21ST CENTURY ENGINEER
and
SUSTAINABLE DEVELOPMENT

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Engineering Profession

"Engineering is a great profession.

There is the fascination of watching a figment of the imagination emerge through the aid of science to a plan on paper.
Then it brings jobs and homes… it elevates the standards of living and adds to the comfort of life.
That is the engineer's high privilege". [Herbert Hoover, engineer, author, humanitarian, and 31st US President]

Engineering Profession

- **Engineers are critical agents in the process of**
  - **knowledge acquisition,**
  - **creation,**
  - **diffusion,**
  - **transfer and**
  - **commercialization.**
- **Engineers are Society's Technical problem solvers.**
- **Engineers strive for improvement in productivity and for better performance to benefit more number of people.**

Engineering Profession

Engineering is about applying knowledge (in a systems sense) from a broad range of disciplines (including Mathematics, Physical & Biological Science, Economics and Information Technology) to create technological processes, products and services that meet societal needs and enhance the '*Quality of Life*'.

Engineering Profession

The technological process capabilities and engineering skills have enhanced

- **agriculture productivity,**
- **textiles production,**
- **power generation,**
- **transportation,**
- **communications,**
- **Bio-medical equipments,**
- **pharmaceutical products,**
- **building materials,**
- **construction of buildings,**
- **Defence equipment and Weapon Systems &**
- **Space based Satellites and systems.**

Engineering Revolutionized and improved virtually every aspect of '*Human Life*'.

The engineering processes and the engineers have driven the advancement of living conditions of humans and provided them with better standards of living.

Adverse Impact of Engineering

Engineering has spurred and led the industrial revolution. But, in the process it has created important classes of problems, including:

- Human exposure to toxics in food, air, water and soil
- Rising demand for energy for transport, manufacturing, heating & cooling
- Depletion of non-renewable resources (petroleum, metals, phosphorus)
- Excessive demand for water for homes, agriculture and industry
- Rising demand for land for housing, food production and economic activities (production, retail, transportation)
- Ever increasing number and size of landfills
- Ecosystem damage and habitat loss due to pollutant discharges
- Impact on global climate

…. And the 'litany' goes on

Need for Sustainable Development

In the wake of changing Technological, Environmental, Social and Economic conditions, it is necessary that we should re-orient ourselves from development to sustainable development.

The role of Science & Technology in sustainable development is viewed in a new way with emphasis on technologies for empowerment like Education, Information, Communications etc., and Environmental sustainability like sustainable Agriculture, Clean and Renewable Energy, Improved Resource Efficiency.

The focus of technologies in Sustainable Development is whole systems.

SUSTAINABILITY
AND
SUSTAINABLE DEVELOPMENT

Sustainability is the process of moving human activities to a pattern that can be sustained in perpetuity.

At Global level, Sustainability and Sustainable Development are about striking a balance between environmental concerns of national resources, techno-economic systems and their development and societal concerns of human capital and social expectations, which results in "*Development that meets the needs of present generation without compromising the ability of future generations to meet their own needs*".

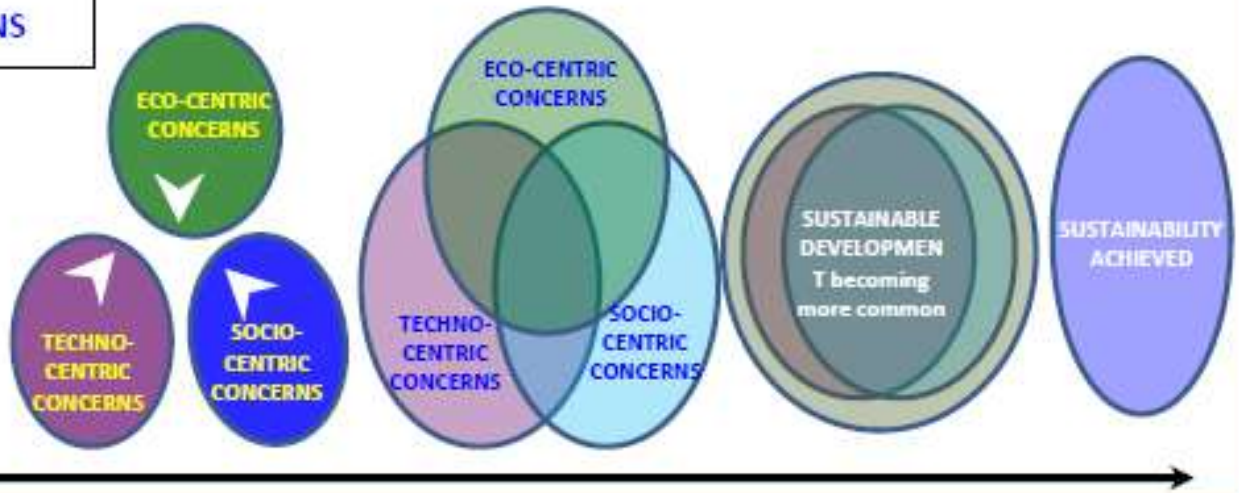
SUSTAINABILITY & SUSTAINABLE DEVELOPMENT

- MEETING THE NEEDS OF PRESENT GENERATION WITHOUT COMPRISING THE ABILITY OF FUTURE GENERATIONS TO MEET THEIR NEEDS
- BALANCING ECONOMIC DEVELOPMENT, SOCIAL EQUITY AND ENVIRONMENTAL PROTECTION HELP ACHIEVE SUSTAINABILITY
- FOR SUSTAINABILITY AND SUSTAINABLE DEVELOPMENT, STRIKE BALANCE BETWEEN
  - ENVIRONMENTAL CONCERNS OF NATIONAL RESOURCES
  - TECHNO-ECONOMIC SYSTEMS & THEIR DEVELOPMENT
  - SOCIAL CONCERNS OF HUMAN CAPITAL AND SOCIAL EXPECTATIONS

