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Opinions and Perceptions of Various Stakeholders of the GMO Landscape in the Indian State of Maharashtra

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Review Article

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ABSTRACT

"The issue of GMOs is probably the best example of the scientific community not communicating well, science has treated the public as a large lecture hall. That puts people to sleep."

'Dietram Scheufele' Professor in Science Communication, UW-Madison.

The major scientific controversy of the 21st century is that of GM crops with about three dozen nations banning its cultivation. There are a number of studies by academicians in the western world to study the underlying reasons and beliefs for the public acceptance/rejection of the technology. Studies in India and other developing countries have been very few because of the comparatively later introduction of GMOs. A study of public opinions and awareness of GMO's will give several insights into how old policies need to be changed and new policies to be implemented. It will also tell us to what extent cultural and social beliefs influence their opinions. In this study I begin how GM technology has its foundation in artificial selection which started millions of years ago and how has it reached its present technologically advanced state. I also discuss the politics and controversies surrounding GMOs in the western world as well as in India. I then discuss the various concerns surrounding GMOs and how cognitive science plays a role in reinforcing these concerns. Finally, I present the results obtained from a survey of a limited number of participants from various groups influencing the GMO landscape in Maharashtra and derive some key conclusions and recommendations based on the results.

INTRODUCTION

A brief history of the three agricultural revolutions

The road to modern GM technology was very gradual; it took three agricultural revolutions to reach finally where we are now.

The Neolithic revolution/first agricultural revolution started with the transition of human societies from hunting and gathering to farming. Early humans started transitioning from a hunter gatherer life style into an agricultural life style around 10000 years ago. They had no concept of genetics yet DNA evidences show domesticated dogs came around ~32000 years ago as a result of continued artificial selection of many generations of wolves. One of the first crops to be domesticated was the wheat which was crucial for the transition into the agricultural lifestyle. The domestication of wheat was instrumental in the agricultural revolution that took place in the fertile crescent of the middle-east around 10000 years ago. The domestication of animals and crops lead to people creating permanent settlements which in turn gave rise to job specialization, complex political structures, the rise of industry and commerce etc. [1].

The second agricultural revolution too place in conjunction with the industrial revolution that took place in Europe. The

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industrial revolution was accompanied by large scale migration of people into cities which meant a large urban population to be fed. This led to the revolution that would move agriculture beyond subsistence to generate the kinds of surpluses needed to feed thousands of people working in factories instead of in agricultural fields. There were many reforms taken by the governments that helped the second industrial revolution, for e.g. the Great Britain's Enclosure Act that facilitated consolidation of fields into large single-owner holdings. It was also accompanied by technological innovations like the seed drill that enabled farmers to avoid wasting seeds and to easily plant in rows, making it simpler to distinguish weeds from crops. Farmers also started using fertilizers and artificial livestock by the 1830s. These led to an increased agricultural output that made it possible to feed the large urban population whereas the surplus was sold off for profit.

The third revolution known as the Green Revolution took place during the 1970s and 1980s. It mainly benefitted the Asian and Latin American population and was largely responsible for preventing a food crisis in these countries during the 1970s and 1980s. It was specifically aimed to help farmers all around at the word. It was an international effort aimed to developing new practices that would enable farmers to improve crop performances and agricultural productivity within the same amount of land.

It was made possible mainly due to two technological advancements:

1. Scientists created hybrid varieties (not GMOs) with higher yield than the parent varieties and ability to grow in different climatic conditions in different regions.
2. The use of chemical fertilizers.

However, the Green Revolution did not benefit many other parts of the world to the same extent. For instance, no seeds appropriate for Africa were developed and the poor economic conditions of African countries meant no capital for purchasing the hybrid varieties of seeds [2,3].

Birth of molecular biology and GM technology

The earliest scientific experiment that led to the birth of modern GMOs was done by Gregor Mendel who lived in what is now the Czech Republic and is considered as the father of modern genetics. He performed hybridization experiments which involved breeding plants of same species having different phenotypic characteristics. He worked mainly with pea plants (because of ease of performing experiments and recording the observations), between 1856 and 1863, and his work was later drawn upon in genetic engineering. In 1944 Avery and co showed that the genetic material is DNA through bacterial transformation experiments. In 1954 Watson and Crick showed the double helical structure of DNA. In 1963 Marshall Nirenberg deciphered genetic code and showed how DNA directed the synthesis of proteins. During 1972 and 1973, the most important experiment leading directly to the rise of GMOs took place, U.S. biochemists Herbert Boyer and Stanley Cohen performed what was previously thought impossible: They developed a technique called recombinant technology that allowed them to cut pieces of DNA at specific sites and inserting them to the DNA of other organisms [4].

Politics and commercialization

In the 1970s scientists were just starting to learn the method of engineering DNA from various sources into different combinations previously unknown. Although they knew of the unlimited possibilities that this would offer in the future, they were not sure of any potential health and environmental risks that would happen. So, in Feb 1975, at the Asilomer Conference Center in Pacific Grove, California one of most important meetings in the history of science took place known as the Asilomer conference. It was interesting to note that the people who sounded the alarm concerned about the experiment and their end products were not politicians, journalists or religious groups but scientists themselves. The conference was organized by Nobel laureate Paul berg and included professionals biotech, law and medicine to draw up guidelines to ensure the safety of recombinant DNA technology. The conference regarded as one of the most important case studies for science communication as it marked the beginning of public discussion of science policy [5].

In 1980 general electric developed a crude oil degrading genetically modified bacterium and filed a patent for it, but living organisms were not patentable. The Supreme Court eventually changed the rule: A live, human-made micro-organism is patentable subject matter under 35 U.S.C.101. and granted the patent. In 1982 the US FDA approved the first GMO drug, Humulin, which was human insulin produced from *E. coli* using recombinant technology, developed by Genetech. In 1983 Monsanto developed the first genetically modified plant by inserting antibiotic genes into tobacco plant. Subsequently many other developments took place in the 1980s and 1990s such as the first GM crop trials, US FDA approval of GM seeds and Flavr Savr tomatoes. These genetically modified tomatoes have a higher shelf life than conventional tomatoes and were the first GM food product to reach the consumer.

