Megha Manjunath
Waukee High School
Waukee, IA
India, Factor 1

India: Food Security and Agricultural Productivity through GM Seeds

India is an agricultural country and basically the economy is agrarian. This has not changed in the last 60 years since the country earned its independence. Even though India has made tremendous strides in economic growth and industrialization – agriculture remains the backbone of Indian economy. As Mahatma Gandhi said, "India lives in villages and agriculture is the soul of Indian economy". Nearly two-thirds of its population depends directly on agriculture for its livelihood. India uses about 60.89 percent of its land for farming. The land holding of a marginal farm family is roughly 1.18 hectares of farmland. The vast majority of Indian farming depends on seasonal rains. Agriculture provides direct employment to 70 percent of working people in the country. Thus even today, the entire economy of the country is being sustained by agriculture, which is the mainstay of the villages.

The green revolution of the early 1970s (1970-90) enabled the country to achieve self-sufficiency in food grain production and to face the immediate threat of famine. However, this growth did not sustain due to population growth and slowed agricultural productivity in the late 1990s. The projected food grain production in the country is estimated to reach 218 mn tonnes for the 2009-2010 crop year which shows a decline compared to previous years--234 million tonnes--(IANS, 1). As two-thirds of India's population depends on rural employment for living. "Farmers in India suffer from a lack of food security," states Dr. M.S. Swaminathan. As the world's second largest population and with the largest percentage of land under cultivation, agricultural productivity in India remains very low.

In spite of the progress made in agriculture**,** the rural population struggles to make a livelihood. Problems like malnutrition, lack of education, and inadequate health care, which stem from deficiencies in agricultural productivity, are proving to be the bottlenecks for sustained economic growth in the country. As Indian agribusiness and World Food Prize Laureate Dr. B.R. Barwale noted, in the immediate aftermath of World War II, "famine and the prospect of mass starvation haunt[s] the Indian sub-continent and other parts of the globe." Recent statistics suggests India has nearly 20 percent of the world's undernourished populace, 33 percent of the babies are born underweight, 21 percent of population does not get one meal a day causing 50 percent of children are malnourished (Chamberlain, 1). These staggering statistics easily expose the life of an average rural Indian subsistence farmer, who tends to have large families with 4-6 children per family on average. In most cases these children cannot be educated in state school systems or attend educational camp visits from humanitarian organizations because they are forced into "child labor" at early ages. Therefore, the illiteracy rate in rural areas stands at a shocking 41.3 percent. Just like education is often unattainable in rural India, a significant 65 per cent of the population does not have access to modern medicine or adequate healthcare. This is the cruel reality the country faces as one of the world's emerging economies.

The decline in agricultural productivity is due to primitive agricultural practices adopted by majority of subsistence farmers and lack of access to modern agricultural technologies. Problems associated with inequitable allocation of water in many states, deteriorating irrigation infrastructure, stringent land regulation**,** weak natural resources management and inadequate infrastructure and services in rural areas have further slowed down the agricultural growth. To cite as an example, many parts of India, especially the southern plateau, have severe shortage of water for agriculture. With water tables receding to alarming levels, many farmers are unable to adopt modern farming methods like "drip irrigation" etc., due to

prohibitive associated cost with newer technologies. Besides the projections of population growth estimates a growth rate of 1.1% which will put India's population above1.3 billion by 2020. The country is now faced to grow more food for its ever growing population, and green revolution technologies may not be sufficient to meet the demand. It's imperative that the country brings about a second green revolution or even better and longer-lasting "evergreen revolution" by incorporating innovative and modern technologies that increases the output significantly. Therefore, India must become agriculturally productive to feed its burgeoning population while ensuring a brighter future for its citizens (Anand, Personal Communication).

Biotechnology offers prospects in addressing problems concerned with agricultural productivity. Faced with the multitude of problems related to ever increasing population, depleting land and water resources, concerns over environmental safety- biotechnological intervention to supplement conventional plant breeding efforts is indispensable. Biotechnological techniques has enabled crop production of superior quality, mass production of elite planting materials, compensate land shortages and genetic improvement of the plants by genetic engineering.