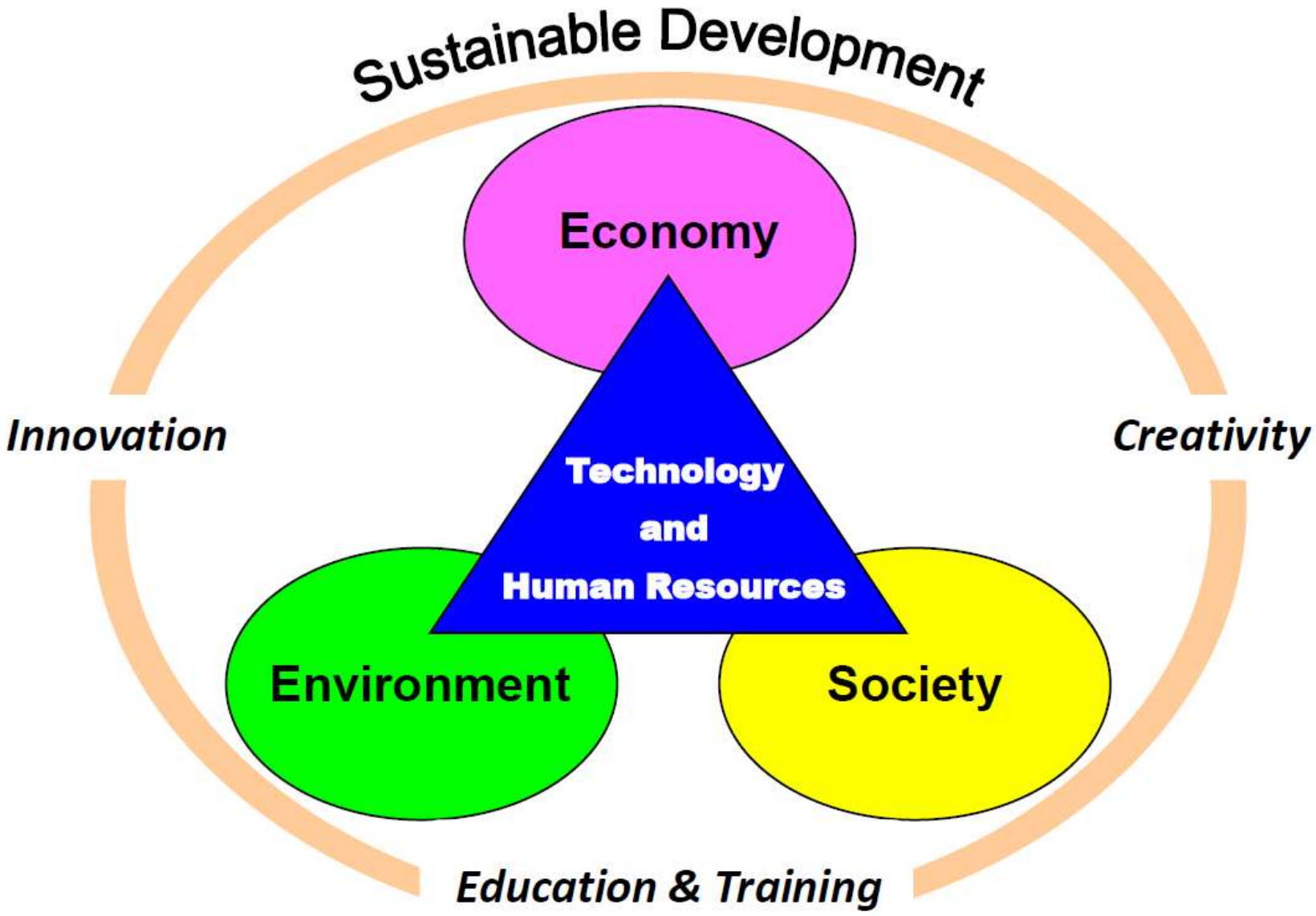
Three Dimensions of sustainability



Moving towards Sustainable Development



The Foundation of Sustainable Development



Sustainment Development Model



A 21st Century World



Information Explosion

Global Economy

Cognitive Revolution

International Partnerships

Diverse Workforce

Finite Resources

Creative Transformation

Environmental Sustainability

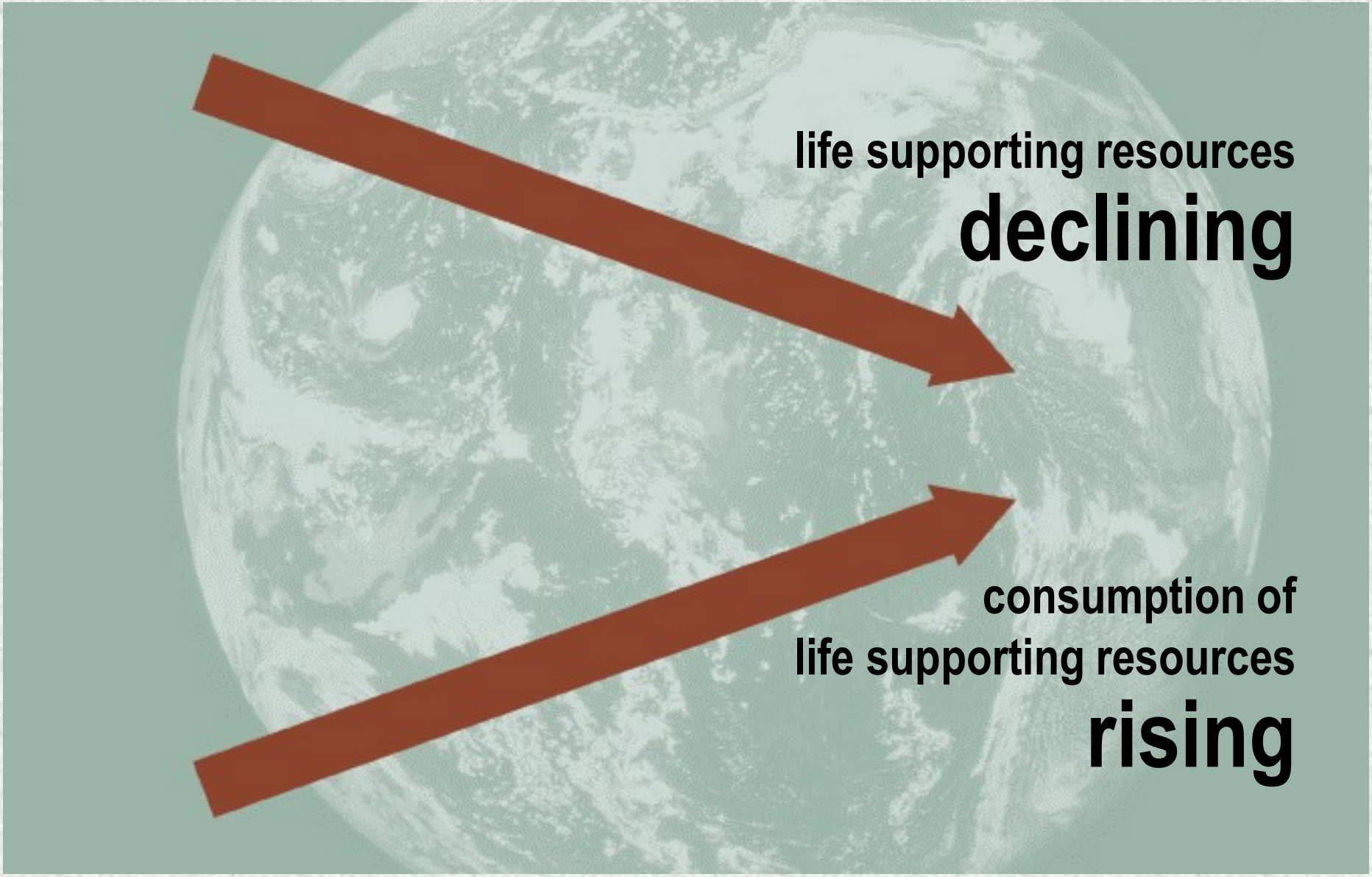
Continuous Innovation

Demographic Shifts

Infrastructure Renewal

Career-Long Learning

Global Perspective





The greatest challenge for 21st century engineering:
global sustainability

Six necessary & desirable Transformations for Sustainability



1. An energy revolution – Facilitating a global energy transformation (>80 % reduction in CO2 emissions by 2050)

2. Future food - a food system transformation to achieve +70% production by 2050 through Sustainable Intensification

3. An urban planet - Achieving sustainable urban living

4. The rising billion - Adapting to the population transition and preparing for a world of 9 billion people

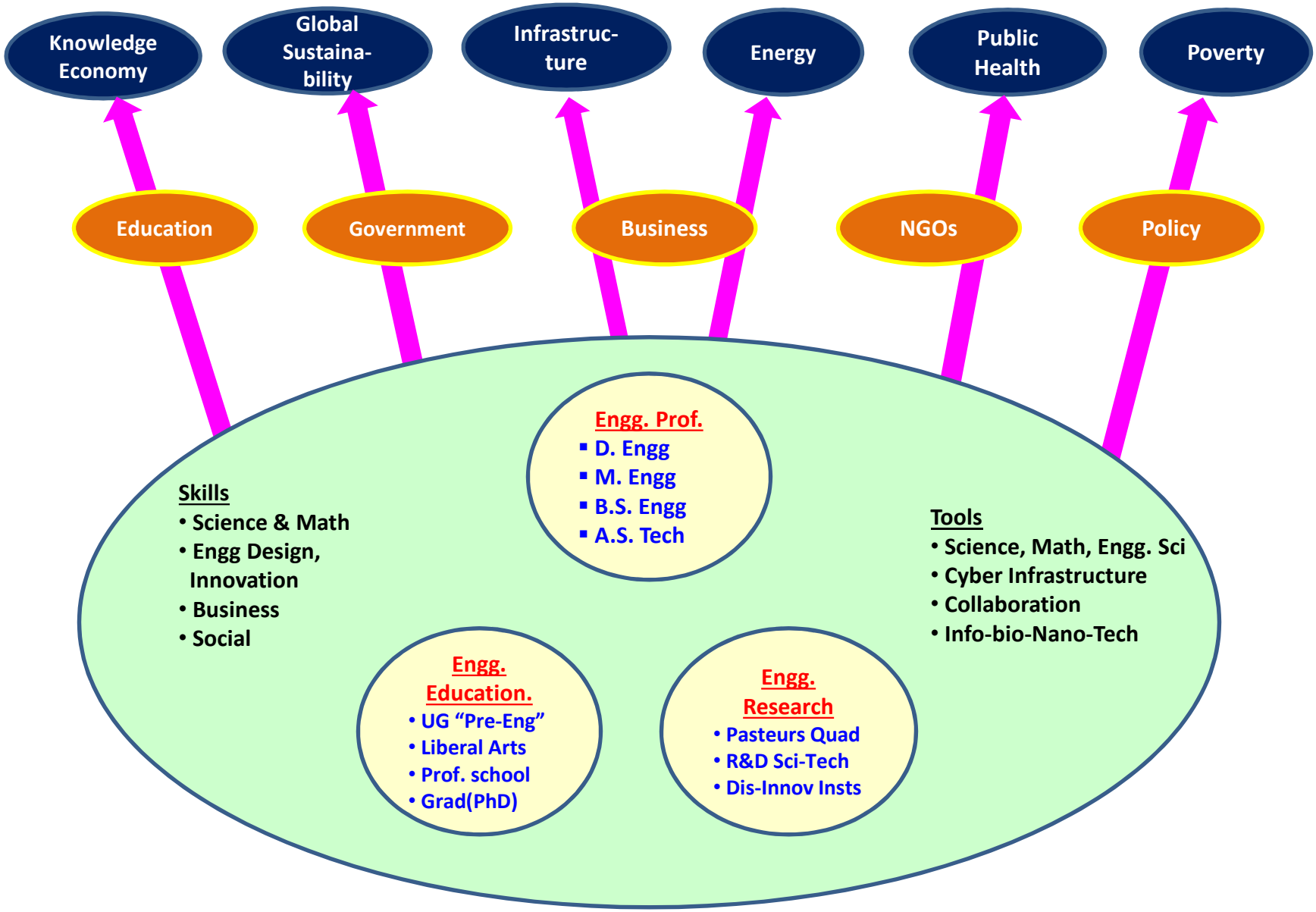
5. Protect, restore & sustain - A biodiversity Management Transformation

6. Strengthen global governance - A private and public Governance transformation



The shift to more sustainable technologies will mean significantly reducing the amount of energy and materials we use in producing our goods and services while decreasing risks to humans and the environment.
(*Bridge to a Sustainable Future*, Clinton White House, April 1995)

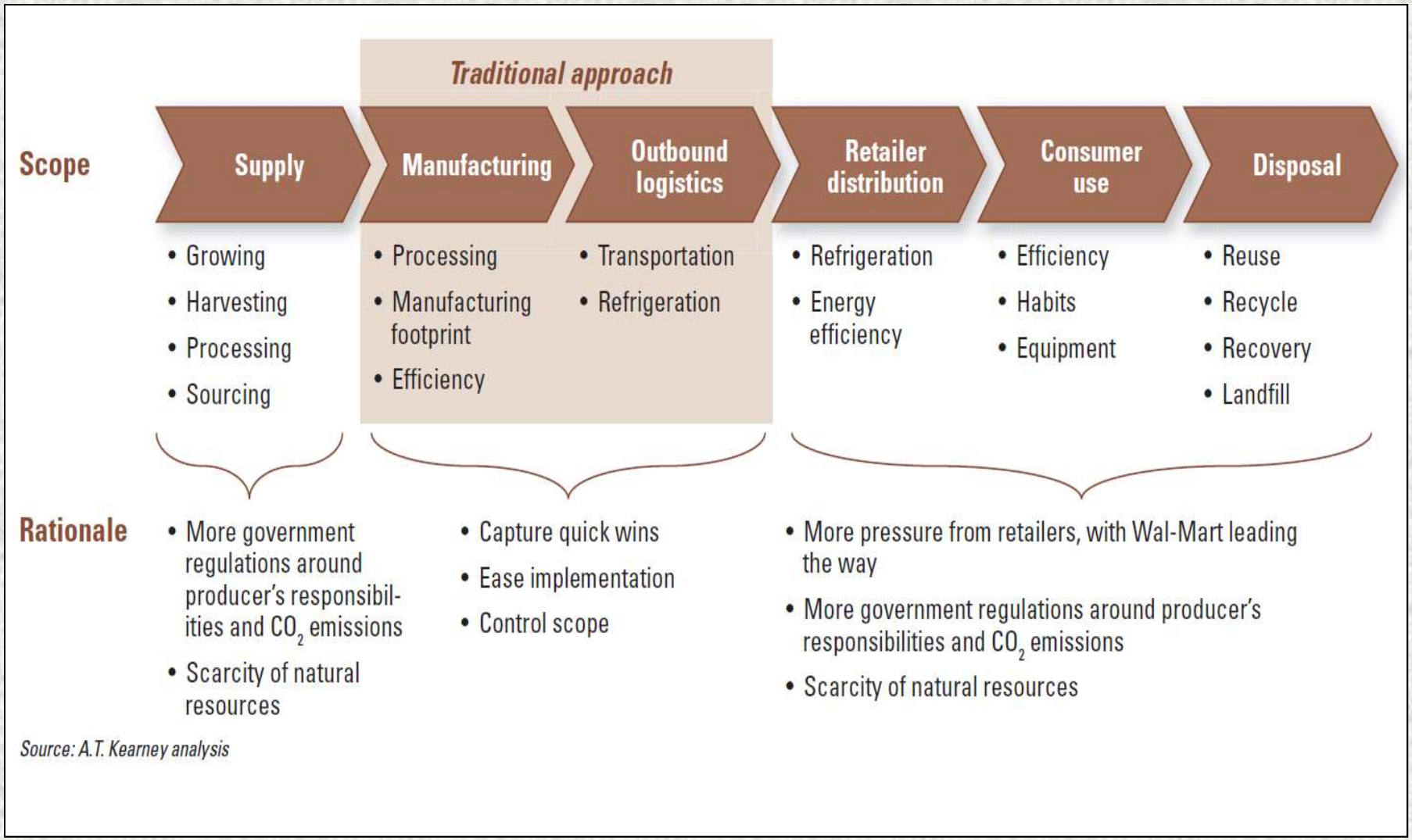
Grand Challenges of 21st Century Engineering