But towards the beginning of the twentieth century public perception started turning hostile towards GM crops in the west due to growing environmental and health concerns. This was kicked off by Greenpeace in 1996 when Monsanto released the first herbicide tolerant GM soybean. The anti-GMO campaigns along with media attention intensified more stringent regulation and legislation on GM products such as the FDA modernization act. It also pressurized big food manufacturers like Sainsbury, Burger King etc. to reduce or remove GM ingredients in their food products. The EU also imposed an unofficial ban on GMO-based products, withdrawing support for experimental or commercial growth of new GM crops and to import GM food products and its position remain unchanged till date [6].

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GMOs in India

GMOs and the politics and challenges associated with it are reasonably new in India compared to the western world.

The first GM crop to take roots in India is Bt-cotton, in 2002. It is genetically modified to produce insecticidal toxins derived from the bacterium Bacillus thuringiensis. These toxins are called Cry-proteins are highly specific to pests. Once again like in the west, Greenpeace kicked off the protests demanding that the Indian government ban Bt-cotton citing high financial risk for farmers in purchasing the seeds as the main reason. However, data collected between 2002 and 2008, and controlling for non-random selection bias in technology adoption, shows that Bt has caused a 24% increase in cotton yield per acre through reduced pest damage and a 50% gain in cotton profit among smallholders. Available data show no evidence of a 'resurgence' of farmer suicides. Moreover, Bt cotton technology has been very effective overall in India. Nevertheless, in specific districts and years, Bt cotton may have indirectly contributed to farmer indebtedness, leading to suicides, but its failure was mainly the result of the context or environment in which it was planted. The increase in suicides among Indian farmers is an unanticipated consequence of the bank reforms the country undertook since the early 1990s. The protests against Bt-cotton were unsuccessful as it continues to be used till date in many areas in India.

However, the scenario with edible crops is different. In 2010 environmental minister Jairam Ramesh blocked the release of Bt Brinjal owing to lack of consensus among scientists and opposition from Brinjal-growing states. Another recent example is that of GM-mustard or popularly known as Dhara mustard hybrid (DMH-11). Unlike other crops – maize, Bajra, rice, sunflower and cotton for instance – there are no commercial hybrids for mustard. The reason is simple: mustard is a self-pollinating plant. Hence it would need to be genetically engineered to enable hybridisation. Scientists at Delhi University achieved this by means of the two genes Barnase and Barstar, derived from a soil bacterium called Bacillus amyloliquefaciens. The Barnase gene confers male sterility to a plant in which it is inserted and enables crossing of the male sterile line with the fertility restorer (Barstar gene) line to produce fertile hybrid plants and seeds. GEAC (Genetic Engineering Appraisal Committee) gave green signal to GM Mustard for field trial, but SC stayed the order and sought public opinion on the same. The Supreme Court is expected to give a decision on the matter on April 12th, 2017 [7].

GMO challenges

Profit incentive: Biotechnology especially GM technology has an enormous potential for commercial gain through which is evident through the large transnational corporations such as Monsanto, Dupont, and Novartis. Most private companies in the crop Industry focus their research on staple products of western nations such as maize and wheat [8].

Research funds: More funding on biotechnology and GM technology have reduced the funds available for research on sustainable and alternative agricultural methods, biological control etc. These methods have led to the development of iron and calcium fortified rice, salinity resistant rice, and nitrogen fixing legumes in Third World countries. Hans Herren, the director of the International Centre of Insect Physiology and Ecology in Nairobi who played a crucial role in ending a famine in Africa during the 1980's with an action plan based on biological control feels that funding for such research activities are not available now GM technology is drawing too much money [9].

Biodiversity and environment: Environmental concerns over GMOs is due to the fact that it may led wipe out many other strains that is being used and decrease the biodiversity. Another concern is the rise and spread of Super weeds resulting from increased use of herbicide on herbicide tolerant GM crops.

However, studies on Bt-cotton in India and soy-beans in the US have shown that GM crops played a positive role by improving underutilized alternative crops, making them more feasible for wide-spread domestication. It has been found that overall commercialization of GM crops have reduced the impacts of agriculture on biodiversity, through enhanced adoption of conservation tillage practices, and increasing yields to decrease pressure on additional lands for cultivation [10].

GMO technology has also played an important role in reducing the environmental impact caused by herbicide and insecticide use between 1996 and 2014 it has reduced pesticide spraying by 581.4 million kg (-8.2%) and, as a result, decreased the Environmental Impact Quotient [EIQ] associated with pesticide usage by 18.5% [11]. This is also relevant to countries like India that have provided pesticide agricultural commodity maximum residue limits (MRLs) for agricultural foods in order to facilitate agricultural exports and implications on public health. For example, the average daily intake Lindane and DDT (both are insecticides) by Indians was reported to be 115 and 48 mg per person respectively, which were higher than those observed in most of the developed countries [12,13].

However, over reliance on the use of Glyphosate by some farmers, in some regions, has contributed to the development of weed resistance. This had prompted farmers over the last decade to employ reactive and proactive weed management strategies incorporating a mix of herbicides. As a result, some of the original environmental gains associated with changes in pesticide usage have diminished.

Hence it is important to note that if the technology is used in the right way it will have significant environmental benefits but if the associated farming practices are not sustainable it can yield negative results.

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Food allergies: Health concerns over GMOs surrounds food allergies. When a new gene is inserted into another species there is chance that it may interact with other genes and lead to new gene products or higher quantity of original gene products that can trigger allergic reactions.

However, one thing anti-GMO campaign forget while claiming GMOs cause allergic reactions is the fact that ninety percent of food allergies are caused by the common allergens in peanuts, tree nuts, milk, eggs, wheat, soy, shellfish, and fish. The 1996 case of Brazilian allergens identified in transgenic soybeans cannot be used as an argument because the Brazil nut GMO soybean has never been approved for the market, according to the international principles of food safety (FAO/WHO), before any GMO food gets market approval, the structure of the introduced protein should be compared to all known allergens. Further experiments are also conducted to evaluate any potential allergenicity. Hence one should keep in mind that there already many existing policies and regulations to check for allergens in GMO foods more stringently than with non-GMO foods. The US have approved around 30 GMO crops and till date no allergens have been found in GMO products approved for human consumption [14].

