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Perspectives in Biodiversity, Food and Future for India

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The last two centuries have brought the world unprecedented environmental problems that we must control if we wish our civilization to persist. The problems have resulted from an increase in the total human population over the past two centuries from one billion people to the present 7.4 billion; an even more rapid rise in consumption; and the failure of technology to keep pace with the changing numbers of people and their demands for consumption. Even more frightening is the fact that our numbers are projected to grow to nearly 9.9 billion within the next 34 years (by 2050), at an average increase of 200,000 people net per day during that period. Over the same 34 years, the current population of 1.3 billion people in India is projected to rise to 1.7 billion (www.prb.org). In view of the current demands we are placing on the environment in India and throughout the world, those predictions are alarming in the context of what we actually are doing and what we may be willing to do about them.

How did we reach our current challenging condition? At the time when our ancestors developed crop agriculture and domesticated animals, about 12,000 years ago, the global human population numbered only about one million people, with about 100,000 in Europe. As agriculture has spread around the world to encompass about a third of the planet's land surface, the numbers of people have grown rapidly, so that 500 years ago there were about 500 million people on earth, with about a third of them, some 170 million, living in India. In about 1810, the global human population reached one billion people for the first time, with about 270 million, roughly a quarter of them, in India. The population of India was growing more slowly than that of other regions.

The past two centuries have been more tumultuous than any earlier period in our history. A few decades after the Industrial Revolution reached full stride, the whole world was consolidated into nations and colonies, and rivalries between them increased greatly. Britain and France outstripped earlier colonial powers in seizing lands all over the world, with Russia and the United States annexing territories along their borders and Japan, with Germany and Italy when they were consolidated, attempting to set up their own colonies. As this process has continued over those past 200 years, some 200 million people have been killed in wars over land and other kinds of wealth. The world sadly remains filled with national and regional rivalries that are continually bursting out and leading to even more deaths. Most nations and groups of people seem to want to consume more than its rivals, and many remain willing to go to war to attain those ends. Changing national boundaries and internal moves for independence are based on the same principles, but do not move us collectively any closer to a sustainable world that can manage its planetary ecology sustainably.

A serious problem is that there are not enough resources to go around. Global Footprint Network (www.footprintnetwork.org) estimates that the people of the world combined are consuming about 164% of our planet's capacity for sustainable productivity on a continuing basis. In other words, it would require about 64% more capacity for sustainable productivity than exists on earth for us to attain collective stability at the present population level. Theoretically, we could achieve stability by attaining a level population, adopting socially acceptable levels of consumption throughout the world, and improving our technology, but we are not gaining on the problem at present. Even if we did so, we would not be gaining on our current levels of hunger, malnutrition, or poverty, even though we would no longer be permanently destroying our planet's resources that might otherwise be used for the future. Fifty years ago, we were consuming about half as much of the world's capacity for sustainable productivity as we are now. The subsequent doubling of our population and even greater rise in our consumption have sent us well past our planet's capacity for sustainable productivity, and we must face the consequences.

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Some countries consume more than their share of the world's productivity. Since our overall use of 164% of the total global capacity for sustainable productivity exceeds the total available, a given country can increase its consumption, or standard of living, only through improved technology, improved resource management, or by gaining some kind of an advantage over other countries. India's Ecological Footprint, a measure of the total amount consumed within the country, has doubled since 1961, while its population has nearly tripled from 460 million to 1.3 billion people. Thus the average amount consumed per person in India has decreased during this period. Up to 264 million people in India are estimated to have reached a middle class income level during this period, so that the average lot of the poor in India has declined over this same 60 years. In view of these circumstances, it will take an incredible amount of care for India to shift from an economy that has grown at the expense of its environment to one that flourishes by nurturing and preserving it.

