eliminate dependence on fossil fuels and accelerate the use of mass transportation.
8. *We will create an environment in which all people will understand their connection to the natural world and to other humans.* They will understand their "ecological footprint", i.e., they will know where products and services come from, where wastes go, and what they do to humans and other living species. They will appreciate that driving a car in Ohio may cause flooding in Bangladesh through global warming, or that cutting down forests in Brazil may deprive someone in

Hungary of a lifesaving drug. For all people – led by professionals such as engineers – minimizing their ecological footprint and "walking lightly" on the planet will be **"second nature."**

9. *We will ensure that all current and future generations of humans are able to meet their basic needs, pursue meaningful work and have the opportunity to realize their full human potential personally and socially.* In today's world of (over) consumerism an average person in developed country receives 2,000 advertising messages per day oriented toward consumption. The public is often portrayed as a group of consumers, not citizens. But increased consumption and material acquisition alone has not led to a happier, safer and more secure population.
10. *We will have timely economic, social and environmental signals that encourage environmentally and socially sustainable behavior.* The economic measures of success we use today, such as the GNP and consumer price index, discourage conservation and encourage waste, consumption, and the substitution of capital for jobs. The price of goods and services reflects all the profits to the producers but does not include all the social, environmental and health costs to the society. In a sustainable society we would have more **development**, i.e., **qualitative improvement** in people and value added to resource use **than quantitative growth** in resource and energy intensive economies. We need to think hard about full cost (including social and environmental) accounting for economic activities, development of macroeconomic indicators which **truly reflect societal well-being** (e.g., Index for Sustainable Economic Welfare, Genuine Progress Indicator) and taxation which **taxes the undesirables** (energy and resource consumption) and **not the desirable** (education, health, employment).
11. *We will put all-out efforts so that nations act like a Global Family.* The relationship between the developed and the



developing countries must be changed. Industrial countries must reduce their consumption of the world's resources in the face of the desperate need of developing countries to improve well-being, health, reduce all forms of poverty and inequality, and social instability. A child born in the US today will consume as much of the earth's resources and produce as much waste as more than 100 Bangladeshi children. We also need new approaches for transferring technology, for training and education, for good health and well-being and for providing financial assistance to developing countries. These approaches must address population deprivation, improving the educational and social status of women, the international debt problem, cooperation in all possible fields of humane development, and the need for sustainable economic strategies.

#### **B.4. What should be the Role of Engineers and Engineering Education?**

Let me be straight: **Engineers – socially responsive and visionary ones – must lead this new industrial revolution and carry forward the above vision for human development and cooperation.** The professional bodies of engineers are well-placed to make sustainable development a high priority in engineering and business -- both in practice and in the education of future engineers. They are in a place to promote codes of practice, education, mentoring programs and policy changes that will encourage the engineering profession to lead this revolution.

Let me forward one more issue to ponder over/on. A current fundamental problem is the underlying assumption (by many) that environmental protection should be left to environmental professionals. But environmental specialists alone will not help us move toward a sustainable path. All humans consume resources, occupy ecosystems and produce waste. We need **all professionals** to carry out their lives and activities in a manner that is environmentally sound and sustainable. However, the truth is that, the current education and training of most environmental professionals who are and will be employed by government, industry, academia and environmental

organizations is narrowly focused and incomplete. Most of these professionals are trained in dealing with a subset of environmental problems such as air pollution, water pollution, or hazardous waste, but are not trained to deal with environmental issues in an integrated and holistic fashion. The focus of training is on controlling pollution and waste once created and in remediating environmental damage, rather than reducing or eliminating pollution and waste generation at the source.

I am of the opinion that designing a sustainable future requires a paradigm shift towards a systemic perspective which encompasses the complex interdependence of individual, social, cultural, economic and political activities and the biosphere. The engineers of the future must be much more interdisciplinary -- the lines between the traditional engineering disciplines must be much more fluid or removed completely. Engineers will have to join forces with biologists, chemists, meteorologists, economists, planners, political scientists, ethicists and community leaders to lead society on a sustainable path. Since it is likely that we will double the amount of housing and building construction in the twenty-first century (and buildings utilize a tremendous amount of materials and energy) it is imperative that engineers team up with other professionals to revolutionize construction. This is just one of many examples of much intended second nature-based new industrial revolution.

I believe that there is a special role for engineers in the future. Rather than being the engineers that primarily design technologies to control or remediate pollution, I believe the **engineers will be the interdisciplinary, systems specialists** who will bring together, coordinate and manage all the specialists to solve complex problems of promoting sustainable development.

In addition, all engineers must play a much stronger role in the public policy process to provide the right incentives for industry and others to move on a sustainable path so that engineers can be encouraged and supported to design sustainable technology. Engineers must be better informed of the interdependence of environmental, economic, health and social issues, inform others and become leaders. If this does not



happen, then the agenda will be set by others who neither know the benefits nor the limits of technology in a changing society.

Here, I see a necessity of change in the mindset. Such a shift in the thinking, values, and actions of all individuals and institutions worldwide calls for a long term societal effort to make environmental and sustainability concerns a central theme in all education, particularly for engineers, economists and business people. If we are to achieve a sustainable future, institutions of higher education must provide the awareness, knowledge, skills, and values that equip individuals to pursue life goals in a manner that sustains human and non-human well-being. This is critical since higher education prepares most of the professionals who develop, manage, teach in and influence society's institutions. It is, however, important to note that to the best of my knowledge to date, no engineering school has made design for the environment, industrial ecology, pollution prevention or the relationship of technological development to sustainability the **cornerstone of engineering education**. Here, the content of learning must embrace an **interdisciplinary, systemic approach** to address environmentally sustainable development on local, regional and global scales over short-, medium- and inter-generational time periods.

### **C. Some Concluding Remarks**

I believe we have two choices as a society: First, continue business as usual -- promote population and rapid economic growth that maximizes materials and energy and then head for the new horn of plenty, with no time for recycling, efficiency or restoration as the cure for all our social, health, political (and some say) environmental problems. Let nature set the limits which will come through environmental collapse, poverty, inequality, malnutrition, social instability, and war. Let me put it bluntly: One definition of insanity is doing the same thing over and over again and expecting a different result!

A second choice is for humans as the most self-aware species that can learn very quickly, to take deliberate individual and collective steps to find civilized and cooperative ways to live in harmony with each other and the rest of nature. This means respecting and living within nature's limits, using energy and resources as efficiently as possible, maintaining the integrity of the life support system and helping all people meet their needs. This second choice is the best choice. And "socially responsive" engineers are better placed to take up this challenge to make the best of the opportunity to design the knowledge base and technology that will lead us to a sustainable common future.





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