Food shortage isn't exactly the problem: This is a very legitimate concern, The World Bank states that the world food supply in 1994 was enough to meet the needs of 6.4 billion people, however due to economic and political reasons the supply was not able to reach all groups of people. Hunger affects certain groups more prominently such as children, people in rural areas and those living in underdeveloped nations. Three fourths of people who are hungry live in Asia, Africa, or Latin America. Hence adequate economic and political reforms should also be taken [15].

Ethical concerns: The ethical issue concerning GMOs surrounds its potential ability to solve world hunger. Many people think that GM technology would make farmers entirely dependent on the big MNCs for seeds and supporting necessities like herbicides. An example is the technology exists that produce sterile seeds, called "terminator technology," the seeds prevent the spread of GMOs through cross pollination. This means that farmers need to purchase new seeds every year and thus placing an economic burden on them [16].

Bernard E. Rollins have broadly classified the ethical concerns surrounding genetic engineering into three groups: Intrinsic wrongness, dangers to the human society, and harm to other sentient creatures.

Intrinsic wrongness: the main idea is associating genetic engineering with notions of blurring species, "messing with nature," violating the sanctity of life, "playing God," etc. This ethical concern is based on the premise that the wrongness of the action is not based on a function of benign results or negative utility or danger – it is just wrong. Concerns of this kind are an example of bad ethics (not based on rational thinking) and one might think it might not play a significant role in genuine scientific issues, but data shows otherwise. A study conducted by the US Office of Technology Assessment showed that 46 percent of the public felt that "we have no business meddling with nature".

The second type is based on the potential dangers that can arise from the technology. This has a rational basis as we have seen numerous cases in which reassurances from researchers about the safety of new inventions and technologies turned to ashes: the escape of "killer" bees, the Chernobyl and Three Mile Island disasters; the various space shuttle tragedies. The ethical difference arises because scientists and public weigh the benefits *versus* risks on a different scale. For example, biotechnologists may feel that (for example) the possibility of one death in a thousand is a reasonable risk in exchange for the benefit of some new biotechnological innovation. However, the ordinary public with no vested interest in biotechnology may demand no greater risk than one in a million.

The third type, a pure ethical concern, revolves around the effect of genetic manipulations on the health, welfare, and well-being of those sentient creatures being manipulated: the animals. This has more significance when animals are genetically modified for commercial production like the "Beltsville Pigs". To check the animal suffering arising from commercial production, Bernard E. Rollins have proposed the PRINCIPLE OF CONSERVATION OF WELFARE which states that "given any proposed genetic engineering of animals, the animals should be no worse off, in terms of suffering, after the new traits are introduced into the genome than the parent stock was prior to the insertion of the new genetic material". This would effectively check the production of suffering animals for profit or increased "efficiency" but at the same time would not hinder genetic engineering that benefits the animals and producers, such as increased disease resistance [17].

Role of cognitive science in GMO acceptance

Expectations intuitive in nature make the human mind more prone to particular misrepresentations of GMOs. One aspect of the intuitive mind that promote GMO antagonism is psychological essentialism which is the belief that all organisms have an unchangeable, unobservable core which defines their identity and in turn their development and behavior. This affects people's perception of GMOs, primarily because they interpret DNA as the essence of organisms. A survey conducted in US showed that more than half of the respondents agreed with the idea that tomatoes with genome modified using catfish DNA would taste like fish. Another type are teleological and intentional intuitions that creates a quasi-religious view on nature for example GMO opponents accuse scientists who produce transgenic plants of 'playing God' and condemn their acts as 'against nature' and terming biotech food as 'Frankenfood'. Another intuition that influences people's perception of risk assessment of GMOs are the emotions of disgust. Disgust evolved probably in response to adaptive problems related to pathogen and poison avoidance. Anti-GMO activ-

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ists take advantage of the emotions the public with edited images that imply that GM food cannot be trusted, such as tomatoes with syringes or suspiciously blue biotech strawberries amid fresh red ones [18].

Cognitive beliefs also play a positive role in mediating the relationship between consumer innovativeness and loyalty to non-GMO foods. Consumer innovativeness is the urge of customers to buy or adopt new products in the market hoping to get a different and fresh experience. However, in developing countries personal income may largely determine loyalty to non-GMO foods and could lessen importance of innovativeness and cognitive beliefs [19]. Studies have also shown that people hole cognitive biases in accepting information on GMOs and that prior belief clearly affects how people assimilate information. People with confirmative bias are more likely to misinterpret information and accept only part of the new information in agreement with their prior beliefs which helps them to conserve their prior beliefs [20].

Studies have also shown confirmation biases in scientists resulting in what is called filer drawer effect. In this scenario scientists may be confronted with a "negative" result, he might opt to either not spend time publishing it or exclude some subjects (in case of clinical trials) to make the negative results statistically insignificant. Although data fabrication and falsification are probably rare, but other questionable research practices are relatively common. Quantitative studies have repeatedly shown that financial interests can influence the outcome of the research especially those sponsored by biotech industries [21].

Significance of the study

There have been a number of studies in the developed countries regarding consumer perception towards GMOs and GMO foods. However, such studies in India are fewer, particularly because adoption of GM technology in agriculture is recent and also limited to Bt-cotton. Even field trials of newly developed crops GM Mustard and Brinjal faced opposition from different sections of the society and eventually had to be put on hold. In this context it is important that scientists, policymakers as well as managers of agri-business companies address their legitimate concerns and devise strategies to mitigate them. Also, while doing so they should not adopt a one size fits all approach and instead look at the concerns of each stakeholder group differently and devise separate strategies to address them. This study and the recommendations offered by it are a step in that direction.