Transformation of Engineering

Traditional Engineering:	Sustainable Engineering:
• Considers the *object*	• Considers the *system* in which the object will be used
• Focuses on technical issues	• Integrates technical and non-technical issues
• Solves the immediate problem (*now*)	• Strives to solve the problem for the indefinite future (*for ever*)
• Considers the local context (*user*)	• Considers the global context (*planet*)
• Assumes others will deal with politics, ethics & societal issues	• Acknowledges the need for engineers to interact with experts in other disciplines related to the problem

PRODUCT LIFE-CYCLE APPROACH TO SUSTAINABILITY



Holistic and Total Life-cycle Approach

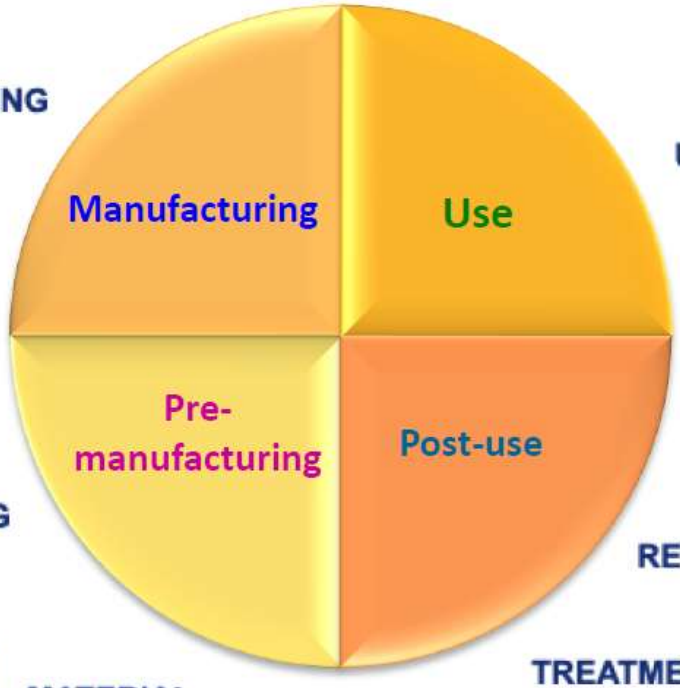
Emphasis on all four product life-cycle stages