During the same period (1961 to the present), while India's population has tripled and its consumption doubled, China's population has doubled while its consumption has tripled. Much of China's growth in consumption has been fueled from abroad, with China now consuming 2.5 times its internal capacity for sustainability, compared with India's 1.8 (www.footprintnetwork.org). The more that a nation exceeds its internal capacity, the more food and other commodities it has to seek around the world and pay for them one way or the other; as this process unfolds, the situation worldwide becomes increasingly unstable. With the U.S. consuming 1.9 times its internal capacity, Britain 3,5 times, Switzerland 4.2 times, and Japan 7.1 times, part of the reason for the difficulties inherent in international relationships become obvious, as does the need for reform and greatly enhanced global cooperation. Many specific environmental problems for which we share a common responsibility have become obvious however our divided and fractious world chooses to deal with them.

Global climate change is the most widely recognized of the environmental challenges that face us. A fruitful conference of the parties to the United Nations Framework Convention on Climate Change Intergovernmental Panel on Climate Change was held in Paris in December, 2015. The parties agreed to a goal of holding global temperature increase to 2°C, and to attempt to hold them to 1.5°C, and their agreement has subsequently been ratified by a sufficient number of nations and come into effect. If all nations continued with a "business as usual" scenario, we would likely force a 4°C change in average global temperatures, in which case large sections of the world would become uninhabitable. Even with a successful pursuit of the goals set in Paris, the effects on agricultural lands will be massive and our ability to keep pace with the demands of a rapidly growing population will be subject to serious doubt.

India will have a very difficult time achieving its emissions goals and meeting the targets set in Paris although Prime Minister Modi's government is determined to do so. The complexity of multiple missions and agencies involved in achieving progress makes effectively dealing with the situation difficult. Much of the India's (and the world's) economic progress has been based on relatively cheap energy from many sources, a number of them highly polluting and forcing climate change. Alternatives must be found and deployed on a massive scale that would seem to require international subsidies in many directions and of many kinds. At a global level, it may already have become impossible to hold global temperature increases within the 2°C target set in Paris. The global level of carbon dioxide in the atmosphere, 280 ppm at the start of the Industrial Revolution, reached 400 ppm in the autumn of 2016 and is still increasing, with 350 ppm probably the level at which the earth can continue to support the activities to which we are accustomed. For India, increased monsoons, higher temperatures, melting glaciers, the intensified use of water that accompanied the Green Revolution and the projected 2 meter rise in sea level by the end of this century will all adversely affect agricultural productivity, which will suffer major losses both locally and globally unless climate change is limited through common action.

Biological extinction receives less attention than climate change, but it is in fact a much more serious problem, simply because it is irreversible. Five major extinctions have taken place nearly the roughly four billion year history of life on earth, and our growth in numbers coupled with greed for every more consumption is now driving the sixth. By studying the fossil record, we can determine by extrapolation that there has been about 1 extinction per million species per year over the past 66 million years, but that now this has grown to

at least 1,000 species the historical rate (Pimm et al., 2014). The massive extinction we are causing is such that many geologists believe that our era deserves a special name, the Anthropocene, signifying our total dominance and the destruction that we are causing to our life support systems. The world in which we live now is very different from the one in which our ancestors lived a few thousand years ago, and it is not clear whether we will be able to adjust to the rapidly-changing new conditions we have brought about. As tropical ecologist Daniel Janzen of the University of Pennsylvania pointed out half a century ago, "The world is a garden, and we're all its gardeners." Whatever is saved, we will save; whatever is lost, we will destroy. This time, and the opportunities it represents, will never come again.

The loss of species seems a bad thing intellectually and perhaps morally, but it is much more than that. We base our lives entirely on the properties of organisms, which have not only created the conditions on this planet into which we evolved, but continue to provide all of our food, more than half of our medicines, and many other substances that we use directly. The ecosystems that they comprise maintain the quality of the atmosphere and the waters and provide for balance in the living systems in which we live as members. Destroying plant, animals, fungi, and microorganisms is the worst thing that we could possibly do in relation to the prospects for our civilization to last decades or centuries into the future. Nevertheless, the destruction of habitats for agriculture and urban expansion, global climate change, the spread of invasive plants and animals and diseases all over the world, and the overharvesting of particular plants and animals from nature – all of these combined relentlessly drive the process of extinction.