METHODOLOGY

To address the research questions, a survey was developed and administered to a sample of different stakeholders of GMOs landscape within the population in Maharashtra. The stakeholders are namely consumers (N=30), Plant biotechnologists (N=10), members of NGOs with an anti-GMO stance (N=15), organic farmers (N=14) and farmers involved in the cultivation of Bt-cotton (N=12). The survey was designed such that it would cover:

1) statements that measured respondent's knowledge of GM crops and vaccines; 2) statements that assessed the respondents support for GM technology 3) statements that determined how factors like intrinsic wrongness, its potential danger to the humans and harm to other sentient creatures (loss of biodiversity) 4) statements that assessed how the potential benefits of GMOs would outweigh these factors. The respondents were given three options for each of the statements: disagree, no opinion and agree. The entire questionnaire is shown in Appendix.

RESULTS

The entire responses of the different groups surveyed are shown in Appendix. Key highlights will be discussed here **(Figures 1-10)**.

Consumers

All respondents are from the educated urban middle class.

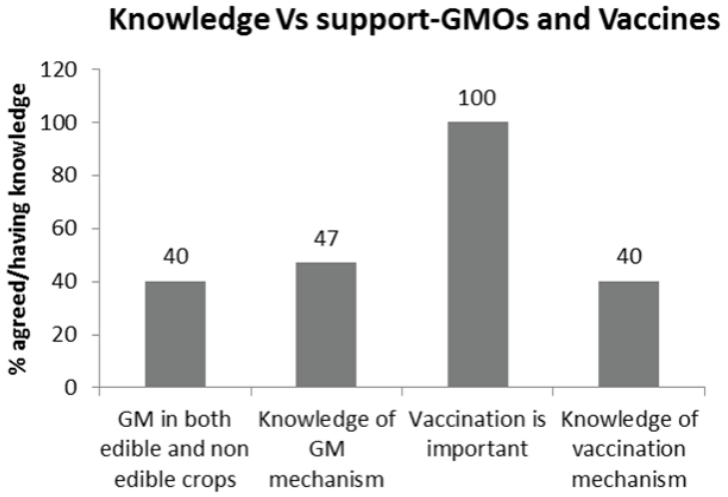

Figure 1. Pecentage of consumers supporting vaccines and GM foods *Vs*. having the knowledge of mechanism of the same.

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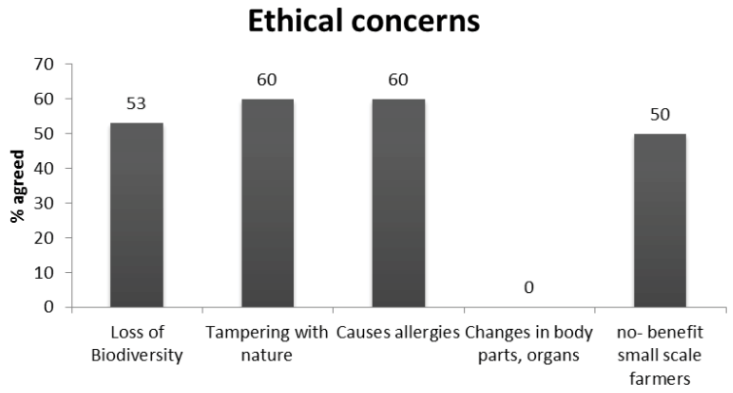

Figure 2. Percentage of consumers holding different ethical concerns.

1. Knowledge of GM technology: Only 47% of the respondents knew what the principle behind GM technology exactly was. 100% of the respondents agreed that there is a lack of information of GMOs among the public.
2. Application of GM technology: Overall the support for the use of GM technology was average with about 60% of the respondents agreeing for its use in increasing drought and insect resistance in crops with a fewer respondents (47%) agreed for its application in increasing the yield and nutritional value of the crops. 20% respondents agreed with totally abandoning GM technology. And only 40% of respondents stated that GM technology should be used in both edible and non-edible crops.
3. Opinion on Vaccines: Consumers have very strong support for vaccination with all of the respondents agreeing that vaccination is very important but only 40.0% of the respondents knew what a vaccine was.
4. Ethical concerns: Intrinsic wrongness seems to be the most prominent ethical concern among consumers with 60% of the consumers agreeing that GM technology is tampering with nature. 53.3% agreed that GM technology leads to a loss of biodiversity. 60.0% agreed that GM foods might cause allergies in Humans. None of the respondents had an opinion that GM foods might cause problems like change in body organs, infertility etc. (concept of Franken foods). 50% of the respondents were also of the opinion that GM technology has not benefitted small scale farmers **(Table 1)**.

Table 1. Percentage responses to the questionnaire.

Consumers			
Statement	**% disagreed**	**% no opinion**	**% agreed**
GM technology is based on transfer of genes from one organism to another	47	53	0
We should use GM technology to improve the yield of crop.	33	20	47
we should use GM technology to improve the nutritional value of crops	33	20	47
we should use GM technology to improve drought/disease resistance	20	20	60
concentrate only on developing more sustainable farming practices	60	20	20
focus on both GM technology and also sustainable farming practices.	20	20	60
There is a lack of Communication and awareness to public regarding GM technology	0	0	100
Most research shows only the positive side of GM Technology but not the whole picture	30	50	20
Media portray GM technology in a bad light.	20	43	37
Manufacturers like Monsanto are at the leading edge of a food revolution	20	67	13
Manufacturers like Monsanto are in it for the money	0	43	57
Most Vaccines are killed or weakened organism injected into your body.	0	60	40
Vaccination of children is very important.	0	0	100
Vaccines currently used have harmful effects	80	20	0
GM technology should be used only for non-edible crops like cotton	40	20	40
GM technology should be used for both edible and non-edible crops	40	20	40
GM technology Should not be used at all	60	20	20
GM crops reduce the use of pesticides in the environment.	20	43	37
GM crops reduce the use of pesticides in the food	20	43	37
GM crops causes a loss of biodiversity	27	20	53
GM crops cause allergic reaction in Humans after consumption	20	20	60
GM foods lead to problems like infertility, changes in body organs and parts etc.	80	20	0
GM technology is tampering with nature	20	20	60
GM products only profit multinationals making them.	30	20	50
GM products benefit small-scale farmers.	50	20	30

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Scientists

All scientists surveyed were plant biotechnologists.