Genetic engineering is a fast emerging biotechnology tool that has revolutionized modern agriculture. This technology enables manipulation of the genetic makeup of cells and move genes across species boundaries to produce novel plants and organisms. Genetically modified (GM) plants/seeds which are direct products of genetic engineering have become the latest in biotechnology. GM crops have specific changes introduced into their DNA by genetic engineering techniques for a specific purpose. The GM crops currently in the world markets are mainly aimed at an increased level of crop protection through introduction of resistance against diseases, insects and tolerance to herbicides. This technique is also currently used to develop crops to increase tolerance to drought and as well as improve the nutritional values. Currently, more than 25 countries in the world have successfully adopted the GM technology.

In comparison to the western countries, India has achieved limited progress in modern agriculture over the last decade, as witnessed by the stagnation of food grain production. The consequences are insufficient food security and food inflation has risen to 18 percent (Kinetz, 1). To increase the food security in the country, the Indian government has recently started investing significantly in agricultural biotechnology and crop genetics including developing, testing and marketing GM crops and seeds to food markets. "Ensuring the safe and responsible use of biotechnology has to be done by regulatory mechanisms and also by public opinion--by the nongovernmental movement, organizations which go into the ethical aspects of technology," explains Dr. M. S. Swaminathan (SGI Quarterly, par. 14).

For example, rice is the most consumed commodity in India. Genetic modification in rice can provide a new plant variety that greatly benefits the Indian populace. Many scientists believe that adding more nutritional value to the average rice crop would be most beneficial. GM technology is capable of isolating a beneficial gene from one plant and introducing it in rice to increase the nutritional value in an ordinary rice variety. For example, *Golden rice* was developed in Germany, through GM technology with increased iron and Vitamin A. Active research is pursued in Japan to develop allergen free rice cultivars. India will greatly benefit in adopting these advanced technologies.

The degradation of the environment is one of the main causes for the necessity of the implementation of GM seeds, which must be marketed and sold to the smallholder farmers under appropriate conditions.
The use of GM seeds will produce crops with the ability to survive harsh conditions and withstand impact of climate change which has become a major factor contributing to reduced crop productivity world-wide. As climate change begins to take effect, rain follows irregular trends. Knowledge from local weather

patterns renders useless to farmers. The durability of genetically modified seeds will increase crop yields by producing abatements in annual crop failure.

Through the utilization of GM seeds, an increase in food quantity and annual income will take place. Also, GM seeds help to preserve the environment by conserving water during extremely dry seasons and by preventing the damage of crops in severely wet seasons. These grim seasons have major effects on both smallholder farmers and their crops. Annual failures of crop harvests due to excessive or insufficient amounts of water may lead to problems such as a sizable reduction in income. As monsoon-related weather patterns become increasingly difficult to predict, GM seeds can generate crops that will survive irregular weather and climate changes. As Prof. M. S. Swaminathan stated "if conservation of natural resources goes wrong, nothing else will have a chance to go right," (Frankel, par. 18).

Although other methods of poverty reduction like water management may aid in a decline of failed crop harvests, GM seeds produce sustainable crops that adapt to their environment. Non-profit and government organizations must implement GM seeds, which will survive excessive and inadequate levels of water during the monsoon, when soil becomes waterlogged and useless, and during the dry season. The development of plants that can grow in tough conditions, such as drought, or dry or poor soil, may make it easier to farm marginal lands, helping to keep fragile soils such as wetlands and rainforests out of food production (Prakash, par. 14). Additionally, GM seed varieties reduce soil erosion, because they encourage the adoption of soil-conversing practices such as "no-till." Professor C.S. Prakash states:

> [U]sing biotechnology to develop crops requiring fewer chemicals to protect them from weeds and insects; crops that are more productive or that grow in harsh conditions; crops that require less land and water to grow the same amount of food; to develop foods that are richer in vitamins and nutrients and to develop foods that stay fresh longer without rotting or spoiling can aid farmers who are subject to failing in agricultural productivity.

