Chapter 1

# Roles and Opportunities for Information Technology in Meeting Sustainability Challenges

In Today's world, computing is heart of the large socio-economic system. Computing is affecting our daily lives from financial to transportation, healthcare etc. Because of this, there is need of new innovations to tackle with the growing sustainability challenges. IT can play the very vital role in achieving the target for future by new technology, innovations addressing the current sustainability challenges. In other word, IT and computing can help to address the sustainability challenges.

Sustainability is not a technical problem, nor only the technical solutions be sufficient. Instead, solutions ultimately will require deep economic, political, and cultural adjustments, as well as major, long term commitment in order to put technical advancements and enablers in operation at scale. Information Technology can act as a bridge between the technical and social solutions by providing the improved communication for necessary economic, political, and cultural adjustments.

The main areas in which IT and sustainability research is divided into three as follows: built infrastructure and systems, ecosystems services and the environment, sociotechnical systems.
Built infrastructure and systems include buildings, transportation systems, and consumed goods. The use of ICT like smart buildings, smart logistics, and smart electric grids can be used to improve the sustainability in above areas.
Ecosystems services and the environment is the study or understanding of environment and ecosystems and the challenges it is facing. The study can be done using computational modeling and simulation of Earth, sensing and collection of data which helps to understanding of the carbon and nitrogen cycle in the atmosphere and other emissions.
Sociotechnical systems is related to the study of human behavior. Real-time information and associated tools can be applied to a range of problems, like acute crisis management, to urban planning, to promoting and the understanding of behavioral impacts on water, and biodiversity.
There are some more areas in which IT and sustainability can have significant impact on the future.
The Smart Grid- The use of ICT can helps to solve the problems of use of excess electricity by providing the necessary information of how they can be reduced and decreased the consumption of it. Further it can also help to move toward the more sustainable way of generation of electricity.
The food systems- Current agricultural practices pose challenges to the sustainability of the food system, as well as to the broader social, economic, and environmental systems. The ICT can be used to increase the efficiency of food production in the sustainable way by providing consumers with information about the sustainability of food production.
The development of sustainable and resilient infrastructures- Climate change, resource consumption, and land use are linked to natural and human-made disasters. Models and Simulation tools can be used for the urban planning in the sustainable way.

Chapter 2

# Elements of a Computer Science Research Agenda for Sustainability

In this chapter, it discussed about the main goal of Computer Science in sustainability. The computer science researcher listed the four broad areas that can have the significant impact on sustainability.

- Measurement and instrumentation;
- Information-intensive systems;
- Analysis, modeling, simulation, and optimization and
- Human-centered systems.

Measurement and instrumentation- Until 1990s, sensors were used to collect the data but after the development of analog to digital conversion, they are deployed and have the broader use. The development of embedded computing, information-rich operation, and cross-system integration have been more useful to solve the sustainability challenges.

Information-intensive systems- In modern days, there is lot of data is generated. Transaction processing, communication, Simulation, scheduling etc is producing vast amount of information. This vast amount of information and data can be addressed with these kind of process such as big data, Heterogeneity of data, coping with need for data proxies, Coping with biased and noisy data and Coping with multisource data streams.

Analysis, modeling, simulation, and optimization- With analyze and simulation, this helps in extraction of meaning information from the complex data. Model allows to decompose smaller meaning information so that progress can be made. Good models will help in creating solutions for sustainability problems.

Human-centered systems- Human-centered systems is an area which is related to the sustainability solutions to be applicable to real world situations. This is possible only when technology is specific to the needs of the people. The sustainable systems must be designed with the understanding of human need and it should be beneficial to the human society.

Chapter 3

# Programmatic and Institutional Opportunities to Enhance Computer Science Research for Sustainability

In this chapter, it is pointing out that CS research can be helpful for addressing the sustainability issue. The chapter is aimed primarily at the CS research community—including both researchers and funders. This chapter also discussed about describes the connection between universality, bottom-up approaches, and sustainability.

a. Computer science approaches for addressing sustainability
   Computer science and information technology are essential to meeting sustainability challenges. CS offers different tools to solve the sustainability challenges. Fundamentals of the computer science field itself offer unique and important contributions to sustainability such as abstraction design, algorithms, operating systems and layering, real-time systems, machine learning, human computer interaction (HCI), and databases. Therefore CS research and sustainability must have the potential to make a real difference in moving toward a more sustainable future.

b. Towards Universality
   Achieving universality typically involves developing well-structured innovative solutions, applying them to the problem at hand, evaluating their efficacy, and using this evaluation to guide further improvement, enhancement, and new directions. As the iterations of application proceed, the universality of the approach is discovered and refined.

c. Education And Programmatics
   A significant opportunity for change is in the area of education. This change should include educating computer science students to achieve impact with computing, computational methods, and systems approaches in important domain-specific areas. Research institutions—both universities and the funding organizations - could better address the needs of authentic multidisciplinary research, in terms of publication venues, funding, criteria for promotion, research infrastructures that help enable sustained collaboration, and cross-training.

d. Evaluation, Viability, And Impact Analysis
   The greatest challenges in research is to establish evaluation metrics that are both actionable and meaningful across the constituent disciplines. This can be accomplish by identifying methodological opportunities for optimizing research outcomes and impacts.

This chapter has argued for a bottom-up approach to research that values application-driven results while also supporting the iterative process that eventually leads to more universally useful contributions.