1. Knowledge of GM technology: All of the respondents knew what the principle behind GM technology exactly was and agreed that there is a lack of information of GMOs among the public.
2. Application of GM technology: Scientists had a very strong positive view for the use of GM technology with all of the respondents agreeing for its use in increasing drought and insect resistance in crops as well as in increasing the yield and nutritional value of the crops. All respondents agreed that GM technology should be applied to both non-edible as well as edible crops.
3. Opinion on Vaccines: Scientists have very strong support for vaccination with all of the respondents agreeing that vaccination is very important and all knew what a vaccine is.
4. Ethical concerns: Opinions regarding loss of biodiversity was unclear among scientists with 60% stating no opinion, 20% stating it might cause a loss of biodiversity and 20% disagreeing. 80% disagreed that GM technology is tampering with nature while 20% stated no opinion. 80% disagreed that GM foods might cause allergies in Humans while 20% stated no opinion. All disagreed that GM foods might cause problems like change in body organs, infertility. 40% of the respondents stated that GM technology have benefitted small scale farmers while 20% disagreed **(Table 2)**.

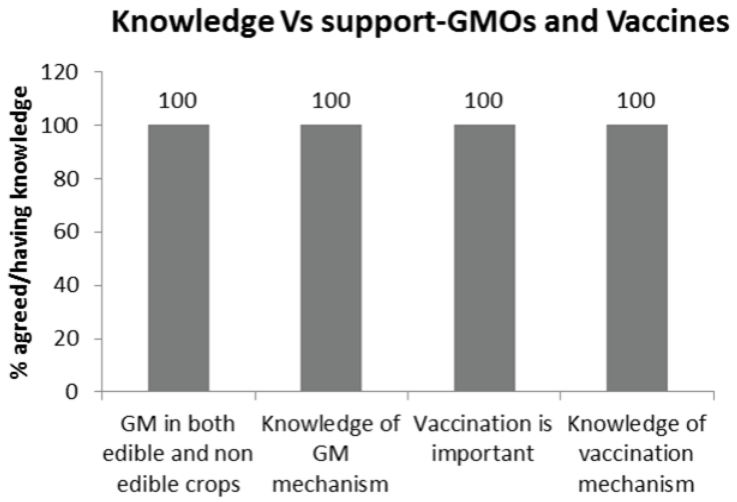

Figure 3. Percentage of scientists supporting vaccines and GM foods *Vs.* having the knowledge of mechanism of the same.

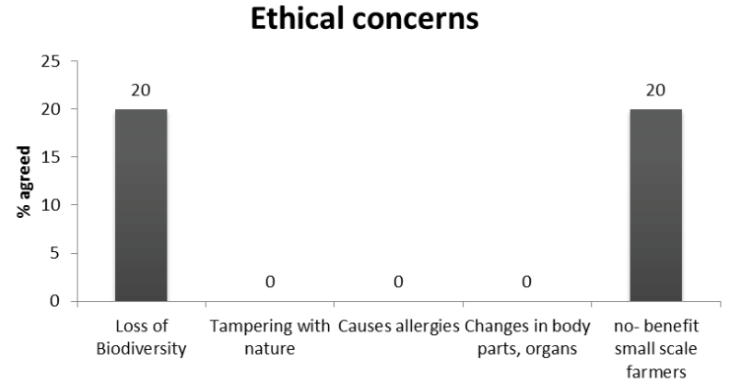

Figure 4. Percentage of scientists holding different ethical concerns.

Table 2. Percentage responses to the questionnaire.

Scientists			
Statement	**% disagreed**	**% no opinion**	**% agreed**
GM technology is based on transfer of genes from one organism to another	0	0	100
We should use GM technology to improve the yield of crop.	0	0	100
we should use GM technology to improve the nutritional value of crops	0	0	100
we should use GM technology to improve drought/disease resistance	0	0	100
concentrate only on developing more sustainable farming practices	0	0	100
focus on both GM technology and also sustainable farming practices.	100	0	0
There is a lack of Communication and awareness to public regarding GM technology	0	0	100

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Most research shows only the positive side of GM Technology but not the whole picture	100	0	0
Media portray GM technology in a bad light.	0	70	30
Manufacturers like Monsanto are at the leading edge of a food revolution	20	20	60
Manufacturers like Monsanto are in it for the money	0	20	80
Most Vaccines are killed or weakened organism injected into your body.	0	0	100
Vaccination of children is very important.	0	0	100
Vaccines currently used have harmful effects	100	0	0
GM technology should be used only for non-edible crops like cotton	100	0	0
GM technology should be used for both edible and non-edible crops	0	0	100
GM technology Should not be used at all	100	0	0
GM crops reduce the use of pesticides in the environment.	0	40	60
GM crops reduce the use of pesticides in the food	0	40	60
GM crops causes a loss of biodiversity	20	60	60
GM crops cause allergic reaction in Humans after consumption	80	20	0
GM foods lead to problems like infertility, changes in body organs etc.	100	0	0
GM technology is tampering with nature	80	20	0
GM products only profit multinationals making them.	40	40	20
GM products benefit small-scale farmers.	20	40	40

Organic farmers

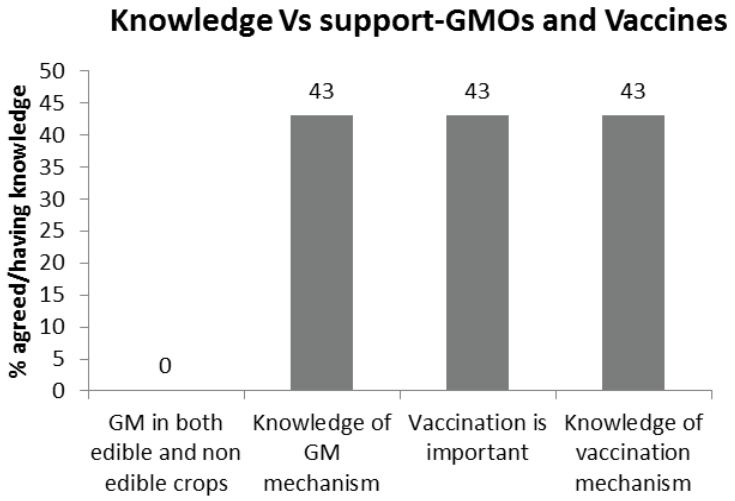

Figure 5. Percentage of organic farmers supporting vaccines and GM foods *Vs*. having the knowledge of mechanism of the same.