Countless numbers of India's rural smallholders seek out urbanization as they leave small villages and farms to find work in bigger cities. The farmers left behind bear an enormous burden as they try harder to become more agriculturally productive. GM seeds can aid farmers who do not seek out urbanization to become agriculturally productive.

India can use China, another developing country, as an example for agricultural success as they have implemented relaxed policies for GM seeds. Chinese policies are more tolerant than those of India's and are providing China with substantial agricultural productivity for China to feed its expanding population. "China is often cited as one of most successful developing countries. This is not surprising given the impressive development of plant biotechnology and the record adoption of genetically modified crops," (Huang, 1). With moderately regulated policies and intervention of governmental and non-profit organizations, India will benefit from the same nature of growth. Whether India, like China, will ultimately embrace GM seeds is a question with profound implications (Kinetz, 1).

Measurements charting the trends of GM seeds indicate that GM seed use has declined over the years; therefore, food security within rural communities has not increased. Potential hazards from GM seeds are the main concerns for smallholder subsistence farmers, who would forfeit their employment if such hazards or risks were to occur.

Genetically modified seeds have generated public outcries' since they were first introduced in the mid 1990s relating to human health risks, environmental hazards, and economic concerns. Pertaining to potential hazards to the environment, criticisms include hazards to other organisms, reduced effectiveness of pesticides, and gene transfer through pollination. Plants like corn, potato and cotton have been

genetically modified with gene sequences from *Bacillus thuringiensis* (B.t.) to protect against insects without any synthetic spray. Critics state that growing such B.t. crops could pose a threat to other organisms as in the case of Monarch caterpillar. It was overstated that monarch caterpillars feeding on milkweed plants growing in and around corn fields covered with B.t. corn pollen blown from neighboring fields showed high mortality. Also, some skeptics speculate GM crop plants with a gene for herbicide tolerance may cross-pollinate with weeds shifting the herbicide resistance gene from the GM crops into the weeds providing them with herbicide tolerance as well.

All of the concerns for environmental safety are strictly theoretical and have limited evidence proving the existence of such situations. Pertaining to the Monarch larvae, scientist justify that only certain species of insect larvae are prone to perish once exposed to the B.t. gene. Thus, Monarch larvae would survive exposure to pollen from B.t. corn because the B.t. toxin is very specific and lethal to certain insect species. Scientists argue that all modified genes do not spread through pollination and that gene transfer through pollination would be impossible because of this modification. Likewise, if appropriate regulatory management practices are implemented, weeds cannot cross-pollinate with genetically modified plants. The movement of genes from GM plants into conventional crops or related species in the wild (referred to as "outcrossing"), as well as the mixing of crops derived from conventional seeds with those grown using GM crops, may have an indirect effect on food safety and food security. To avoid this risk, several countries have adopted strategies to reduce mixing, including a clear separation of the fields within which GM crops and conventional crops are grown (Narasimhamoorthy, Personal Communication).

Human health risks present another problem from GM seed usage. Another questionable scenario includes allergies that may occur from GM crops harvested from genetically modified seeds using genes that produce allergic reactions and whether or not GM seed use is lethal to the human body. The solution for preventing allergies or toxicity from occurring is using genes that derive from sources that are both natural and allergen-free. GM seeds are now routinely tested for direct harm and for horizontal gene transfer. "There are many differences of opinion here, but what is important is the safe and responsible use of biotechnology," concludes Dr. M. S. Swaminathan, "We must weigh the benefits and risks objectively and transparently, then decide," (SGI Quarterly, par. 11). The U.S. Agency for International Development, Agricultural Biotechnology Support Project II, and Program for Biosafety Systems state:

> The development of an effective national biosafety system is important to encourage the growth of domestic biotechnologies; to ensure safe access to new products and technologies developed elsewhere; and to build public confidence that products in the marketplace are safe. The absence of a suitable framework affects the ability of the public and private sectors to invest in biotechnology and to make the products of biotechnology available to that the benefits they afford can be realized (12).