Agriculture for the Future

We collectively are confronting a major problem in maintaining the sustainability of our agricultural systems and it will undoubtedly get worse unless we take a number of strong measures now. At present, we devote about a third of the Earth's surface to agriculture, most of it to grazing, and yet we are not feeding the people who are here now adequately – much less laying the foundations for the 2.5 million additional people projected to be added to our population over the next 33 years. It may seem somewhat strange that India, while consuming an estimated 1.8 times its sustainable productivity, is currently a net exporter of food: in fact, the world's seventh largest. The food is one of the commodities being traded, in effect, for goods from abroad to support a rising rate of consumption. India's trade balance is substantially negative. Even with a level population, India would need to increase its internal productivity greatly to live within the boundaries of its own sustainable productivity.

With specific respect to food and hunger, many millions of Indians starved to death from the time of the Bengal Famine (1943) to the beginning of the Green Revolution (1967). There are now three times as many people to feed as there were during those years. India's Green Revolution resulted in increasing the extent of croplands, double-cropping through intensive irrigation, applying more fertilizer, and introducing improved genetic strains of crop plants. Despite these measures, the population continued to increase more rapidly than food production during this whole period. No level of agricultural productivity can feed a continually growing population.

To feed all people adequately, we would need to maintain a level human population that might not be as large as the rapidly-growing one that we have now. Socially-justifiable consumption levels that could be accommodated through sustainable productivity would need to be adopted worldwide, a process that would necessitate the full empowerment of women and children everywhere. Technology would need to be improved as one element of the equation. Obsolete economic theories that imply that the goods we get from nature will be replenished as the demand for them grows will need to be modified to take into account the actual conditions on the planet we inhabit. On a finite planet, it is basically immoral to assume that economic prosperity can be attained by continually adding more young children to a given population – sort of a perpetual motion machine that cannot possibly lead to long-term stability when we are all dealing with limited resources. India would need to accept and implement these policies in order to find its own stability in a world that it would help to create.

Meanwhile, India faces great challenges in improving its agricultural productivity so that it can feed its people, even the poor ones, sustainably and into the future. For the whole history of agriculture in the country, improved genetic varieties of crops have been employed, and the sunflowers, potatoes, tomatoes, rice, and maize grown in India today bear faint resemblance to the earliest strains of those species that were cultivated, thanks

to genetics. By the way, all of those crops are from North or South America originally, except of course, rice. With three times as many people in India as at the time of the Green Revolution, it is not strange that some agricultural practices that proved fruitful then have now come into question. Heavy fertilization and application of pesticides and herbicides, double cropping (sometimes now triple, with no regard for the soil), and wasting water all contribute to the problem. These, along with the burning of agricultural straw that causes dense, unhealthy pollution over much of northern India once the monsoon season ends) might be considered excesses left over from the Green Revolution. Those who initiated the improvement of agriculture in India, however, never intended that every step they recommended would be followed endlessly until it caused serious harm in a country where the population meanwhile was tripling and the demand for consumption also shooting upward.

The major damage being done both to India's agricultural lands and its environment in the name of increased productivity, seemingly carrying on what were once agricultural improvements to extremes, should make one question the sustainability of India's position as a net food exporter. In effect, does pounding the last bit of productivity out of overused soils simply amount to a way of helping to make up India's trade deficit while rapidly lowering its internal capacity for sustainable productivity? The declining condition of the soils, the need to counter the effects of salt water seeping in around the coasts, and the effects of pollution everywhere would certainly seem to call for a very serious re-examination of agricultural regulations and practices worldwide.

A key element in maintaining the sustainability of our agricultural systems is the genetic diversity of the crops themselves – agrobiodiversity. When agriculture first became widespread, several hundred generations (some 10,000 years) ago, there was a great of local experimentation with different strains of the crops that were being used. Even at the time of the voyages of Columbus, five centuries ago, global commerce was still in the future, and there were only about 500 million people in the world. Very distinct centers of agriculture had been developed in the Eastern and Western Hemisphere, as well as throughout Eurasia and Africa, and all farming was practiced on a small scale. As a result of this dispersion of centers for agriculture, there was a great deal of diversity among crops and domestic animals, and many more species were involved in feeding people than is the case at present, when about 100 plant species provide more than 90 per cent of our food and three – rice, wheat, and maize – almost two-thirds of the total. Many species of plants that were once important food sources locally are no longer used anywhere or are very rarely used as crops.