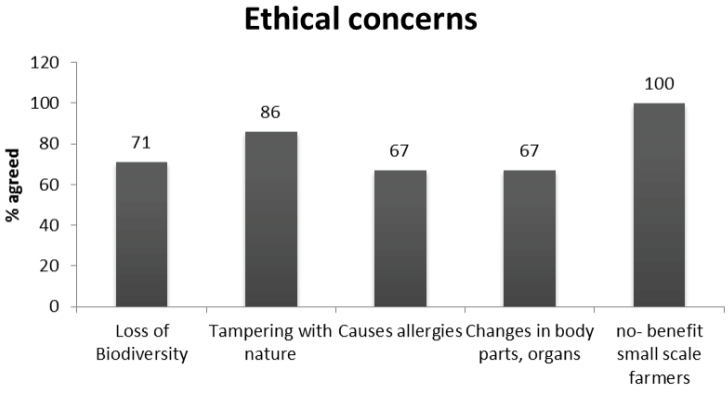

Figure 6. Percentage of organic farmers holding different ethical concerns.

1. Knowledge of GM technology: Only 43% of the respondents knew what the principle behind GM technology exactly was. 100% of the respondents agreed that there is a lack of information of GMOs among the public.

2. Application of GM technology: Organic farmers had a very negative view for the use of GM technology with 57% of the respondents being against for its use in increasing drought and insect resistance in crops, 14% for and 29% having no opinion. The percentage (71%) was even higher for against its use in increasing the yield and nutritional value of the crops. All respondents held the view that it should not be used in edible crops.

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3. Opinion on Vaccines: Surprisingly only 43% of the respondents agreed that vaccination is important whereas 43% disagreed. Only 43% knew what a vaccine exactly was. Interestingly all the respondents who knew what a vaccine was stated that vaccination is important.

4. Ethical concerns: An overwhelming 71% agreed that GM technology causes loss of biodiversity while 29% stated no opinion. 86% agreed that GM technology is tampering with nature and 67% agreed that it might cause problems like allergies as well as change in body organs, infertility etc. All of the respondents held views that GM technology have not benefitted small scale farmers **(Table 3)**.

Table 3. Percentage responses to the questionnaire.

Organic farmers			
Statement	**% disagreed**	**% no opinion**	**% agreed**
GM technology is based on transfer of genes from one organism to another	21	36	43
We should use GM technology to improve the yield of crop	71	29	0
we should use GM technology to improve the nutritional value of crops	71	29	0
we should use GM technology to improve drought/disease resistance	57	29	14
concentrate only on developing more sustainable farming practices	14	0	86
Focus on both GM technology and also sustainable farming practices.	71	29	14
There is a lack of Communication and awareness to public regarding GM technology	0	0	100
Most research shows only the positive side of GM Technology but not the whole picture	0	57	43
Media portray GM technology in a bad light.	64	29	7
Manufacturers like Monsanto are at the leading edge of a food revolution	79	21	0
Manufacturers like Monsanto are in it for the money	0	21	79
Most Vaccines are killed or weakened organism injected into your body.	36	21	43
Vaccination of children is very important.	43	14	43
Vaccines currently used have harmful effects	43	14	43
GM technology should be used only for non-edible crops like cotton	71	29	14
GM technology should be used for both edible and non-edible crops	100	0	0
GM technology Should not be used at all	14	14	71
GM crops reduce the use of pesticides in the environment.	64	36	0
GM crops reduce the use of pesticides in the food	64	36	0
GM crops causes a loss of biodiversity	0	29	71
GM crops cause allergic reaction in Humans after consumption	0	36	64
GM foods lead to problems like infertility, changes in body organs etc.	14	21	64
GM technology is tampering with nature	0	14	86
GM products only benefit multinationals making them.	0	0	100
GM products benefit small-scale farmers.	100	0	0

Bt-cotton farmers

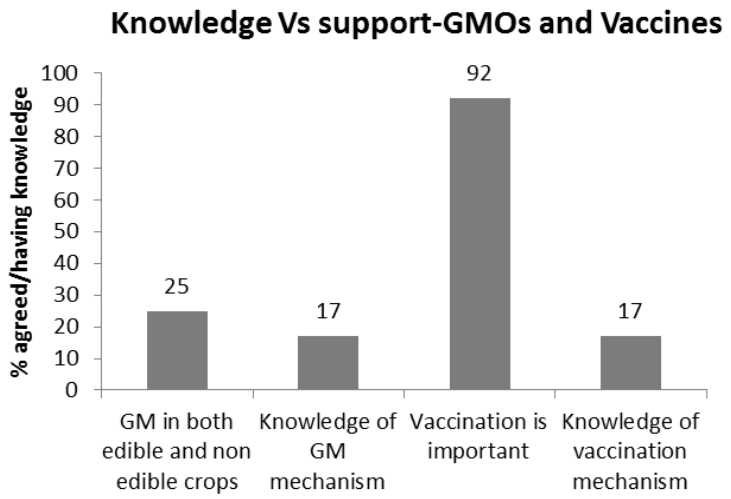

Figure 7. Pecentage of Bt-cotton farmers supporting vaccines and GM foods *Vs.* having the knowledge of mechanism of the same.

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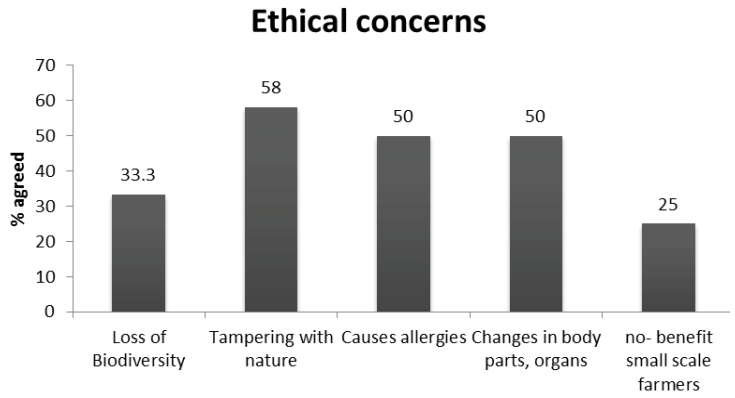

Figure 8. Percentage of Bt-cotton farmers holding different ethical concerns.