Bringing GM seeds to the markets of India is a lengthy and costly process as major agri-biotech companies expect a profit on their investments in genetic modification. Most seed research done in India has been established by Monsanto, a large agri-biotech company. They claim to have spent millions in research and choose to price GM seeds very high. This affects the ability of thousands of farmers to purchase GM seeds at preposterously high prices.

Indian agriculture will need to adopt drastic new measures to counteract these high prices and prevent financial burden on smallholder farmers. Hence, scientists propose that non-profit organizations and other non-governmental companies must step in and help market and sell seeds. "It is hoped that in a humanitarian gesture, more companies and non-profits will follow the lead of the Rockefeller Foundation and offer their products at reduced cost to impoverished nations," (Whitman, 6,7).

Many policies, practices, and investments should be implemented in order for GM seeds to bring economic and agricultural success to India's rural farmers. Such policies include GM seeds to not only be used, but also for the Indian government to play a key role in creating better policies than the pre-existing to help market and sell genetically modified seeds to India's impoverished.

Practices involve smallholder farmers taking the responsibility to follow government policies on how to maintain genetically modified seeds. Investments made by both the government of India as well as non-profit organizations consist of distributing GM seeds in the best manner to markets at the lowest prices for India's smallholders. Dr. M. S. Swaminathan explains:

> The answer is for governments to provide more funding to public-sector institutions like universities, government institutions or institutions such as our ecotechnology center in Chennai, to enable them to develop technologies that are available to the poorest farmer (SGI Quarterly, par. 20).

In 2002, the Indian government passed legislation encouraging the use of GM seeds. "India has allowed certain GM crops but under tightly-regulated conditions," reports Subodh Varma. Although these policies are in existence, smallholder farmers cannot progress due to their austere nature. Potential dangers from the unrestrained use of GM seeds cause many governments to introduce tough regulatory systems. Additionally, to keep from confronting an economic burden, many governments take disciplinary actions.

One of these policies, inhibiting agricultural productivity, states that farmers cannot use GM seeds from their fields for their next harvest, but instead should buy more seeds from the government after each harvest. Monsanto was involved in research using "suicide gene technology", which produces plants that would be feasible for only one growing season that produces non-germinating male sterile seeds. Monsanto has pledged to abandon all research using this suicide gene to help India become more dependent on GM seeds. If India were to make small changes in this policy, smallholder farmers can keep their GM seeds from previous harvests and use them to increase their crop yields and income in proceeding harvests. These farmers, as well as India as a whole, will widely benefit from an increase in agricultural productivity due to the adoption of GM seeds.

Amidst the challenges in agriculture, India's B.t. cotton success story stands out midst of the past controversies over B.t. and GM crops. Mr. Jagresh from Agricultural University in Dharwad, India says, "Within eight years of introduction, India's cotton farmers have adopted B.t. cotton seeds on approximately 90 per cent or over of India's total 22.5 million cotton acres." He states that better yields and less maintenance has made GM seeds a farmers favorite. He concludes, "Give a farmer higher good quality cotton yields, better returns (fair market price), and more convenience when farming, and he is likely to adopt a new product," (Prabu, 1). Another piece of evidence suggests empowerment of the rural women in the B.t. growing farms in India. Dr. Arjunan Subramanian, University of Warwick, and co-workers in a recent report document the use of GM insect-resistant B.t. cotton generated not only higher income for rural workers but also more employment, especially for hired female (Subramanian et al., Nature Biotechnology, 2010). When compared with conventional cotton, B.t. cotton generated additional employment, raising the total wage income by 40 US dollars per hectare. The study also reported largest increase in wages for hired females with a gain of 55% in average income. Therefore B.t. cotton enhances the quality of life of women through increasing income and reducing 'femanual' work." (University of Warwick, 1). This kind of success boosts the next generation of GM seeds/crops to become more popular in the farming sector.

Low costs for GM seeds can boost the economy and supply more to those who are impoverished. Many governmental and non-governmental organizations, communities, India's government, and other

companies must all implement these suggestions in India to truly prosper from the use of genetically modified seeds.

