CSTEP
CENTER FOR STUDY OF SCIENCE, TECHNOLOGY & POLICY

Sustainable Alternative Futures for India (SAFARI):

Briefing Note on the Project

Project Background

India's current population of 1.35 billion is expected to reach 1.7 billion by 2060[1], according to the United Nations Department of Economic and Social Affairs. Urbanisation is poised to exceed 50% by 2050[2]. Without adequate resource and energy planning, these could result in greater congestion and poorer quality of life in the near future. Already, a section of the population does not have sufficient access to basic necessities like food, housing, clean water and air, electricity, healthcare, etc. In terms of the Human Development Index (HDI), India ranks 130th out of 189 countries[3], with around 21% of its population living under the poverty line[4]. India's developmental aspirations, therefore, need to consider both filling the existing gaps as well as meeting the increasing needs of the population in the future.

As the country attempts to overcome these challenges and achieve the Sustainable Development Goals (SDGs), the government of India has also emphasised its commitment to climate action by ratifying the Paris Agreement[5] and formulating its Nationally Determined Contributions (NDC) targets[6]. Reconciling the two guides this research: How can India plan a growth trajectory to achieve its development goals that is both sustainable and also reduces its greenhouse gas (GHG) emissions?

Rationale for Modelling Approach

Many modelling studies use GDP as the primary metric of development, and as an exogenous socioeconomic driver for sectoral demand alongside population and energy intensity. The Sustainable Alternative Futures for India (SAFARI) model, developed at CSTEP, is different in that it does not use GDP as the primary metric of development and welfare. In SAFARI, demands arising from achieving various developmental goals (Figure 1)—food, housing, healthcare, education, power, water, and transport—are the main drivers of growth. We estimate both the embodied energy and operational energy required to meet these goals (i.e. life-cycle energy).

The importance of capturing interlinkages and interdependencies in modelling exercises cannot be overemphasised, as it helps policymakers leverage synergies and limit trade-offs between various goals. Moreover, it has been found that the synergies between climate action and other SDGs are best harnessed (and trade-offs limited) when planned in tandem[7]. To this end, we have used system dynamics simulation modelling, which can account for these dynamic relationships, to develop the SAFARI model.

[1] **Population projection by the United Nations**

[2] Today urbanisation in India is around 34%.

[3] Over the past two decades, India's **HDI** has improved at only 1.5% per annum (from 0.427 to 0.64).

[4] In terms of the **Multidimensional Poverty Index (MPI)** India ranks 53rd in the list of developing countries.

[5] India's Declaration while ratifying the **Paris agreement**

[6] To reduce the emissions intensity of its GDP by 33-35% from 2005 levels, increase non fossil-fuel based sources of electricity to 40% of the total installed capacity, create carbon sinks of 2.5–3 billion tonnes CO_2e through forest cover and promote a sustainable development trajectory for the country by 2030.

Figure 1: *Developmental goals in SAFARI*

[7] Fuso Nerini, F., Sovacool, B., Hughes, N. et al. Connecting climate action with other Sustainable Development Goals. Nat Sustain 2, 674–680 (2019)

Project Objectives

To build a model that estimates the materials, energy, emissions, and macroeconomic implications for India to achieve a 'desired quality of life' for all

To develop that model into a visualisation tool to aid policy decision-making towards India's 2050 strategy (in line with the Paris Agreement)

We expect the visualisation and planning tool to enable policymakers create and test their strategies virtually, and identify 'unintended consequences' of their policies and develop sustainable alternative pathways for India's future.

Progress and key findings

In the first phase of this project, we defined 'desired quality of life' (DQoL) in terms of basic development goals and quantified benchmarks, through literature review and expert consultations. In the second phase, we started building the model to project materials and energy demands arising from the goals.

In the third (current) phase of the project, we[8] have developed an **electricity-supply-module** that responds to demands, allows us to explore the extent to which fossil-free electricity generation is possible and simulate various energy mix pathways depending on different policy goals. In this phase, we also 'soft-linked' a computable general equilibrium (CGE) model to assess the macroeconomic implications of achieving the goals, and are developing preliminary integrated scenarios.

The goals that we chose (in Phase 1) include achieving food security, bridging the housing shortage, constructing sufficient infrastructure for healthcare and education, sustainably meeting transport and cooking demands through clean fuels, and ensuring adequate power and water supply for various sectors. Apart from their emphasis on fulfilling fundamental human needs, the developmental goals were selected for their bearing on energy demand and emissions.

- **Most of the DQoL goal benchmarks will not be achieved in the business-as-usual (BAU) trajectory**. For instance, current 'housing-for-all' targets of the government will not meet the true housing shortage in the country. Taking into account factors like dilapidation, household congestion (especially important in times of a pandemic), and minimum space requirements for a decent quality of life, SAFARI indicates that India might need an affordable housing target that is double the current estimated number in urban areas.