1. Knowledge of GM technology: Only 17% of the respondents knew what the principle behind GM technology exactly was. 100% of the respondents agreed that there is a lack of information of GMOs among the public.
2. Application of GM technology: Bt-cotton farmers had a very positive view for the use of GM technology with 100% of the respondents supporting use in increasing drought and insect resistance in crop, and in increasing the yield while only 17% supported its use in increasing the nutritional value of the crops. Only 25% of the respondents felt that the technology should be applied to both edible and non-edible crops.
3. Opinion on Vaccines: Only 17% knew what a vaccine is. In spite of the lack of knowledge 92% of the respondents agreed that vaccination is important whereas 8% had no opinion.
4. Ethical concerns: Only 33.3% agreed that GM technology might cause a loss of biodiversity while 16.7% disagreed and 58% agreed that GM technology is tampering with nature.50% agreed that it might cause problems like change in body organs, infertility etc, these were the same respondents who felt that technology should be restricted to non –edible crops. 75% of the respondents held views that GM technology has benefitted small scale farmers while 25% disagreed **(Table 4)**.

Table 4. Percentage responses to the questionnaire.

Bt-cotton farmers			
Statement	**% disagreed**	**% no opinion**	**% agreed**
GM technology is based on transfer of genes from one organism to another	0	83	17
We should use GM technology to improve the yield of crop	0	0	100
we should use GM technology to improve the nutritional value of crops	33	50	17
we should use GM technology to improve drought/disease resistance	0	0	100
concentrate only on developing more sustainable farming practices	67	33	0
Focus on both GM technology and also sustainable farming practices	0	58	42
There is a lack of Communication and awareness to public regarding GM technology	0	0	100
Most research shows only the positive side of GM Technology but not the whole picture	0	100	0
Media portray GM technology in a bad light.	0	75	25
Manufacturers like Monsanto are at the leading edge of a food revolution	25	50	25
Manufacturers like Monsanto are in it for the money	0	25	75
Most Vaccines are killed or weakened organism injected into your body.	0	83	17
Vaccination of children is very important.	0	8	92
Vaccines currently used have harmful effects	75	25	0
GM technology should be used only for non-edible crops like cotton	25	0	75
GM technology should be used for both edible and non-edible crops	75	0	25
GM technology Should not be used at all	100	0	0
GM crops reduce the use of pesticides in the environment	0	20	80
GM crops reduce the use of pesticides in the food	0	100	0
GM crops causes a loss of biodiversity	16.7	50	33.3
GM crops cause allergic reaction in Humans after consumption	25	0	50
GM foods lead to problems like infertility, changes in body organs etc.	25	0	50
GM technology is tampering with nature	17	25	58
GM products only benefit multinationals making them.	75	25	0
GM products benefit small-scale farmers.	0	25	75

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NGO members

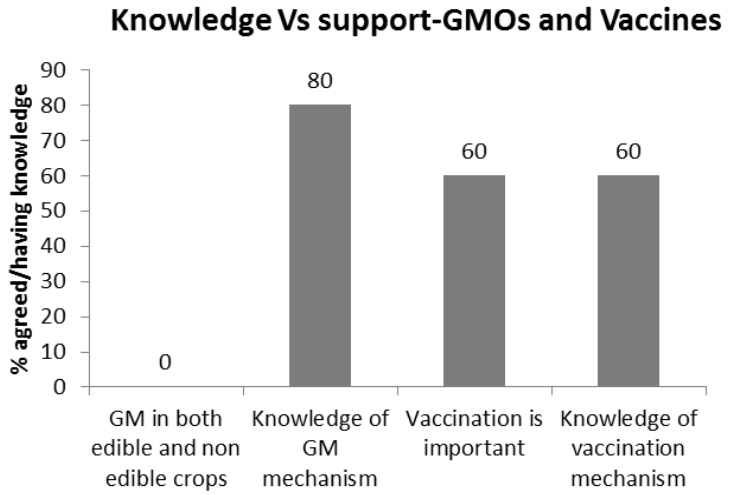

Figure 9. Percentage of NGO members (with anti GMO stance) supporting vaccines and GM foods *Vs*. having the knowledge of mechanism of the same.

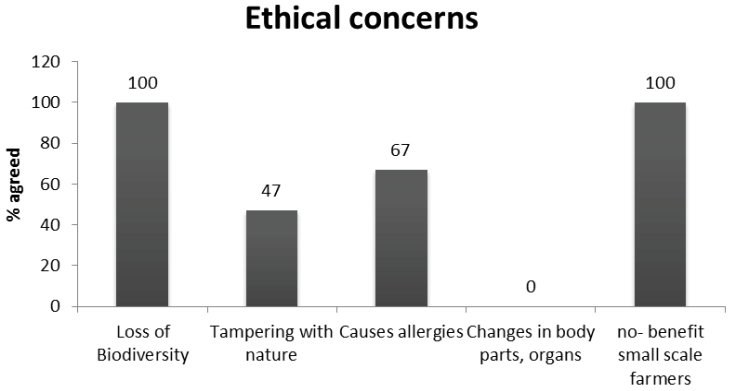

Figure 10. Percentage of NGO members (with anti GMO stance) holding different ethical concerns.

1. Knowledge of GM technology: 80% of the respondents knew what the principle behind GM technology exactly was. 100% of the respondents agreed that there is a lack of information of GMOs among the public.
2. Application of GM technology: NGO members had a very negative view for the use of GM technology with 100% of the respondents against its use in any of the aspects.
3. Opinion on Vaccines: 60% of the respondents knew what a vaccine is. Only 60% of the respondents agreed that vaccination is important whereas a sizeable percentage (26.7%) were unclear of their stand and stated no opinion. 13.3 % disagreed that vaccination is important
4. Ethical concerns: All the respondents agreed that GM technology might cause a loss of biodiversity. 47% agreed that GM technology is tampering with nature whereas 20% stated no opinion.100% of the respondents stated no opinion for the statement that GMOs might cause problems like change in body organs, infertility etc, but 67% agreed that GMOs might cause allergic reactions in humans. 100% of the respondents held views that GM technology has benefitted small scale farmers **(Table 5)**.