As the global population grew from 500 million in 1500 to 7.4 billion today, large areas were brought under cultivation and the small-scale farmers that had maintained crop genetic diversity earlier gradually began to operate on a larger scale that by our time has become a vast scale. Relatively large fields and grazing areas are now characteristic of Europe, and much larger ones in North and South America. Even where small-holders continue to form the backbone of agriculture, as in China and India, they collectively farm vast areas. Under these circumstances, genetic diversity has suffered, even though attention is still paid to finding the best genetic strains for particular areas. For example, in the United States many hundreds of strains of soybeans and maize are grown, and there is really no other option considering the diversity of the farm belt there. Thousands of strains of rice are still cultivated locally in India and China.

To a degree, differences in climate and soils still demand that our crops remain diversity, but global agriculture today presents a very different picture from the one that occurs where small farmers are more scattered, as in southern Mexico or elsewhere in developing countries, with each selecting the particular genetic mix that they grow each year and the whole system remaining diverse. Clearly there is a continuing loss of agrobiodiversity as the intensity of interchange and the desire for ever-higher yields grows. This situation presents a real dilemma, because the rural agriculturists who have served as the guardians of a great deal of the world's agricultural diversity largely live in poverty. Although we might wish them to continue maintaining diversity for us, we cannot expect them to do so with very low incomes and limited access to the higher levels of consumption that so many of us take for granted. Subsidies of some kind will be required if we expect these rural farmers to continue living as they do, and we must also continue to use seed banks as ways to preserve agrobiodiversity properly. Just as for the loss of biodiversity generally, we have a clear moral obligation to avoid the erosion of the diversity that is left.

Why is this so? Simply put, we have altered and are continuing to alter the global conditions in which

agriculture has been developed over the past 10,000 years. It is certain that we shall need a great deal of genetic diversity to keep production going and increase it while maintaining stable conditions in the face of exploding human numbers and the ill effects of conditions such as global climate change that threaten everything we have taken for granted in today's agriculture. We might bring back many crops that have been or are being cultivated somewhere to build productivity in specific areas, or to bring great nutritional benefit to people; a number of these forgotten crops. I have earlier in this paper outlined the truly challenging situation that Indian agriculture is facing at present and must solve for the sake of its people in the future.

Contemporary genetic methods offer great possibilities for the enhancement of sustainable productivity everywhere, and it should be noted that the genes most likely to be helpful in enhancing the properties of a given crop may exist in their close relatives, or even in particular strains of that species. This clearly is an important reason to preserve what remains of agrobiodiversity and the living systems that support it.

The conservation of biodiversity generally is also important for supporting agriculture improvement, and improvement in the characteristics of other productive living systems, because modern genetics has for some four decades offered the possibility of transferring genes from one organism to another. Undoubtedly, our capabilities in that area will increase in the years to come, and it is clear that we are still very far from understand the way genetic systems operates in different parts of the dizzying variety of organisms that share this planet with us and make possible our lives here. If the people of the world really understood what we are losing, and the peril of doing so, they would rise up and devote major resources to saving as much as possible of the rich and largely undiscovered biological diversity that still exists today.

In thinking about how agriculture could be improved if we had the will, it is worth noting the bizarre and completely unfounded opposition to transgenic plants that has been fostered by private groups and alarmed people in such a way as to decrease their chances of improving their health and their lives generally.