> "We need gene technology. We are looking for drought – resistant varieties – disease, pests, salinity. We need gene technology to combat these problems," suggests P.G. Chengappa, vice chancellor at the University of Agricultural Sciences in Bangalore, (Kinetz, 2).

Communities surrounding India and non-profit organizations have the same obligations as they both must help distribute seeds at the cheapest prices for the rural farmers and urban poor. The Indian government must put in place relaxed policies that educate farmers to plant and maintain GM seeds and must aid non-profit organizations and communities to market genetically modified seeds to India's smallholders. As a result of agricultural productivity from the use of GM seeds, the Indian government will be able to invest more money in education and healthcare. Therefore, poverty reduction will occur and smallholder farmers will directly profit with a raise in income and adequate nutrition.

As well as the satisfaction of all smallholder farmers, overall food security in India will boost the economy. These specific obligations, once fulfilled, will provide a brighter future for Indian subsistence farmers that experience decreasing crop yields throughout the year. "Genetically-modified [seeds] have the potential to solve many of the world's hunger and malnutrition problems, and to help protect and preserve the environment by increasing yield and reducing reliance upon chemical pesticides and herbicides," (Whitman, 12).

As India follows examples from other countries, the advantages of GM seeds will be much easier to acknowledge. Thus, GM crops have a definite value to add to Indian agriculture and would enhance food production with reduced input of water, low pesticide usage, and less environmental impact. This will enable the country to become self sufficient in food productivity and sustain economic prosperity.

Works Cited

"1987: Swaminathan." The World Food Prize.2010. World Food Prize Foundation.17 September 2010 <http://www.worldfoodprize.org/en/laureates/19871999_laureates/1987_swaminathan>.

Anand, Ajith. DuPont/Pioneer Crop Genetics Research, Personal communication. September 19, 2010.

Brower, Bill. " Gangeshwar Site Visit." Environmental Conservation Builds Families, India. GlobalGiving. Web. 8 Sept. 2010.

Carpenter, Janet, "GM Crops Can Benefit Farmers." Guardian on the Web 21 April. 2010. 8 September. 2010 <http://www.guardian.co.uk/commentisfree/cifgreen/201/apr/21/gm-crops-benefit-farmers>.

"Census of India - India at a Glance: Number of Literates & Literacy Rates." Government of India: Ministry of Home Affairs. 2010.20 September. 2010 <http://censusindia.gov.in/Census_Data_ 2001/India_at_glance/literates1.aspx>.

Chamberlain, Gethin. "Fifty Percent of Indian Children are malnourished." Rupee News. 18 September.2010.20 September. 2010 <http://rupeenews.com/2010/09/18/fifty-percent-of-indian-children-are-malnourished/>.

Frankel, Otto. Biography - M. S. Swaminathan. Gene Conserve. n.a. 21 September.2010 <http:// www.geneconserve.pro.br/bio_swaminathan.htm>.

"Full Biography." The World Food Prize. 2010. World Food Prize Foundation. 17 September 2010 <http://www.worldfoodprize.org/en/dr_norman_e_borlaug/full_biography/#AboutAuthor>.

Huang, Jikun, et al. "Development, Policy and Impacts of GM Crops in China: A Comprehensive Review of China's Agricultural Biotechnology Sector." Kennedy School Of Government. 2005. 9 September 2010 <http://belfercenter.ksg.harvard.edu/files/chinahuangapril06website.pdf>.

"Human Development United Nations." Infoplease Almanac. 2007. infoplease: Daily Almanac. 17 September 2010 <http://www.infoplease.com/ipa/A0934560.html#axzz102DVXZTk>.

IANS, "2009-10 foodgrain production to be 218.2 million tonnes." Thaindian News 19 July 2010. 25 Sept. 2010 <http://www.thaindian.com/newsportal/business/2009-10-foodgrain-production-to-be-2182-million-tonnes_100398296.html>.