Table 5. Percentage responses to the questionnaire.

Members of NGOs with Anti GMO stance			
Statement	**% disagreed**	**% no opinion**	**% agreed**
GM technology is based on transfer of genes from one organism to another	0	20	80
we should use GM technology to improve the yield of crop	100	0	0
we should use GM technology to improve the nutritional value of crops	100	0	0
we should use GM technology to improve drought/disease resistance	100	0	0
concentrate only on developing more sustainable farming practices	0	0	100
Focus on both GM technology and also sustainable farming practices.	100	0	0
There is a lack of Communication and awareness to public regarding GM technology	0	0	100

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Most research shows only the positive side of GM Technology but not the whole picture	20	20	60
Media portray GM technology in a bad light.	60	40	0
Manufacturers like Monsanto are at the leading edge of a food revolution	100	0	0
Manufacturers like Monsanto are in it for the money	0	0	100
Most Vaccines are killed or weakened organism injected into your body.	0	40	60
Vaccination of children is very important.	13.3	26.7	60
Vaccines currently used have harmful effects	60	26.7	13.3
GM technology should be used only for non-edible crops like cotton	100	0	0
GM technology should be used for both edible and non-edible crops	100	0	0
GM technology Should not be used at all	0	0	100
GM crops reduce the use of pesticides in the environment	100	0	0
GM crops reduce the use of pesticides in the food	100	0	0
GM crops causes a loss of biodiversity	0	0	100
GM crops cause allergic reaction in Humans after consumption	0	33	67
GM foods lead to problems like infertility, changes in body organs etc.	0	100	0
GM technology is tampering with nature	33	20	47
GM products only profit multinationals making them.	0	0	100
GM products benefit small-scale farmers.	100	0	0

DISCUSSION

The application of GMOs in increasing drought and insect resistance seems to be regarded most beneficial among all groups as it even gathered some support from organic farmers. One reason for this could be that traditional and alternative farming methods are very less effective in combatting this problem. There is a serious lack of information about GMOs as there has been 100% consensus for this statement among all groups (see appendix).

Most consumers are not clear about what exactly GM foods are. The survey was conducted among the educated urban middle class in Mumbai. So, it is expected that if a representative sample of the Indian population is surveyed, the awareness would fall further. One interesting observation is that though knowledge of Vaccines and GMOs were on the same level, there was considerably more support for vaccination. The main reason is that vaccination has shown tremendous health benefits in India (like in the case of Polio eradication) whereas GM technology is new and yet to showcase its success in India.

Intrinsic wrongness seems to be a predominate concern among all groups except in scientists, driven by teleological and intentional intuitions. This is one of the main contributing factors for consumers support for GM non-edible crops but not for edible crops. The effect of these intuitions is especially high among the organic farmers with close to half of the respondents holding the view that vaccination is not important. Another implication for this is the support of Bt-cotton farmers for GM cash crops like cotton but not for food crops. This might indicate that in the future if the government start field trials of GM food crops it might even face opposition from the farmers who are actually required for doing the field work. Psychological essentialism also seems to be very high among the farmers with a high percentage agreeing to statements like “GM foods may cause changes in body parts and organs”. Anti-GMO campaigns by NGOs in Maharashtra seems to be mainly driven by mainly two factors: GM technology might lead to a loss of biodiversity and that it has not benefitted small scale farmers as there was 100% per cent agreement for both the statement. Even among scientists there was an agreement to some degree that GM technology have not benefitted small scale farmers.

CONCLUSION AND RECOMMENDATIONS

1. Limitations of this study: The sample size used in this study is very small compared to the vastness of the Indian population. The main aim of this study is to provide insights to design a larger study. For instance, instead of conducting a common survey multiple groups should be identified for targeted policy interventions. Their concerns differ and hence the solutions for the concerns will also differ.
2. As the current government is proposing and planning to start field trials of many GM crops, it should appreciate the poor awareness about GM food and how it is produced among the public. It is crucial in the process of democratic policy ensuring that the population is informed. It is also beneficial in informing them otherwise they might be receiving incomplete and incorrect information from other sources.
3. It is shocking to see a large percentage of individuals in certain groups surveyed holding the view that vaccination is not important in spite of its large scale success. A larger national level survey needs to be done to determine the overall consensus and adequate information about the benefits of vaccination needs to be provided.
4. There needs to be a distinction made between GMOs and organic foods. GMOs can be produced without the use of pesticides and can be therefore as healthy as organic foods.
5. The government needs to win the confidence of the NGOs and take them along. The government need to assure

proper environmental checks and quality controls during field trials will be established. The governments also needs to re-check its policy of the current monopoly of private companies in releasing GM seeds in India and also establish a surveillance mechanism to ensure that inefficient Bt-seeds are not marketed by these companies to get higher profits.

6. Implications for human health: GMO technology has huge role in improving public health especially in the area of nutrition. The implications for human health can be very effectively understood with the example of the Golden rice, a beta-carotene bio fortified GMO crop that can be used to tackle Vitamin-A deficiency. The costs of opposition to Golden rice alone have been estimated at about $200m per year for the past decade. Moreover for 2001 alone, around 2 million preventable deaths have been estimated for Vitamin A deficiency [22].
7. Scientists and citizens should connect which is largely lacking in India. Scientists can play a huge role in raising the scientific temper thereby helping the public especially the farmers to overcome their teleological intuitions and conformational biases. Specifically, they need to address the issues of intrinsic wrongness, loss of biodiversity and food allergies. The arguments against food allergy and loss of biodiversity have already been discussed in the introduction. Scientists need to realize that the Indian consumers are largely driven by emotional and cultural factors and to tag their beliefs as unscientific and irrational may deem counterproductive. Instead they should take the positive approach and propagate the idea that nature has been moving DNA from one species to another for many years since life began. This movement has been the driving force of evolution.

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