MANUFACTURING



USE





MATERIAL
PROCESSING



RETIREMENT

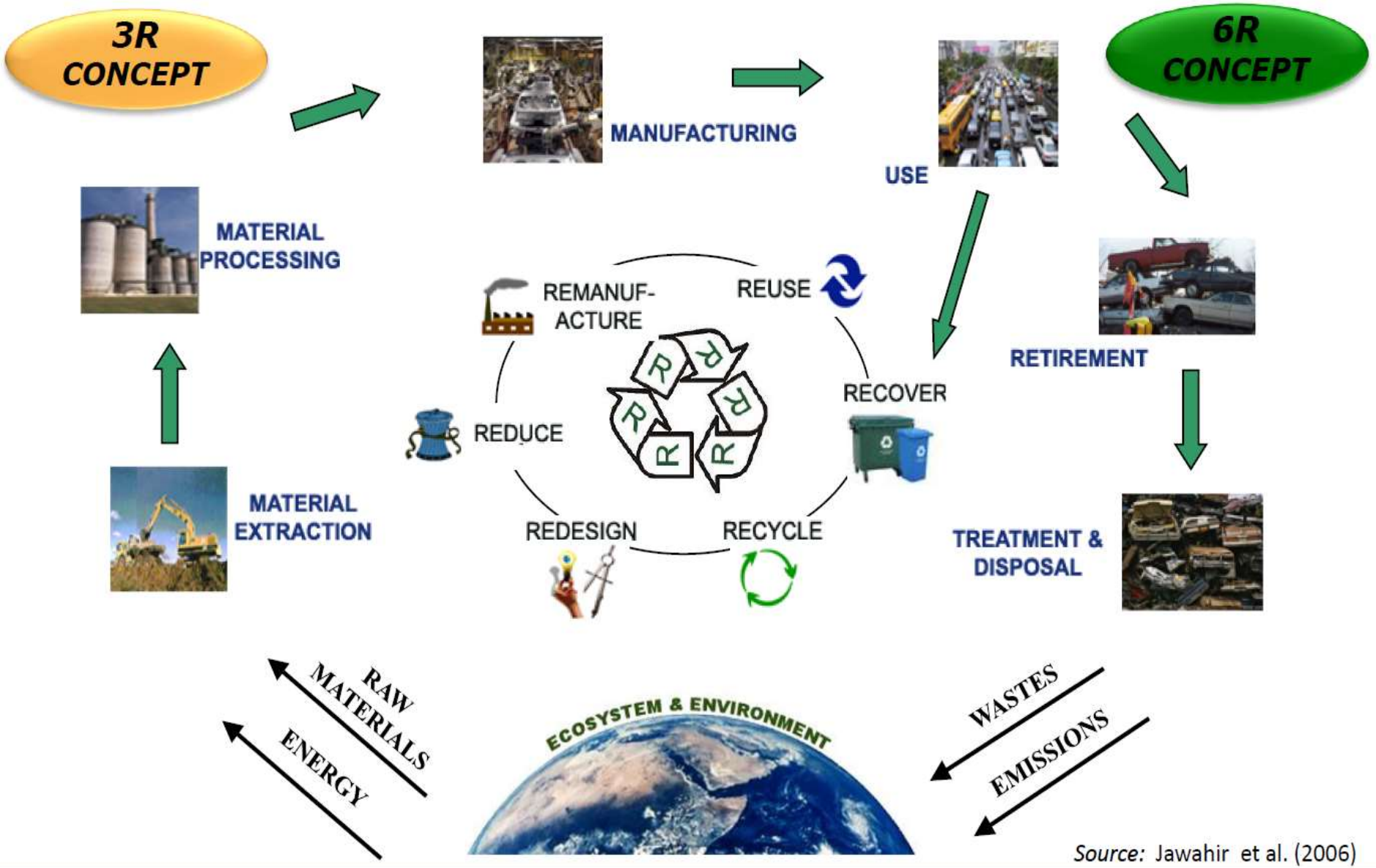


MATERIAL
EXTRACTION

TREATMENT &
DISPOSAL

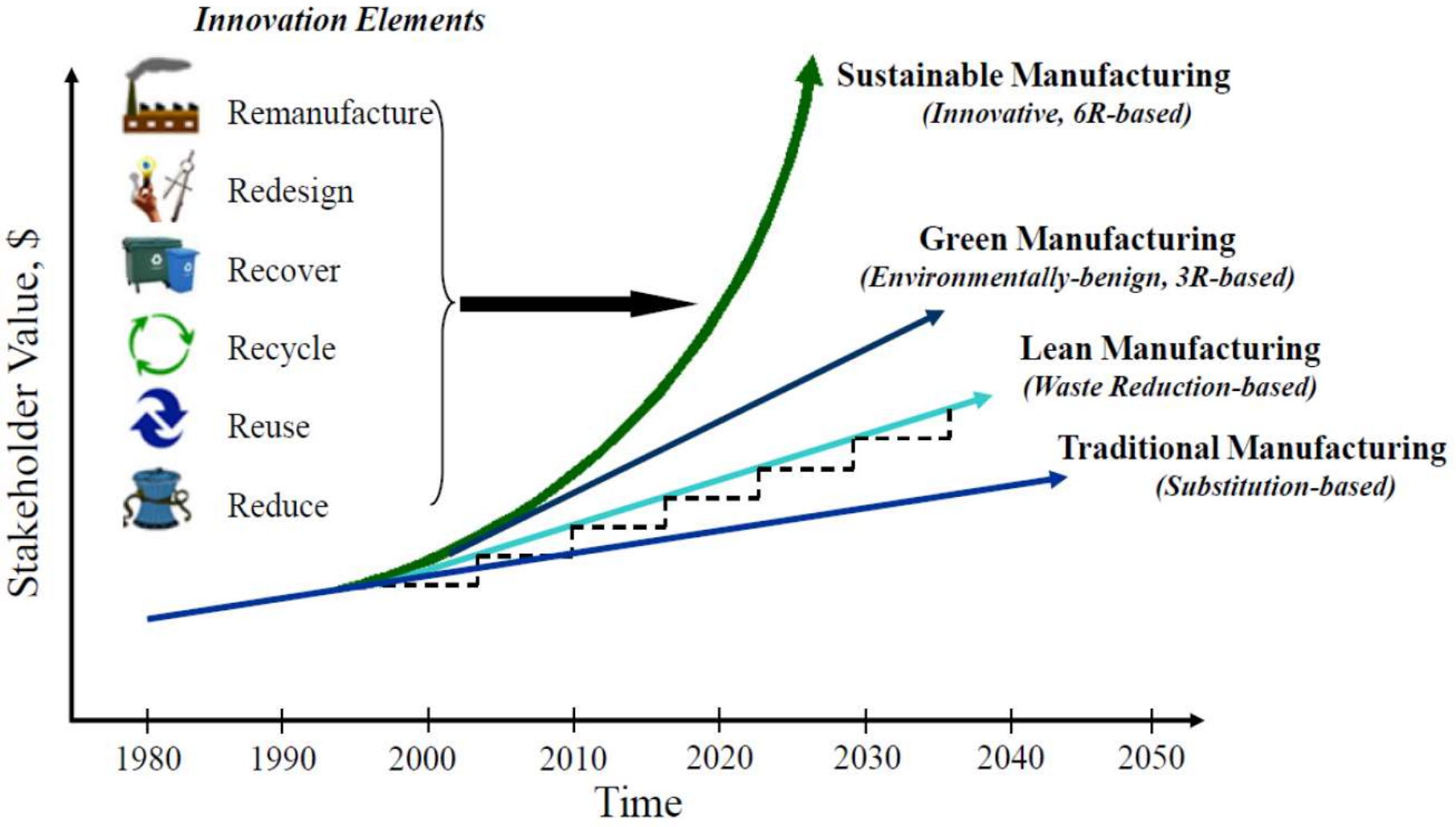


Closed-loop Material Flow – The 6R Approach

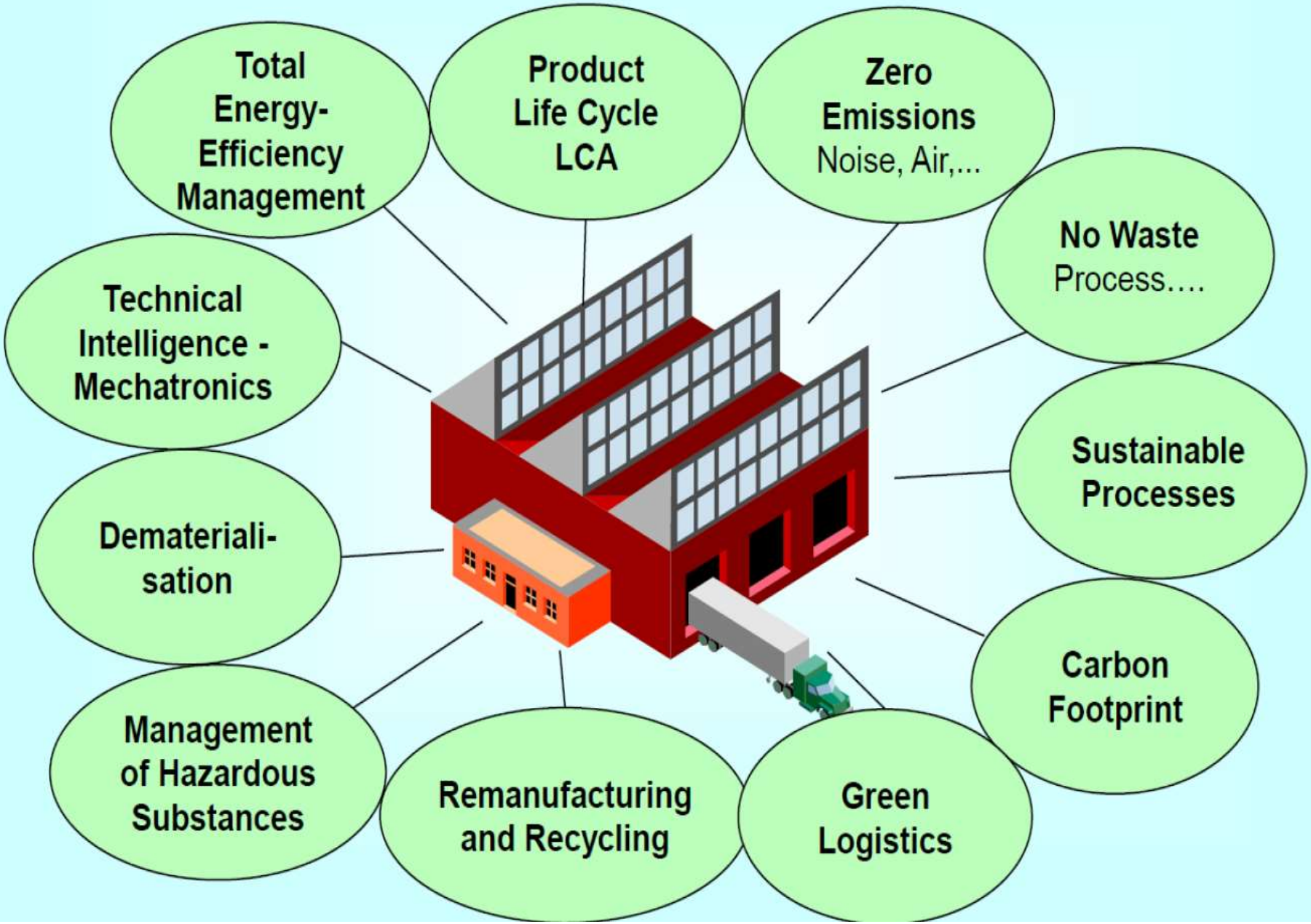


Source: Jawahir et al. (2006)

Evolution of Sustainable Manufacturing



Factory and Nature - The Green Factory: Lean, Clean, Green



Guidelines for engineering processes for Sustainment

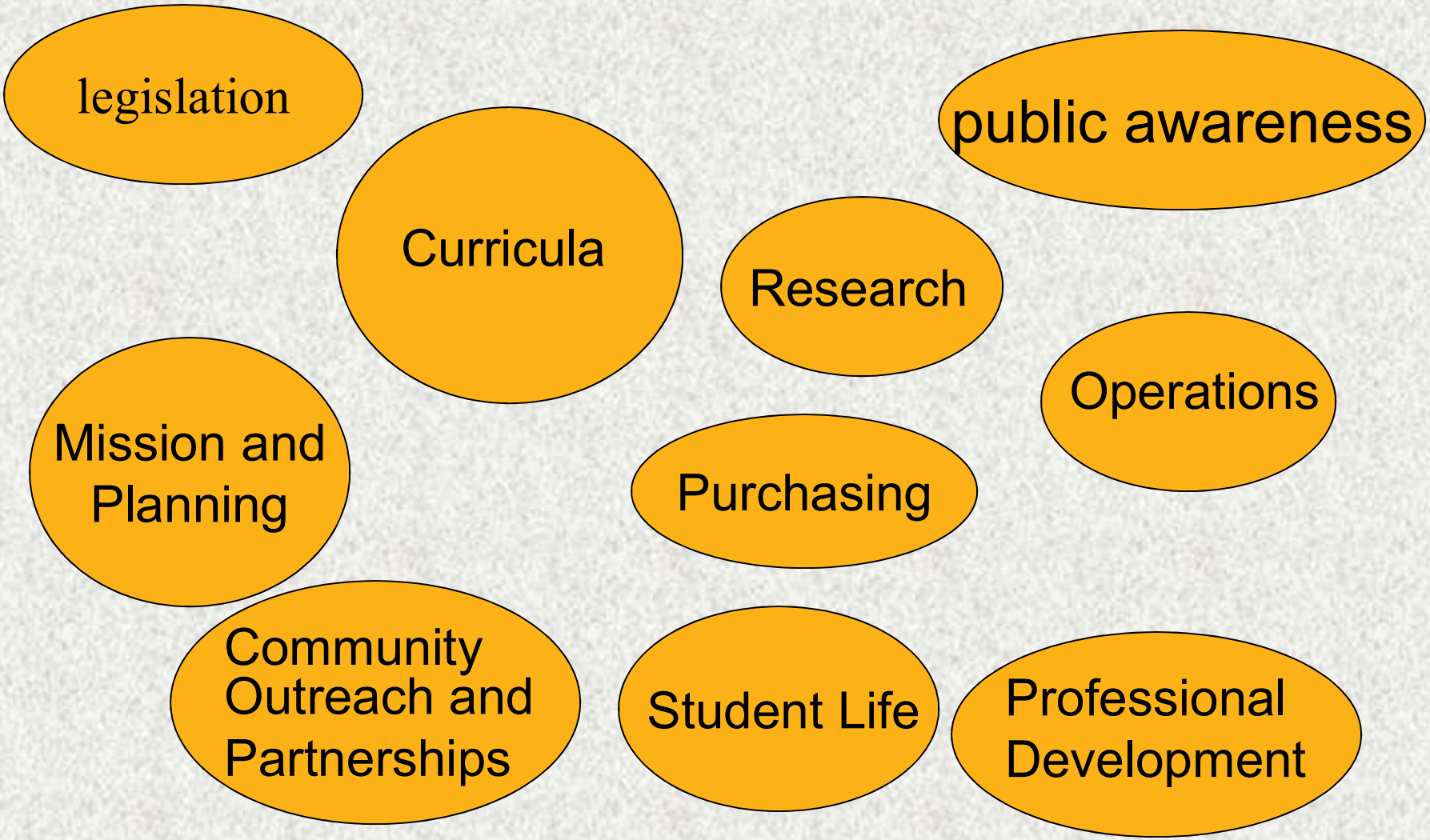
- Larger global vision beyond local and the immediate future
- Seek engagement from all stakeholders and arrive at balanced solution
- Ensure exact needs and wants for the product of service
- Plan and manage product development effectively
- To create and Innovate
- Treat Sustainability as the balancing requirement between Global and Local. Exercise the needed discretionary perspective of usage of local skills and resources to meet global scale requirements.
- Adopt a holistic, 'cradle-to-grave' approach for all product engineering decisions and actions

Guidelines for engineering processes for Sustainment

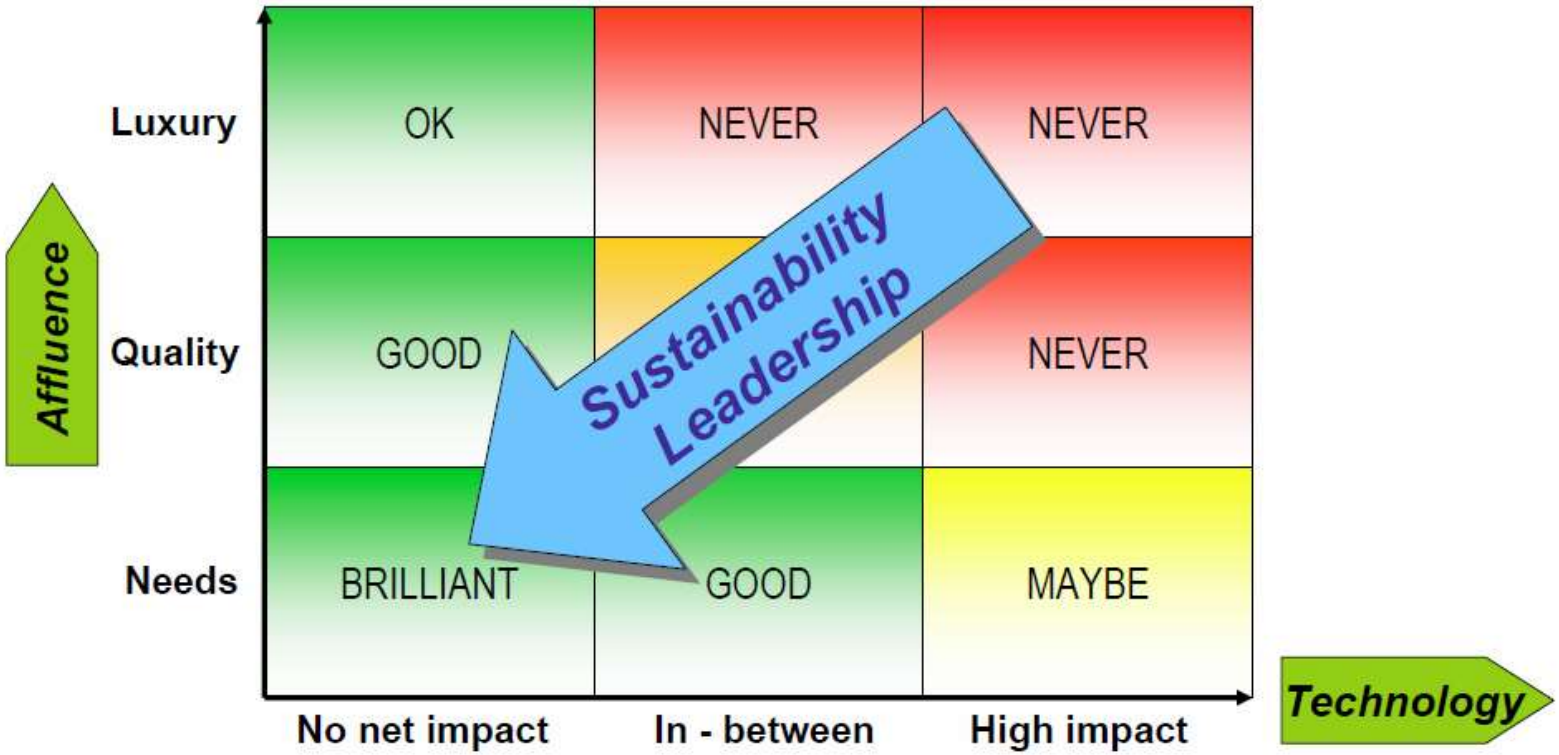
- The principle of engineering for sustainable development should include