Concerning transgenics, the level of confusion can only be called appalling. For India, a particular obstacle to feeding people adequately has been the arbitrary rejection of plants produced by particular breeding protocols, such as transgenics. When scientists learned to transfer genes between one kind of organism and another so as to change the characteristics of the recipient, they were simply mimicking a process that is extremely common in nature, a way in which organisms become better adapted to their environment. When a gene moves from one organism to another, it may be integrated into the genome of the recipient, specify a novel allele or protein that has a positive role, and then becomes a regular part of its host's genetic instructions.

Since the production of GM crops involves specific transfers of individual genes to a specific recipient organism, the resulting transgenic individuals have no traits in common. Specifically, they produce no chemical substance that is common to all GM organisms; whatever they do produce depends on the specific properties of the gene transferred. Consequently, to treat "GMOs" as a class of organisms that should be banned or scrutinized more carefully than other new crop strain is illogical. Crops or animals produced in this way may have desirable, neutral or undesirable characteristics, like those produced in any other way. They deserve neither less nor more evaluation of scrutiny than any other crop strains. Since there is nothing in common between them, there is no way that GMOs could be dangerous as a class, and clear that they bring nothing common to foods *produced* from plants or animals in whose origin this particular genetic strategy has been employed.

In the light of these findings, I have as a conservationist always found it a disgrace that the Cartagena Protocol was enacted in 2003 as part of the Convention on Biological Diversity, consuming large amounts of money and effort for no real purpose. It cannot be demonstrated that a single species of plant or animal has been saved or will be saved as a result of the operations of the Protocol, so why is it part of the CBD? The Convention has had enough trouble saving species, which have mostly slid down hill in numbers and vigor during the 24 years since it was enacted, so why should it, or agricultural productivity be encumbered by a Protocol based entirely on false premises? In the light of contemporary knowledge, writer Andrew Porterfield has aptly dubbed the Protocol a "relic of [an] earlier era promoting GMO fears." It is time to move on.

It is significant that no academy of sciences anywhere in the world, and there have been many dozens of

comprehensive studies, has ever found any potential harm from consuming food produced by GM crops. These include the academies in India, China, Brazil, Mexico, the U.K., the U.S., and everywhere else that this matter has been considered over more than 15 years. A comprehensive review conducted under the auspices of the National Research Council – National Academy of Sciences in the U.S. has reinforced the scientific basis for our understanding (National Research Council, 2016). The same year, 2016, a significant proportion of living Nobel Prize Laureates, exasperated by the non-scientific arguments that were holding back efforts of farmers and nations to produce the food we need, issued a proclamation along similar lines (http://supportprecisionagriculture.org/). The consensus opinion has never changed, but become ever stronger, as the evidence has accumulated, and the opposition that has grown up therefore must be assumed to be either political or fund-raising in character. When and how can this unfortunate situation be resolved so that people may benefit from science rather than suffer as a result of propaganda?

It is also worth pointing out that many medicines (including virtually all insulin used worldwide) and virtually all beer, cheese, and bread produced anywhere use genetically modified organisms in their production. No one seems either to fear them or call attention to the methods of their production, but if the claims about GM crops were true, they would presumably all be poisonous too. Economics triumphs once again? It is fervently hoped that India will through off the burdens imposed on it by false worries and join the rest of the world in realizing the benefits of GM crops, predominant in the United States with no harm having been detected. The apparent benefits of GM cotton, which has been grown profitably in India since 2002, ought to help make the case locally. This one improvement in a major crop is estimated to have added $18.3 billion in farm incomes in India over the past 14 years

Golden rice, in which a single gene was transferred from a bacterium to one of the original strains all of which have been developed much further by conventional methods, provides an example that is particularly painful to contemplate. Using a single innocuous fact about its origin as a basis for combatting the introduction of β-carotene-fortified rice, Greenpeace together with some individuals have denied a dependable source of vitamin A to society, thus condemning hundreds of thousands of children each year to blindness and, in many cases, death. Considering that there is not one shred of evidence pointing to dangers from such rice, these groups and individuals must bear the responsibility for their actions and consider who benefits from their promotion of such non-scientific, unfounded assertions. Having prevented the full development of Golden Rice and kept it unavailable for more than a decade, some are now claiming that it isn't "real." What strange logic that seems!

