Food for all, solution forever

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Indian agriculture is performing well with food production at an all-time high despite adverse climatic conditions, flooding, drought and low income of farmers. Recent estimates indicate that total food production, excluding animal and fishery products, is at the highest ever at about 291.95 million tonnes (mt). The Indian Council of Agricultural Research (ICAR) led National Agricultural Research System, which includes ICAR institutions and State and Central Agricultural Universities has contributed immensely to maintain high production levels. Similar is the situation in other developed and more developing countries. Despite continuous increase in production and productivity, there are fears of shortage of food globally in future, and India is no exception. The reasons for this include continuous increase in population, decrease in cultivable land, increasing input cost, decreasing natural resources, climate change (increase in temperature and decrease in rainfall), lack of interest of youth in farming, ageing of existing farmers, increase in food demand, shift in diet pattern, etc.

According to a recent UN report, average land temperature increase has already crossed the 1.5°C redline mentioned in the Paris Agreement and global temperature has increased by 0.87°C (ref. 1). The report also mentions that 500 million people live in areas that experienced desertification between 1980 and 2000. India is also vulnerable. As of 2011–2013, 29% estimated land in the country underwent desertification and land degradation, besides expansion of real estate and thus decrease in fertile land. Arable land per person has declined from 0.34 ha in 1961 to 0.12 ha in 2015 (Figure 1). So higher production is needed from lesser area, which is putting pressure on natural resources, soil, and water and leading to rampant use of fertilizers, insecticides and pesticides. The natural resources will not sustain if their exploitation continues. In addition, studies suggest that high levels of carbon dioxide reduce nutrients in many crops. For example, due to high levels of carbon dioxide in air, wheat now has 6–13% less protein, 4–7% less zinc and 5–8% less iron[1], which may cause undernourishment in children/youth in future. In order to reduce malnutrition, we produce enough and a variety of food, including bio-fortified foods now. However, a nation-wide study during 2012–2014 on 45 major commodities (including meat, fish, milk, poultry, plantation crops) showed that post-harvest losses from harvesting to retailing in 120 districts ranged between 4.65% and 15.88% (ref. 2), which was about 65 mt based on the production year 2012–13, amounting to about Rs 92,651 crores on the average wholesale price of 2014 (Table 1). Media reports suggest that many countries, including Australia do not even produce the amount of food that we lose during harvesting to retailing every year. If we include food loss at homes, hotels, restaurants, parties, etc. it will be at least double of these estimated losses. Such food losses result in the loss of huge amounts of water, fertilizers, energy and other inputs as well. This also causes carbon emission and global warming, which reduces production and productivity.

Figure 2 depicts the situation of water availability in India. The total water demand for all uses is likely to be in the range 784–843 BCM by 2025 and 973–1180 BCM by 2050 against the utilizable water resources of 1121 BCM (ref. 3). There will be severe water shortage even for drinking in the near future. We have seen such a grave situation in Chennai, Tamil Nadu and many other parts of India in recent years.

The continuous growth of the middle class and increase in its income influence the consumption pattern. More money leads to more and better eating. People eat more cereals, fruits, vegetables and drink more milk and fruit juices. A UN report suggests shifting of the world to

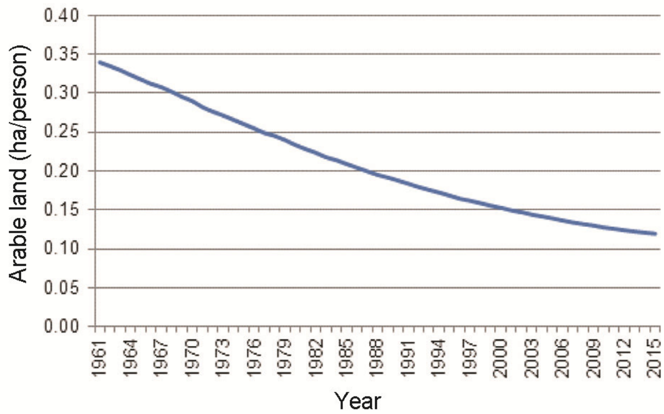

Figure 1. Trends in the decline of arable lands in India.