  - ❖ Involvement of all agencies / stake holders
  - ❖ Reduction of adverse environmental and social impact of engineered products, services and infrastructure
  - ❖ Innovation to provide high quality life
  - ❖ Development of globally competitive products / services / infrastructure
  - ❖ Growth of technology for sustainability of Eco-System

For higher education,
Sustainable Development is being integrated into:



Choosing what you are engineering for - engineers can't be neutral



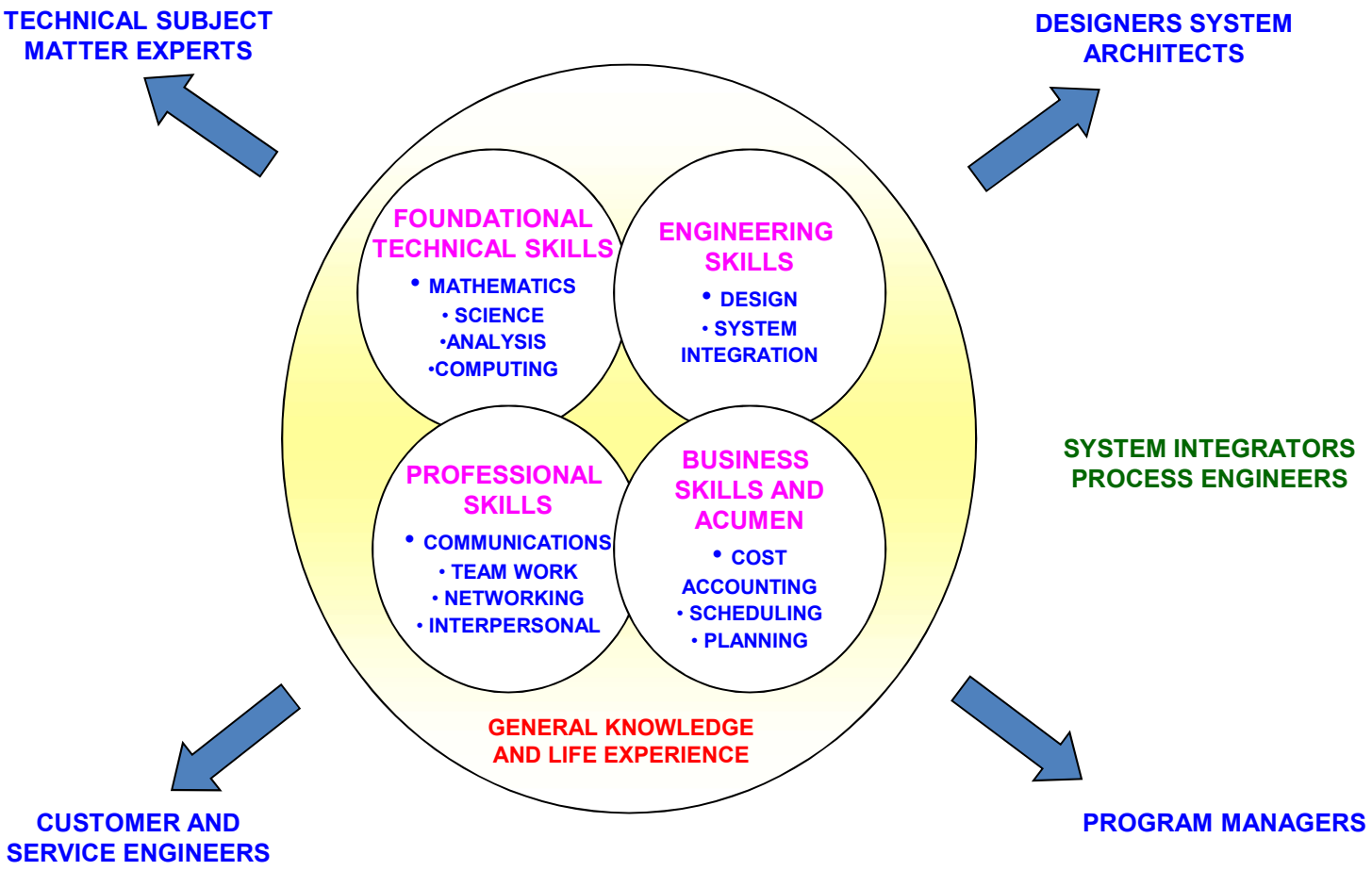
Successful Attributes for the Engineer of 2020

Adaptive Leaders

- Possess strong analytical skills
- Exhibit practical ingenuity; posses creativity
- Good communication skills with multiple stakeholders
- Business and management skills; leadership abilities
- High ethical standards and a strong sense of professionalism
- Dynamic/agile/resilient/flexible
- Lifelong learners
- Ability to frame problems, putting them in a socio-technical and operational context

A WELL-ROUNDED ENGINEER

KNOWLEDGE OF MANY SKILLS WITH CAREER CHOICES BASED ON TALENT, ABILITY, INTEREST AND AMBITIONS



Values for the 21st Century Engineer

- Holistic Values
- Creativity and Innovation in the Product Designers
- Responsibility – Service Orientation
- Entrepreneurship and Risk taking capabilities
- Learning to improve
- Leadership for Change and Global Excellence

Holistic Values

- The whole is greater than the sum of its parts.
- Modern engineer needs to see connections between seemingly disparate components and integrate them so that their combined value is greater than the sum of the values of the individual components.
- Engineers have to interact with other fields such as Marketing, Finance and Production to build products and systems for mass consumption in addition to his engineering tasks.

Creativity and Innovation in the Product Designers

- '*Creative' thinking*' is a critical component of innovation process.
- 21st Century Engineers will have to think outside the box and improve their creative thinking abilities.
- Creativity is an attitude and a skill.
- Modern engineer must be willing to break the norms and persist unwaveringly in their pursuit to innovate better products, process & systems.
- Engineers should set goals of maximizations to their creative efforts.

Responsibility – Service Orientation

- 21st Century Engineers have to be responsible towards humans and the environment.
- Engineers strive to develop technology that helps to bridge the digital divide.
- Bridging the digital divide (development of masses) and profit making can go hand in hand.
- The Indian engineer has to keep this as an axiom in his product design and production technology development exercises

Entrepreneurship and Risk taking capabilities

- Development of new idea is just a first step towards innovation.
- An idea that is developed and put into market, is more important than idea that exists only as an idea.
- Engineers must have an understanding on the methodology and process of marketing their ideas, attract venture capital, strategically operate their business and create wealth.
- Engineers to be action oriented individuals with a desire for achievement and willingness to take risks.

Learning to improve

- Modern engineers to have an excellent '*knowledge base*' coupled with an insatiable desire to continuously acquire new knowledge and skills.

- The illiterate of the 21st Century will not be those who cannot read or write, but those who cannot learn, unlearn and relearn.

- Learning new technical skills is important for engineers.

- A holistic learning approach drives the engineers improve their thinking, communication, problem-solving capabilities and interpersonal skills.

Leadership for change & global excellence

- It is often in times of great change that great leaders are born.
- Engineers as Leaders, recognize the need for change and develop new approaches and goals for the future.
- Engineers with new visions work together with partners in collaborative modes.
- Engineers work & collaborate with Industry, academic institutions, government and formulate strategies and develop & produce new products, processes and systems of excellence.
- Engineer as a leader can bring in change through the results of his efforts benefiting large multitudes of people.

New disciplines & fields for 21st Century Engineer

- *Molecular Biology, Bio-Engineering, Pharmaceuticals,*
- *Food & Nutrition technologies,*
- *Plastics & Ceramics, Composites,*
- *Solid State Physics,*
- *MEMS / NEMS,*
- *Fibre Optics,*
- *Microwaves, Lasers,*
- *Solar Power system,*
- *Lithium Ion cells, Fuel Cells,*
- *Nuclear Technologies,*
- *High Energy materials*
- **Network centric large complex activities**
- **Convergence of Nano / Bio / Info / Cognitive (NBIC) Technologies**
- **Advanced logistics**
- **Autonomous intelligent systems**
- **Quantum computing and encryption**
- **Advanced power sources**
- **Digital Manufacturing**

Engineering Skills:

- Systems Integration : Synthesis
- Engineering Sciences : analysis
- Problem formulation as well as problem solving
- Engineering Design
- Ability to realize products
- Facility with intelligent technology to enhance creative opportunity
- Ability to manage complexity and uncertainty
- Teamwork; sensitivity in interpersonal relationships
- Language and multi-cultural understanding
- Ability to advocate and influence
- Entrepreneurship; management skills; decision making
- Knowledge integration, education and mentoring

ENGINEERING THEORY & PRACTICE
Bridging the Gap by 'Design-Build-Test-Validate'

Design-Build-Test & Validate Projects will help to:-

- ✓ **Teach students how to formulate an engineering problem and to differentiate between "requirements" and "objectives**
- ✓ **Develop both creative and critical thinking skills and abilities**
- ✓ **Reinforce the concept that "*if you can't built it, you can't use it or sell it*"**
- ✓ **Introduce and develop project management skills and an awareness of business practices including costs & budgets.**
- ✓ **Demonstrate the importance of communication skills - i.e "if you can't explain your solution to someone else, you haven't solved the problem".**
- ✓ **Demonstrate the value of team work (synergy and diversity – that two or more diverse heads are often better than one)**

Challenges to build & develop 21st Century Engineer

- **Building expertise in fundamental sciences like Maths, Physics, Chemistry, Biological Science to establish a 'base & foundation' to support the development of future advanced technologies like *Nano technologies and to build system knowledge* [the WHY of a system]**