For people living in the tropics, these methods could afford a way to save their main staple crops instead of to starve. The yield of cassava, for example, is greatly reduced through Africa by a virus disease that could in principle be cured by these methods, and yet their adoption and even testing has been slowed down for years by false worries and fears promoted by a rich and prosperous Europe. At the same time, the worldwide banana crop is in danger of being destroyed completely by three rapidly-spreading fungus diseases, which, according to studies carried out at the University of California, Davis, could be controlled by the thorough investigation of their genes and the application of modern genetic methods to produce improved varieties of these critical food plants.

One of the logical snares inherent in all of the discussions of GMOs and the imaginary damages they might cause is the idea that "if they can be avoided, let's do so," to avoid the implied harm. This relationship needs to become explicit and exposed for what it is – nonsense. If no one has even proposed a credible theory by which plants of transgenic origin could, as a class, inflict harm, then we should absolutely grow them when their characteristics warrant it – not avoid them as a group. Writers and speakers repeat to the point of tedium that GMO are not a "magic bullet," but so what? There is virtually no such thing in any field of human endeavor, only factors that can be helpful in moving us in a particular direction. We really do need to move on to the next stages in the development. Until we do so, we shall simply be trying to solve major problems with our hands tied behind our backs.

The challenges of developing a robust, sustainable, and productive agriculture are huge, both in India and generally. Agriculture must change both to limit and to resist global climate change, and to limit its other pressures on the environment. All are made more severe

by inefficient agriculture and urban sprawl. I have spent much of my life fighting to conserve biological diversity and to work toward a sustainable world. India is fully dependent on its biological diversity and likely to lose even more than half of its species, the great majority of them unknown, during the next few decades. India's biodiversity is among the world's richest, with most groups except vertebrates and plants very poorly known. Meanwhile, bureaucratic snarls coupled to a degree with lack of interest in the subject are retarding both the study of India's organisms and their conservation.

We derive all of our food from plants, directly or indirectly, and, in India, most medicines also. We are just starting to understand the ways in which diverse ecosystems protect our soils and our water supply, absorb pollution, and determine the qualities of our atmosphere and its effect on us. We cannot build a sound future for India or for the world as a whole without paying much better attention to these problems, embracing both their value and the moral precepts that we have built up over the years to protect them.

There at least four important steps that would lead to agricultural improvement in India and generally:

1. Adequately fund studies to help us understand and preserve our remaining agrobiodiversity, in part by encouraging the small farmers who preserve it people who maintain it.
2. Inventory and conserve as much of existing wild biodiversity – so poorly known – as possible.
3. Use scientific principles to determine the future of agriculture, disregarding the false representations of those who benefit from polemics that greatly lower the quality of life for billions of people throughout the world. Blindness, starvation, and premature death are prices that we cannot afford to pay for their lies.
4. Invest much more heavily in agricultural research and development everywhere. Agriculture is in general very poorly understood, which is amazing in view of our utter dependence on it.

The question is not whether we can do better – we simply must. Only by overcoming our inherent selfishness, understand our differences and helping one another to lead better lives can help us to build a sustainable world. The alternative is catastrophe for everyone, sooner than we imagine it might come. As American representative to the United Nations Adlai Stevenson stated a half century ago (1965),

"We travel together, passengers on a little spaceship, dependent upon its vulnerable reserves of air and soil, all committed for our safety to its security and peace; preserved from annihilation only by the care, the work, and, I will say, the love we give our fragile craft. We cannot maintain it half fortunate, half miserable, half confident, half despairing, half slave to the ancient enemies of man, half free in a liberation of resources undreamed of until this day. No craft, no crew can travel safely with such vast contradictions. On their resolution depends the survival of us all."

Those words remain true today, and we must find ways to heed them. The 3.3 billion people who lived then have grown to today's 7.4 billion, and our demand on the world's sustainable productivity has grown past its total capacity, having increased 2.5 times over that half century. If we do not find ways to respond to the challenges we face adequately, we shall have only ourselves to blame for the consequences.

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