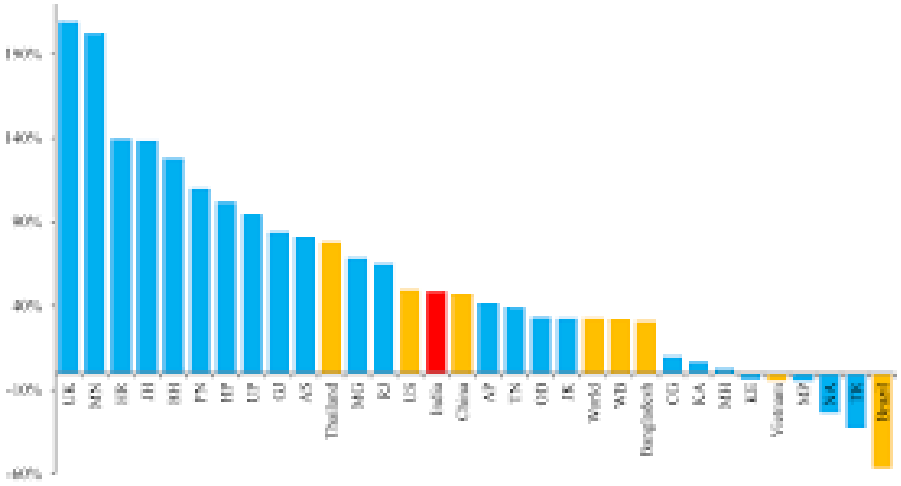
PROBLEM STATEMENT

India has one of the world's largest arable land, second only to the United States, with a net sown area of 140 million hectares. However, it is estimated that nearly 120 million hectares, comprising 37% of the total geographic area, suffer from varying degrees of degradation (MoA&FW, 2016b). Imbalanced fertilizer use is widespread in India, with roots in practices promoted during the Green Revolution. At the time of India's Independence in the 1940s, food insecurity was rampant, with acute food shortages and dependence on imports to feed the population.

However, during the 1960s, high-yielding varieties of cereals, accompanied by the use of chemical inputs such as fertilizer, were promoted. The results were dramatic, with food grain production increasing from 72 million tons in 1965-66 to 121 million tons in 1975-76, eliminating the need for imports and making India self-sufficient in food grains. During the same time, fertilizer use increased from 784,000 tons to 2.9 million tons, and currently stands at 25.9 million tons as of 2016-17 (MoA&FW, 2016a), (MoA&FW, 2018).

On the downside, lack of incentives for judicious resource use led to undesirable environmental effects (Pingali, 2012). In the Green revolution states of Punjab and Haryana, NPK consumption ratios of 31.4:8.0:1 and 27.7:6.1:1 were reported against a desirable average figure of 4:2:1. In addition, flawed fertilizer subsidy policy resulted in a cheaper price for urea, leading to excessive application of N, to the neglect of P and K.



The problem is not uniform across India since fertilizer usage is highly uneven across Indian states. While fertilizer consumption is excessive in certain states, it is well below the world average in certain others, especially in the northeastern region. Average fertilizer use intensity is only around 170kg/ha in India in 2015, which is low compared to other major agricultural producers such as China (506.1 kg/ha) and the Netherlands (258.1 kg ha) ("Fertilizer consumption (kilograms per hectare of arable land)", n.d.).

The negative impact of imbalanced fertilizer use goes beyond sustainability of yields. • Farm profitability is adversely affected. Poor soil health leads to low fertilizer use efficiency,

necessitating a higher amount of fertilizer to obtain the same yield. It was reported that overall fertilizer use efficiency at the turn of the 21st century was as low as 50%, while nitrogenous(N) and phosphatic (P) fertilizer use efficiencies were an estimated 30-35% and 20-25% respectively (Fishman, Kishore, Rothler, & Ward, 2016).

Since fertilizers constitute a major component of the cost of cultivation, the need for more fertilizer puts additional pressure on profit margins. • Fertilizer overuse has a significant environmental impact. Excess nitrogenous fertilizers are washed into agricultural runoff, which can cause hypoxic "dead zones" in coastal waters due to eutrophication. One study reported a link between human agricultural activity and the intensification of a hypoxic zone off the continental shelf of western India (Naqvi et al., 2000). In addition, nitrous oxide (N_2O), which is produced from nitrate fertilizers by denitrification, is a major greenhouse gas (GHG) which significantly contributes to global warming. •

Improper fertilizer use also threatens human health. Use of nitrate-contaminated drinking water is a known risk factor for methemoglobinemia in infants, a potentially fatal condition commonly referred to as the "blue baby syndrome" (Knobeloch, Salna, Hogan, Postle, & Anderson, 2000). Moreover, crops grown in soils with micronutrient deficiencies are known to cause malnutrition. It is estimated that millions of hectares of cropland globally are affected by zinc deficiency, with approximately one-third of human population suffering from an inadequate intake of zinc (Knobeloch et al., 2000).

• In India, fertilizers are provided at discounted prices through government subsidies for the benefit of small and marginal farmers. These depressed prices lead to excessive usage increasing the subsidy burden, which not only exerts pressure on the government’s fiscal situation, but also diverts money from more productive capital investments. In 2015-16, the fertilizer subsidy bill ballooned to approximately $10 billion, constituting around 0.5% of GDP (MoA&FW, 2018).