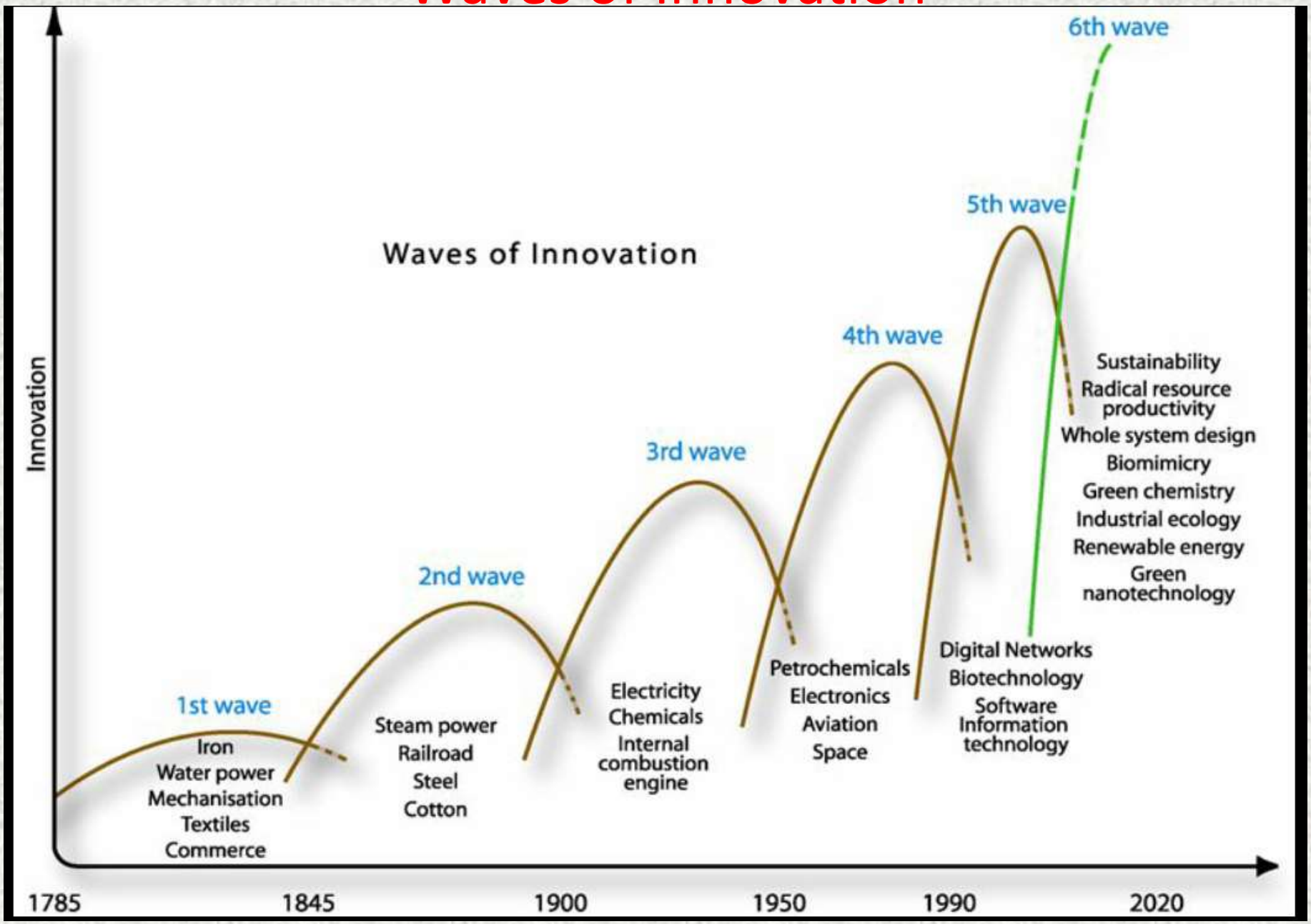
- ***Building a 'national and international perspective and standards'* on the 'subject knowledge' among the 'Teachers in Schools' and 'Faculty in Colleges'.**
- **Creating a culture and mind set of 'design-build-test' and validate in colleges and universities through Awards & Rewards of highest order & making it as a pre-requisite for career entry into industry**

- **Building infrastructure to enable growth of science & technologies in colleges and among universities – specifically Test facilities.**

- **Provision of larger budget for faculty improvement and excellence**

- **Integration of Education, Research and Industry to innovate new products & processes. Sustaining the 'integration' and making it 'productive'.**

Waves of Innovation



The Urban Effect

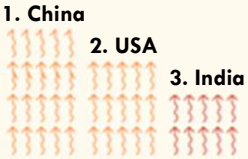
Sustaining Growth in India through better Urban Planning

With a population of more than 1.2 billion, India is projected to be the world's most populus country by 2025. By 2050, it is estimated that India's urban population will constitute nearly half of the country's total population, straining an already stressed infrastructure. Th egood news: urbanization is an indicator of positive economic development. With improved urban planning, India can tackle urbanization challenges and increasing populations to create country that is poised for sustainable growth

Cities

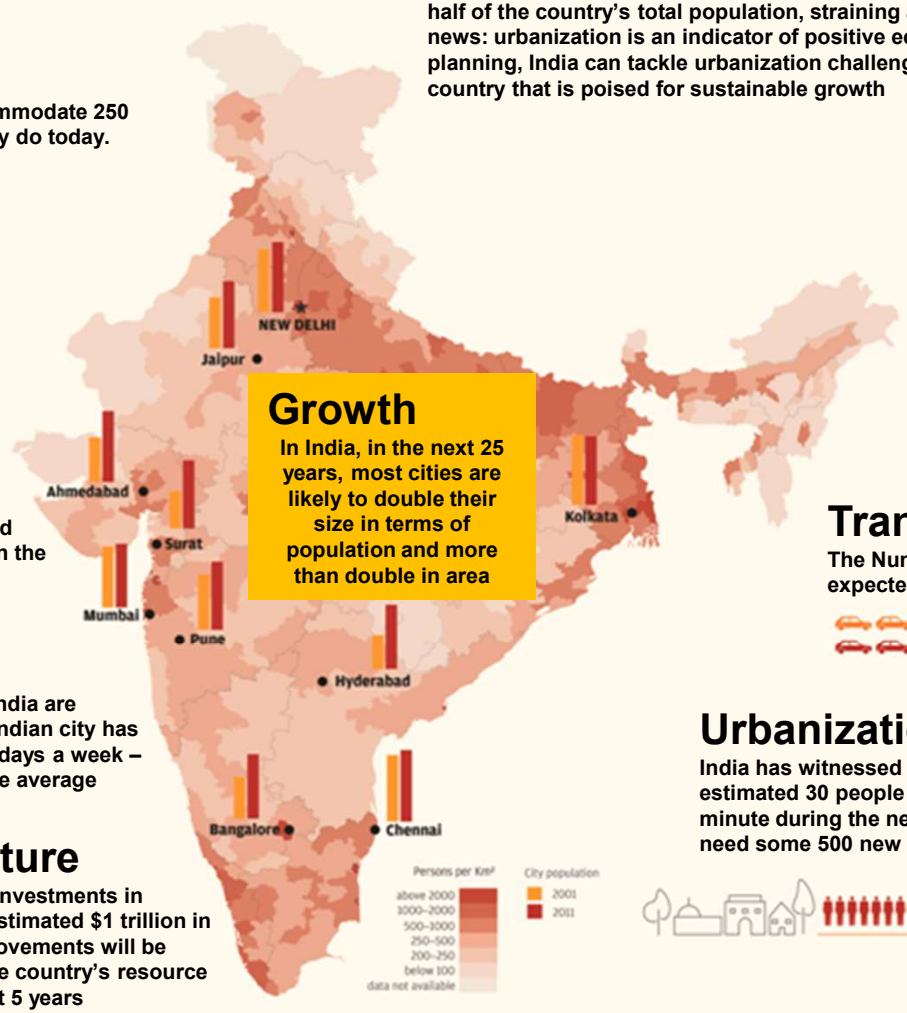
In 20 years, India's cities will have to accommodate 250 million to 300 million more people than they do today. That's the equivalent of 11 New Delhis





Population

By 2015, India is expected to become the world's third largest emitter of carbon dioxide – it ranked fifth in 2005



Growth

In India, in the next 25 years, most cities are likely to double their size in terms of population and more than double in area

Electricity

Of the 1.4 billion people of the world who have no access to electricity in the world, India accounts for over 300 million

Transportation

The Number of private vehicles in India is expected to grow by more than 3 times by 2021



Water

Only 74% of urban households in India are served by piped water supply. No Indian city has piped water 24 hours a day, seven days a week – 4 to 5 hours of supply per day is the average

Urbanization

India has witnessed major urbanization in recent times, with an estimated 30 people leaving rural India for urban areas every minute during the next 20 years. At this rate, the country will need some 500 new cities in the next two decades