- **The energy and emissions footprint of achieving DQoL benchmarks is not considerably higher than that of BAU.** The increase in annual electricity demand to achieve DQoL benchmarks is only 6%-11% higher than BAU. In 2050, for instance, around 500 TWh is the 'extra' demand. Close to 80% of this demand is from the residential sector due to the increase in number of houses (built to meet the housing shortage) and therefore energy-intensive appliances like ACs. The rest is from the agriculture (due to progressively deeper bore wells to extract water) and commercial (due to more hospitals/schools built area) sectors. The total GHG emissions is around 6.1 billion tonnes of CO_2e in 2050, which is 5% higher than BAU.

[8] CSTEP and DESTA Research LLP

- **Achieving DQoL goals is resource-intensive and not fossil-free.** The total water consumption reaches 1,410 billion cubic metres (BCM) in 2050, which is about 25% more than estimates for the total annual 'utilisable' water in India. This means that non-renewable groundwater will be either unsustainably exploited or energy-intensive technologies like desalination may be needed. On the power sector side, the DQoL trajectory requires 10% additional coal capacity compared to BAU, to cater to the increased night-time demands.

- **It is possible to achieve DQoL benchmarks in a relatively sustainable manner through demand-side interventions.** Here we assume better water-use strategies in agriculture (through micro-irrigation and reduced sugarcane cultivation) and the power sector (where limits are placed on water used by power plants), use of alternative construction materials that also reduce cooling demands, increased electric mobility and rail-based freight, and improved energy efficiency across the demand sectors. In this trajectory, almost 1,200 TWh of electricity can be saved in 2050, compared to the DQoL. Due to the reduced demands, 66 GW coal capacity can be avoided and 1.3 billion tonnes of CO_2e can be saved in 2050.

  - Space-cooling requirements (fans and ACs) are expected to contribute to almost two-thirds of residential energy demands, but by using **alternative construction materials** like autoclaved aerated concrete (AAC) blocks, the space-cooling demand can be **brought down by almost 30%.**

  - **While reducing sugarcane cultivation will help save water and achieve food security in a sustainable manner, the trade-off is that India is unlikely to meet its 20% ethanol blending target for 2030.** However, if second generation (2G) ethanol production becomes commercially viable, this trade-off can be addressed successfully.

- In the agriculture sector, apart from water-use efficiency interventions, we explored a behavioural change using SAFARI. **A dietary shift away from water-intensive crops like rice towards coarse cereals like millets could significantly alleviate the water scarcity issue in the country, and has other benefits.** Every year, around 300 BCM of water, and close to 50 Mt of CO_2e (through the avoided rice-methane emissions), can be saved through this intervention. Reduction in water demand for irrigation also results in electricity savings and consequently, subsidy savings to the tune of around INR 50,000-100,000 crore per year beyond 2030.

- **Densification instead of sprawl in urban areas reduces transport sector demand (and emissions) but could have other trade-offs.** Densely constructed communities tend to experience the 'urban heat island' effect, which causes increased cooling demands. Also, taller buildings (typical in densification or vertical development scenarios) require 10%-20% more energy-intensive construction materials like steel. A mild sprawl scenario with increased public transport or a densification scenario with alternative construction materials that reduce cooling demands could be two potential options for sustainable urbanisation.

Next steps

Simulation models like ours are helpful for planning, forecasting, and moderating competing resource needs. They allow users to try out different possibilities and decisions, and then examine the results. In this sense, models such as ours support decision-making processes, and may be referred to as (web-based) decision-support-systems (DSS). To be effective, it is especially important to make this process participatory, since "simulation is not a spectator sport"[9].

System-dynamics models have been shown to be well-suited to participatory policymaking[10]. They provide a good platform for stakeholders to come together and discuss priorities and objectives for policy design in a collaborative manner. Therefore, in the upcoming phase of the project, we will develop SAFARI into a complete, web-based visualisation platform to serve as a DSS. Simultaneously, we plan to finalise our integrated scenarios through stakeholder engagement. This will involve consultations with policymakers, to virtually test policies of interest and visualise various scenarios for India's long-term strategies.

The ultimate outcomes of this project are: providing a platform for cross-sectoral dialogues on sustainable development; and a model that acts as a test bed for policy evaluation, developing Paris-compatible long-term strategies for India.

[9] Desai, A. (2012). Simulation for policy inquiry.
[10] Hightower, R. (2012). Iterative storytelling in public policy: A systems thinking approach.

CENTER FOR STUDY OF SCIENCE, TECHNOLOGY & POLICY

Bengaluru
No. 18 & 19, 10th Cross, Mayura Street, Papanna Layout,
Nagashettyhalli (RMV II Stage), Bengaluru-560094
Karnataka, India

Noida
1st Floor, Tower-A, Smartworks Corporate Park, Sector-125,
Noida-201 303, Uttar Pradesh, India

+91 80 6690-2500
https://www.cstep.in/
@CSTEP_India
cpe@cstep.in