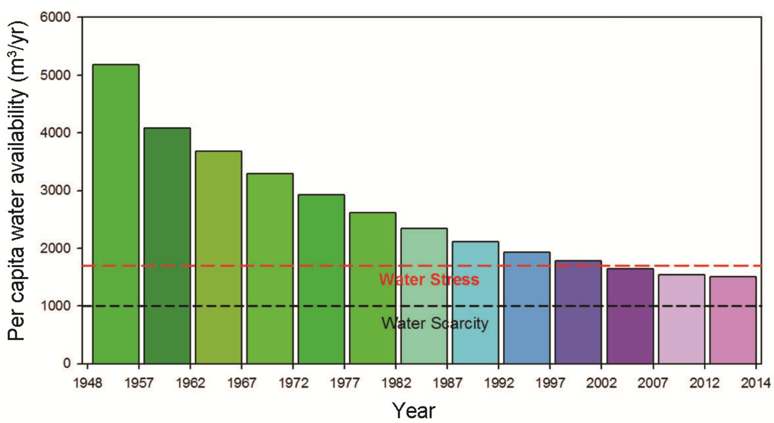

Figure 2. Trends in per capita water availability in India.

vegetarian diet[4]. This will not only reduce carbon footprints, but it is better for health too. For better nutrition, better health and for the saving environment, people could shift to a vegetarian diet, which will further add pressure on natural resources, thus making them more scarce.

Farmers are ageing and youth are not interested in farming. Majority of farmers in India are aged above 40 years. In 2016, the average age of an Indian farmer was 50.1 years (ref. 5). This is worrying because the next generation of the current farmers is not taking up this profession. It means we are approaching a situation where one of the biggest consumers of food will be left with only a few farmers. Not only India, but across the world farmers are ageing and replacements are not adequate. The average age of an American farmer is about 58 years, while the same in Japan is 67 and every third European farmer is more than 65 years of age. So, after a few years, say 20, who will produce food for us? The answer is food scientists and engineers, who can come together, to provide sustainable solutions for continuous production of food using machines and waste/plant residues. For this purpose, the following areas of research may be focused.

Table 1. Monitory harvest and post-harvest losses of major commodities in India[2]

Commodities	Loss (Rs crore)
Cereal	20,698
Pulses	3,877
Oilseeds	8,278
Fruits	16,644
Vegetables	14,842
Plantation crops and spices	9,325
Livestock produce	18,987
Total	92,651

Table 2. Estimated biomass of a few selected major crops

By-products		Production (million tonne)
Rice	Bran	7.0
	Broken	19
	Straw	170
	Husk	20
Wheat	Bran	12
	Germ	3
	Straw	110.0
Maize	Cobs	6.0
	Germ	2.5
	Straw	40.0
Pigeon pea	Hulls	0.5
	Broken	0.4
	Stalks	12.0
Soybean	Meals	7.0
	Hulls	1.0

Saving and recycling of food waste. As is well known, we are producing more than enough food and have comfortable buffer stocks, but we also know that we are losing food after harvest through different ways. Do we produce more to lose more? Is there actually a need for increase in production as of now? In fact, there is need of policy shift. Instead of focusing continuously on increasing productivity and production, more focus should be to save whatever we produce and maintain the current level of production. Suppose we save even 25% of what we lose, then we can add up to 15–16 mt in production and by doing so we can reduce pressure on our natural resources.

Manufacturing food grains using machines. All food grains are milled before making them edible. More than 25–30% grains are broken, become powdery and produce many by-products during milling and thus fetch less profit (Table 2). If collection systems are put in place, using the available technologies and machinery, more grain may be manufactured using these broken and powder for a better price.

Another concept may be to study the grains at different molecular levels from which they are naturally formed. The biochemicals/molecules from the available unusable biomass of plant resources such as tree leaves, wild grass, etc. can be extracted. Then the cellulose of these plant residues can be modified; for example, cotton stalk, rice straw to food-grade starch. Next extract/isolate all the biomolecules available in a particular grain, say rice, using modern extraction technologies. Once these ingredients are made available, grains can be produced using modern precise blending and extrusion technology. In addition, researchers should focus on artificial photosynthesis, aiming towards the production of food in the laboratory.

Robotic animals for milk. We have successfully increased milk production to newer heights. However, with the increasing population, we need to further increase milk production. A robot for the purpose can be developed. Grass, water or any other feeding materials may be the input of the robot. We can call it a robotic cow/buffalo.

The concept is to study the biological system of cow/buffalo and simulate the same using sensor, artificial intelligence and fermentation technology. Energy can be taken by mounting solar panels on the robot machine, design of artificial/synthetic stomach system (some system simulating human stomach for finding glycaemic index of food) is already being developed. Geneticists can design and construct a bio-cell gland system that will process the grass fed to the machine after reducing the size by cutting/grinding, etc. Some work on the development of robots is being done by the US military for carrying loads.

To realize the fruit of above concepts, multi-disciplinary teams comprising agricultural process engineering, robotic engineering, food technology, biotechnology, organic chemistry, etc. need to be formed and take big-bang projects on each aspect of the concept. The success of such project will lead to have engineered food (which is manufactured, not grown) necessary for sustainable feeding of more than 1.7 billion people by 2050 and beyond.

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