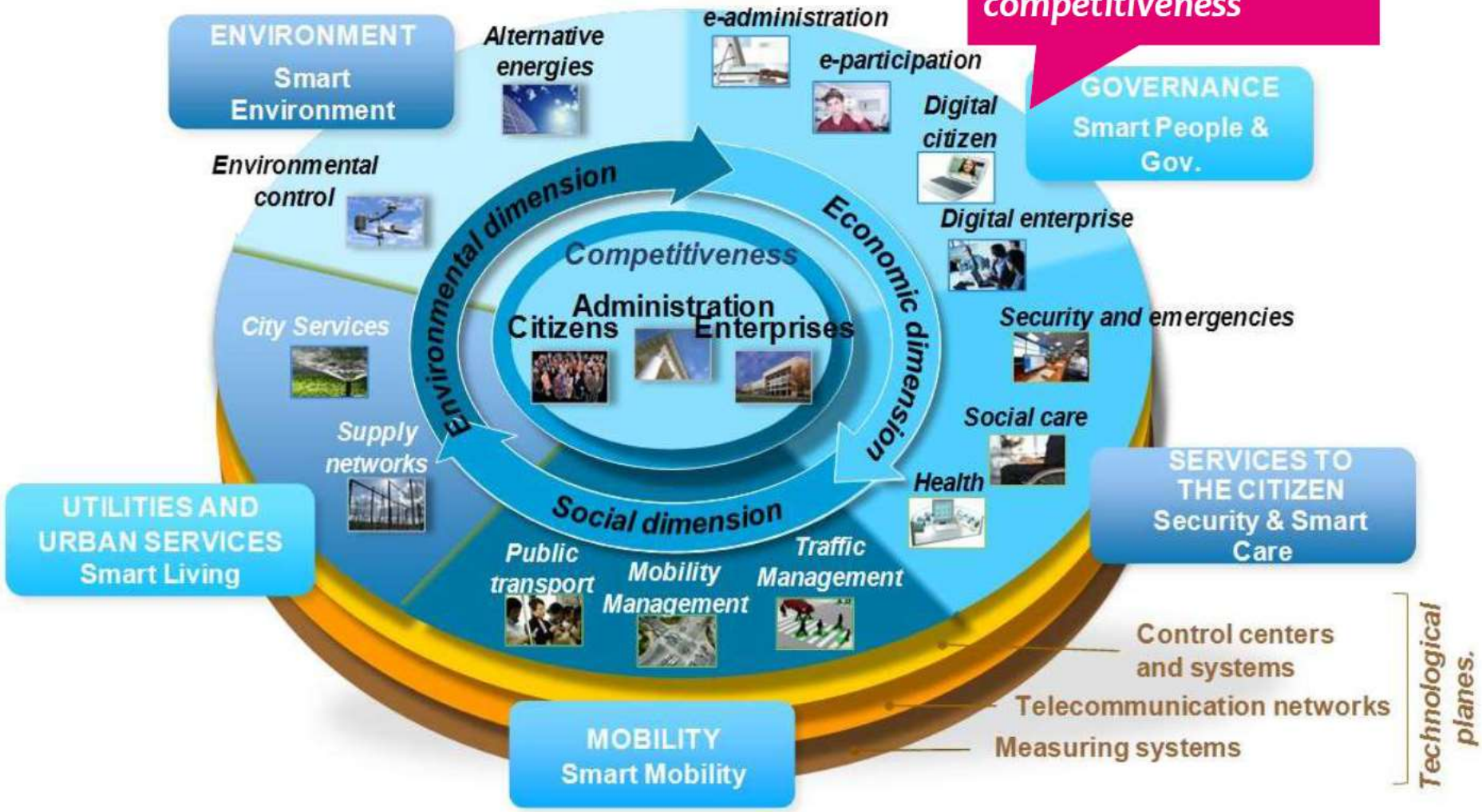


Infrastructure

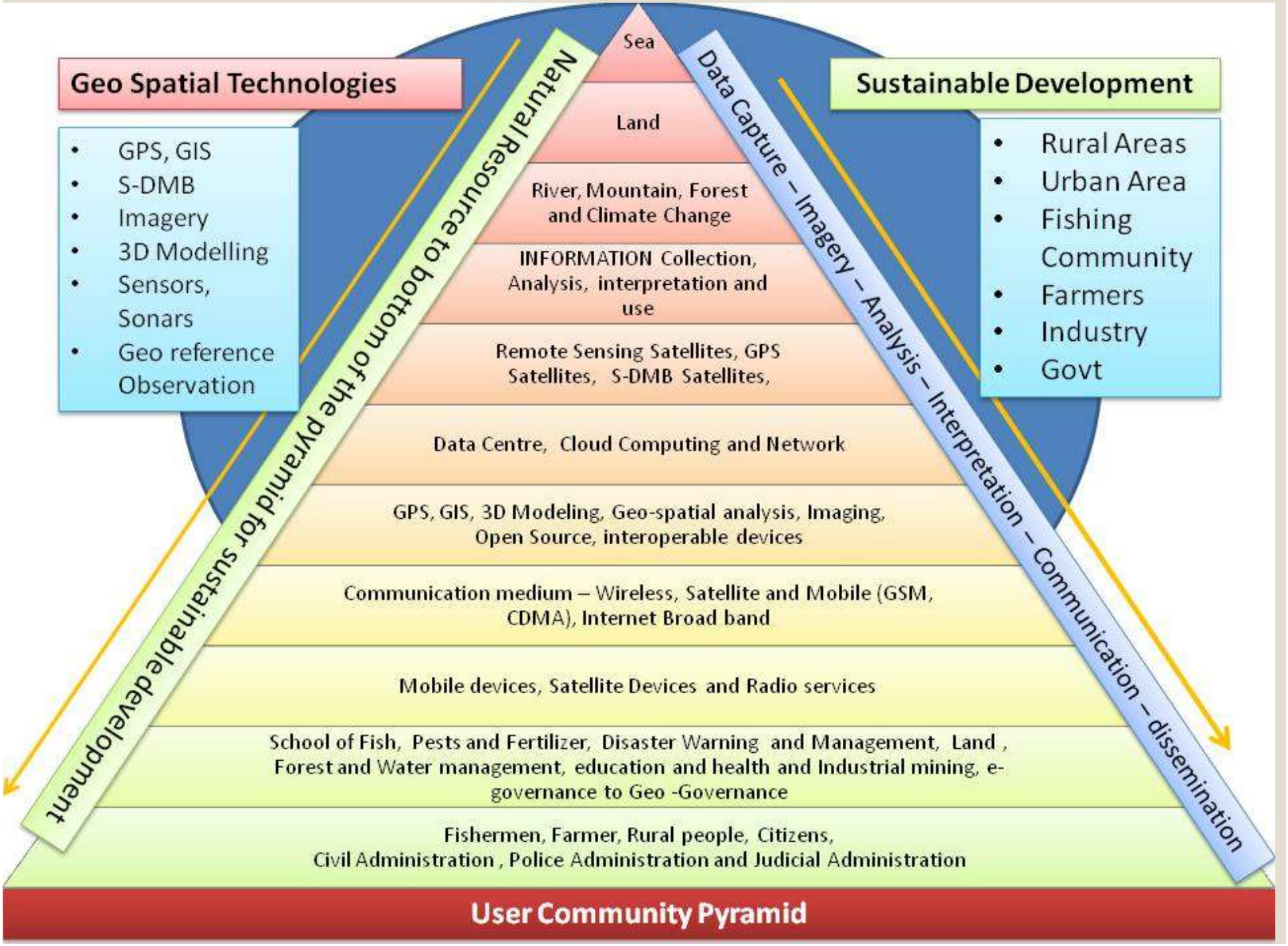
Despite increased investments in Infrastructure, as estimated $1 trillion in infrastructure improvements will be required to meet the country's resource needs over the next 5 years

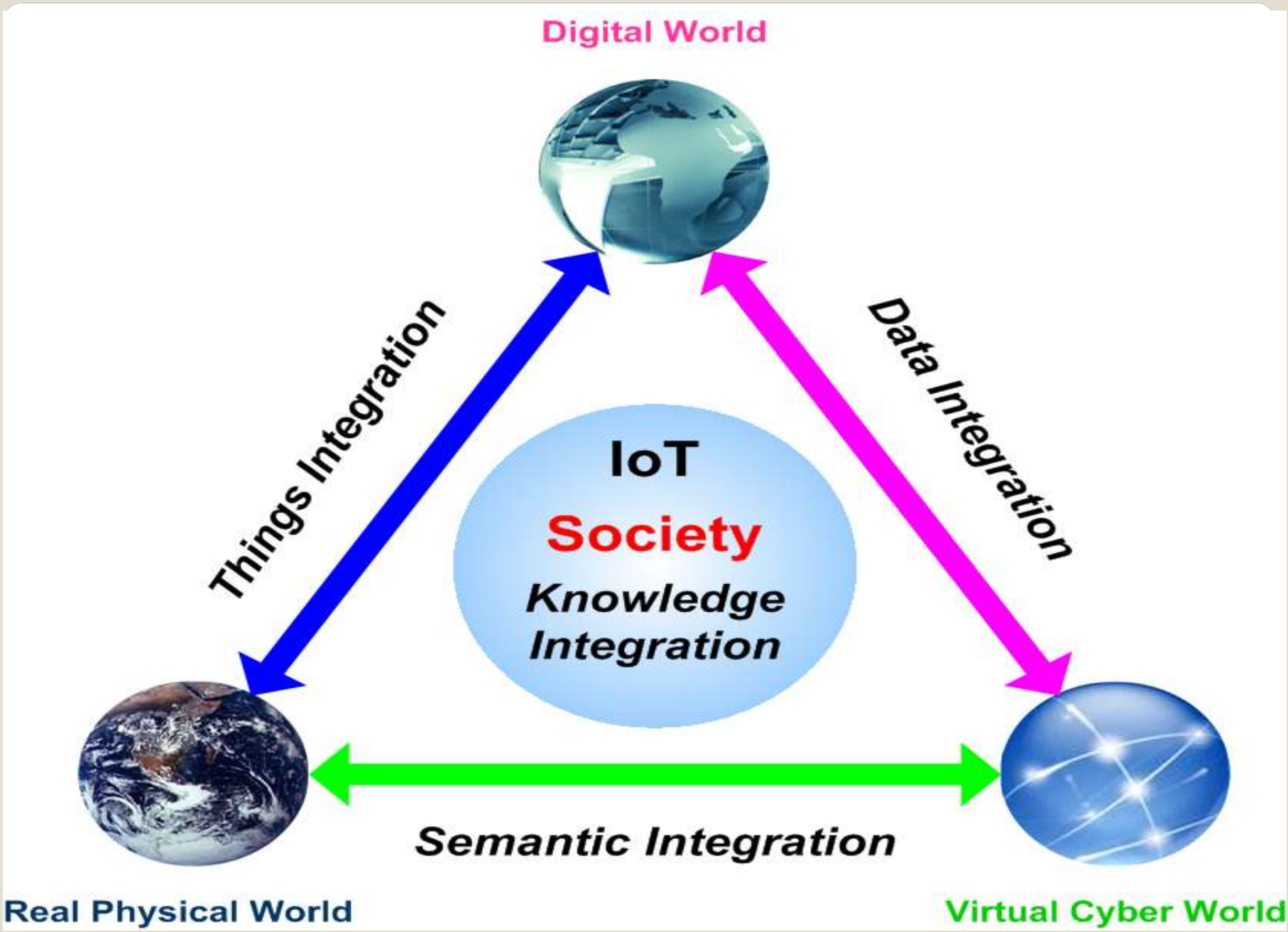
Holistic View of Smart Cities

The deployment of a Smart City activities is carried out based on three technological planes and lays down the conditions for its competitiveness




Transportation
Emergency Services
Buildings
Communications
Smart City Information Integration Hub
Smart Cities Information Map
Energy
Sewerage
Water Management
City Government
Health
City Manager's BI System
Environment & Pollution


Geo Spatial Technologies
GPS, GIS
S-DMB
Imagery
3D Modelling
Sensors, Sonars
Geo reference Observation
Sustainable Development
Rural Areas
Urban Area
Fishing Community
Farmers
Industry
Govt
Natural Resource to bottom of the pyramid for sustainable development
Data Capture – Imagery – Analysis – Interpretation – Communication – dissemination
Sea
Land
River, Mountain, Forest and Climate Change
INFORMATION Collection, Analysis, interpretation and use
Remote Sensing Satellites, GPS Satellites, S-DMB Satellites,
Data Centre, Cloud Computing and Network
GPS, GIS, 3D Modeling, Geo-spatial analysis, Imaging, Open Source, interoperable devices
Communication medium – Wireless, Satellite and Mobile (GSM, CDMA), Internet Broad band
Mobile devices, Satellite Devices and Radio services
School of Fish, Pests and Fertilizer, Disaster Warning and Management, Land , Forest and Water management, education and health and Industrial mining, e-governance to Geo -Governance
Fishermen, Farmer, Rural people, Citizens, Civil Administration , Police Administration and Judicial Administration
User Community Pyramid