"Improving Gender Equity in Access to Land." Food and Agriculture Organization of the United Nations. 2006. FAO Corporate Document Repository. 8 September 2010 <http://www.fao.org/docrep/010/a0664e/a0664e00.htm>.

"India puts on hold first GM food crop on safety grounds." BBC News.9 February 2010. 8 September.2010 <http://news.bbc.co.uk/2/hi/8506047.stm#blq-main>

Jain, Sweeta. "Essay on the Importance of Agriculture in the Indian Economy." Rajput Brotherhood Article Library n.a. 20 Sept. 2010 <http://www.rajputbrotherhood.com/articlelibrary/ 201008302003/essay-on-the-importance-of-agriculture-in-the-indian-economy.html>.

Kinetz, Erika. “India Balks at Genetically Modified Crops.” US News and World Report 16 Feb.2010. 8 Sept.2010 <http://www.usnews.com/science/articles/2010/02/16/india-balks-at-genetically-modified-crops_print.html>.

Meenakshi, Ganguly and Madras. "M.S. Swaminathan." Time 23-30 August.1999. 20 September.2010 <http://ramsap.tripod.com/swami1.html>.

Narasimhamoorthy, Brindha. Specialty Crop Improvement, Kemin Industries, Personal Communication. September 28, 2010.

Pingali, Prabhu, and Yasmeen. “Globalisation of Indian Diets and the Transformation of Food Supply Systems.” 17th Annual Conference Indian Society of Agricultural Marketing. Hyderabad, India. 5-7 Feb. 2004. Keynote Address.

Prabu, M.J., “Improved agronomic practices drive India’s Bt cotton revolution.” The Hindu 23 Sept. 2010. <http://www.hindu.com/seta/2010/09/23/stories/2010092351851500.htm>.

Prakash, C.S. "Benefits of Biotechnology for Developing Countries." AgBioWorld. 2005. 8 September 2010 <http:// www.agbioworld.org/biotech-info/topics/dev-world/benefits.html>.

“Rural Indian Women Benefit From GM Crops.” GMO Compass (2010). 8 September. 2010 <http://www.gmo-compass.org/eng/news/530.rural-indian-women-benefit-gm-crops.html>.

SGI Quarterly. "An Interview with M.S. Swaminathan." SGI Quarterly July 2009.

Shah, Anup. "Poverty Facts and Stats." Global Issues. 20 September. 2010. 17 September.2010 <http://www. globalissues.org/article/26/poverty-facts-and-stats>.

Subramanian, Arjunan et al., GM crops and gender issues. *Nature Biotechnology*, 2010; 28 (5): 404 <http://www.nature.com/nbt/journal/v28/n5/full/nbt0510-404.html>

University of Warwick. “GM Crop Produces Massive Gains for Women’s Employment in India, Study Finds.” Science Daily 28 July 2010. <http://www.sciencedaily.com/releases/2010/07/100728111713.htm>.

U.S. Agency for International Development, Agricultural Biotechnology Support Project II, and Program for Biosafety Systems. “What is Agricultural Biotechnology.” Agricultural Biotechnology (2004). 8 Sept. 2010 <http://www.absp2.cornell.edu/resources/briefs/documents/warp_briefs_eng_scr.pdf>.

Varma, Subodh. “GM foods: How safe are they?” The Times of India 6 Feb.2010. 8 Sept.2010 <http://timesofindia.indiatimes.com/articleshow/5541959.cms?prtpage=1>.

Venkataramani, G. “Country Profile-India.” *New Agriculturist*. New Agriculturist. (WRENmedia), May 1999. Web. 8 Sept. 2010.

"Western India sets example in tackling malnutrition." OneWorld South Asia. 8 Ocober.2008. 17 September. 2010 <http://southasia.oneworld.net/todaysheadlines/western-india-sets-example-in-tackling-malnutrition#top>.

Whitman, Deborah B. “Genetically Modified Foods: Harmful or Helpful?” ProQuest. April 2010. ProQuest. 8 Sept.2010<http://www.csa.com/discoveryguides/gmfood/overview.php>.