Digital World
Things Integration
Data Integration
IoT
Society
Knowledge
Integration
Semantic Integration
Real Physical World
Virtual Cyber World

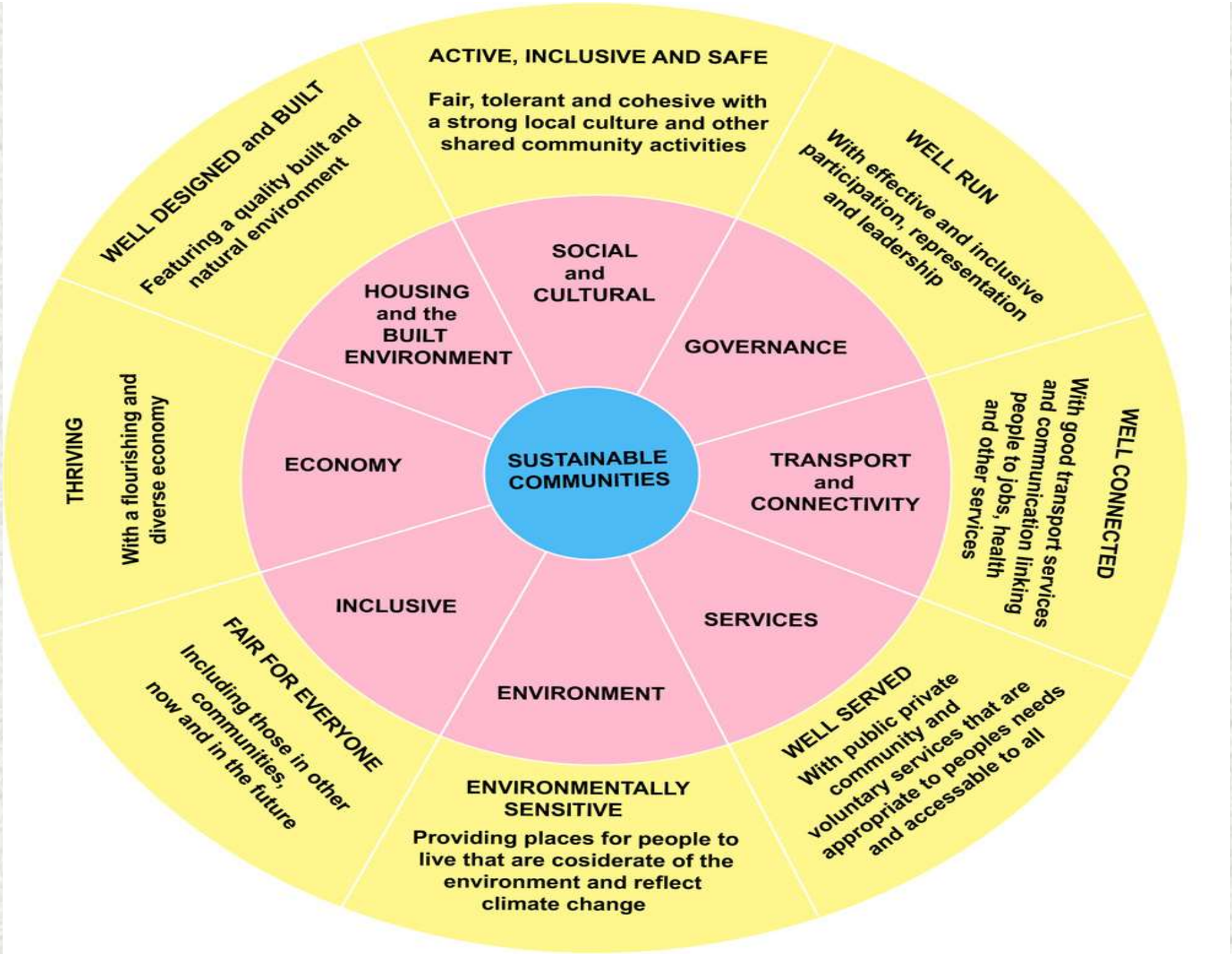
Internet of Things
(assets, devices, mobile and static sensors)

Internet of People
(social networking, crowd-sourcing, workflow)



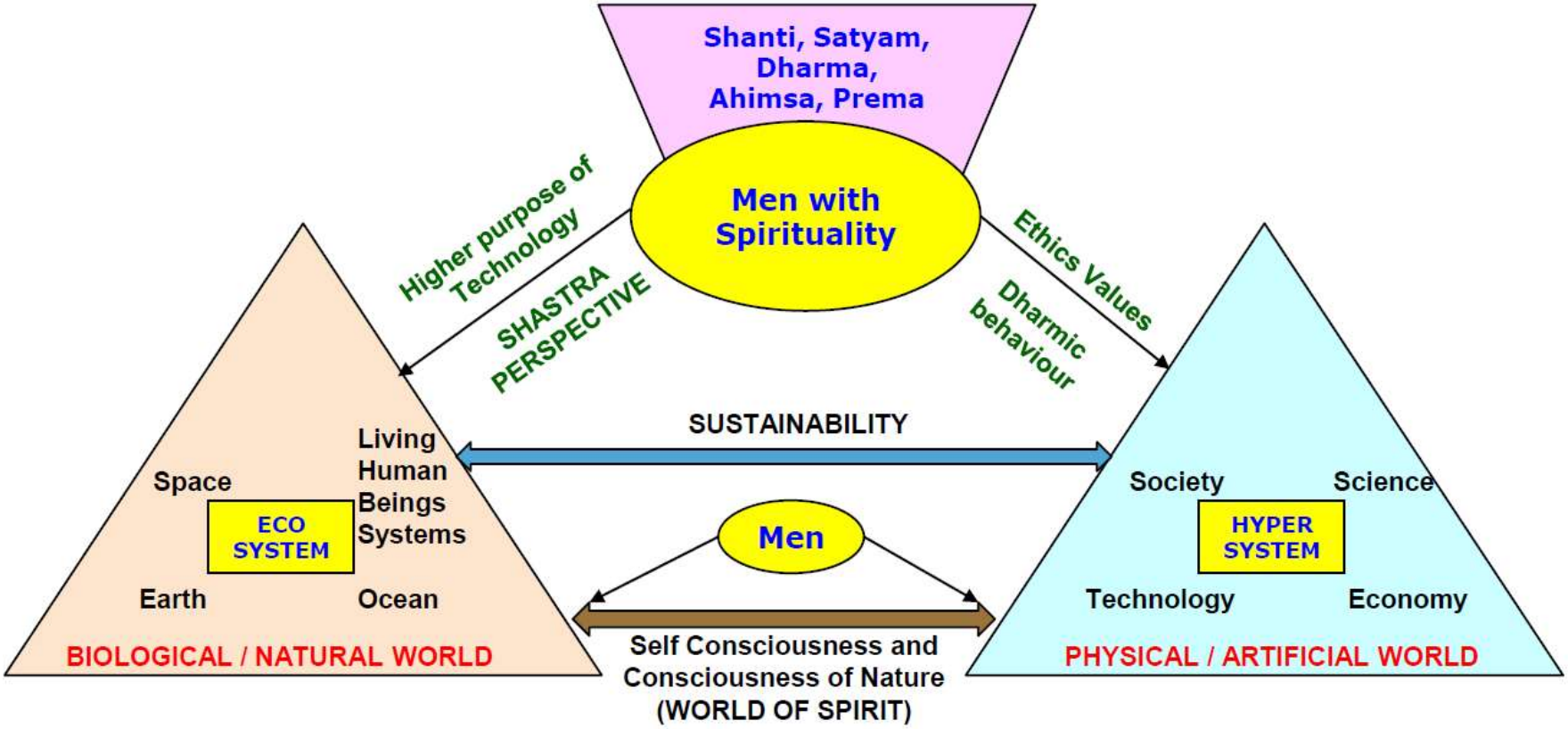
Internet of Services
(cloud-based solutions, processes, tools and operations)

Internet of Data
(Linking of Open Data)


ACTIVE, INCLUSIVE AND SAFE
Fair, tolerant and cohesive with a strong local culture and other shared community activities
WELL RUN
With effective and inclusive participation, representation and leadership
WELL CONNECTED
With good transport services and communication linking people to jobs, health and other services
WELL SERVED
With public private community and voluntary services that are appropriate to peoples needs and accessable to all
ENVIRONMENTALLY SENSITIVE
Providing places for people to live that are cosiderate of the environment and reflect climate change
FAIR FOR EVERYONE
Including those in other communities, now and in the future
THRIVING
With a flourishing and diverse economy
WELL DESIGNED and BUILT
Featuring a quality built and natural environment
SOCIAL and CULTURAL
GOVERNANCE
TRANSPORT and CONNECTIVITY
SERVICES
ENVIRONMENT
INCLUSIVE
ECONOMY
HOUSING and the BUILT ENVIRONMENT
SUSTAINABLE COMMUNITIES


Take Responsibility
Look for Holistic Interconnections
Convene Constructive Conversations
Embrace Creative Tension
Facilitate Emerging Outcomes
Understand Social Change Dynamics
Experiment, Learn and Adjust
Expand Conscious Awareness
Sustainability Leaders…

Spirituality and Sustainability



Self organise through
Micro-Macro relationship
(Internal Commn.)

Self organise through hyperspace of
Science x Tech x Economy x Society
(Internal Commn.)

STRAIN

SLOWER GROWTH

FASTER GROWTH

ECOLOGICAL DILEMA
(LUTMANN)
Present Age

Handprint



- It is vital that we instigate change in order to improve living standards of all and reduce the impact on planet.
- Choices that we make now will shape our opportunities in future and those of future generations.
- But availability of alternative models and vision for sustainable future is not enough, what we need is 'action'.
- Education is a key driver to achieve this transformation.
- Education for Sustainable Development (ESD) encourages a shift from viewing education as a delivery mechanism to a lifelong, holistic and inclusive learning process.
- **Handprint is a measure of ESD action; action that is directed to decrease the human footprint and make the world more sustainable**.

Handprint



- Handprint is a new tool being developed by Centre for Environment Education (CEE), India to help measure action at different levels.
- One needs to ask what one does at individual, community, national and global level.
- The handprint analyses positive impact on the three aspects of sustainability: environment, society and economy.
- Various questions cover each aspect, investigating on amongst others your use of resources, your social engagement and your awareness of sustainable investments.
- While the footprint is the negative effect you leave on global resources, handprint is your positive efforts towards sustainability.

Increase your Handprint !

Decrease your Footprint!



THANKS