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UNEP/GEF Supported Phase II Capacity Building Project on Biosafety

Resource Document on Socio-Economic Considerations (SECs) of Living Modified Organisms (LMOs)

Ministry of Environment, Forest and Climate Change
Government of India

in association with

RIS
Research and Information System for Developing Countries
विकासशील देशों की अनुसंधान एवं सूचना प्रणाली

and

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The Resource Document on Socio-Economic Considerations (SECs) of Living Modified Organisms (LMOs) is the outcome of the MoEF&CC sponsored project under UNEP/GEF Supported Phase II Capacity Building Project on Biosafety and is prepared by the following:

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पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय
Secretary
Government of India
Ministry of Environment, Forest and Climate Change

MESSAGE

India, as a signatory to the Cartagena Protocol on Biosafety (CPB), is committed to comply with its obligations. Article 26 of the CPB provides for an enabling provision to Parties to take into account Socio-Economic Considerations (SECs) arising from the impact of Living Modified Organisms (LMOs) on the conservation and sustainable use of biodiversity.

In this context, Research and Information Systems (RIS) was awarded a two-year research project on 'Developing Guidelines and Methodologies for Socio-Economic Assessment of LMOs' by the Ministry of Environment, Forest and Climate Change under the UNEP-GEF supported 'Phase-II Capacity Building Project on Biosafety'.

I am glad to state that the Resource Document on Socio-economic Considerations (SEC) of Living Modified Organisms has been prepared in collaboration with six agricultural research institutions from across the nation after an exhaustive field survey and with due diligence and sincerity.

This report will serve as a significant narrative in the discourse on the evolution of a frame work for the socio-economic assessment of Genetically Modified crops. It is hoped that this report will act as a key reference material for the policy makers, researchers and other stakeholders.

I would like to appreciate all those who were involved in preparing this report and steering the initiative.

(A. N. Jha)

Place: New Delhi
Dated: 7th June, 2017

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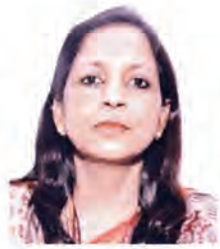

MESSAGE

I am pleased to introduce the Resource Document on Socio-economic Considerations (SEC) of Living Modified Organisms (LMOs) prepared by the Ministry of Environment, Forest and Climate Change in collaboration with the Research and Information System for Developing Countries (RIS) as part of the initiative under the UNEP-GEF supported "Phase II Capacity Building Project on Biosafety".

I am happy to note that RIS has partnered with six prominent agricultural research institutes in India namely Indian Agricultural Research Institute (IARI), Gujarat Institute of Development Research (GIDR), Institute of Social and Economic Change (ISEC), National Academy of Agricultural Research Management (NAARM), Tamil Nadu Agricultural University (TNAU) and University of Agricultural Sciences (UAS) to carry out an exhaustive field survey across six states viz. Haryana, Punjab, Gujarat, Tamil Nadu, Telangana and Karnataka while preparing this report.

This is an extremely important document as it relates to the sensitive issue of socio-economic impacts of GM crops. This report includes a validated model questionnaire for socio-economic assessment; guidelines, tools and methodologies for socio-economic assessment w.r.t both ex-ante and ex-post studies; guidelines and methodologies for cost-benefit analysis and a guidance document of framework for socio-economic assessment of LMOs. It aims to serve as a resource document for all those involved in the development, regulation and approval of GM crops.

I am confident that this report will help in addressing the important challenge of devising a framework for socio-economic assessment of LMOs in India and which eventually will contribute immensely in providing an Indian perspective on defining and conceptualizing any such framework at the global level.

I would like to congratulate all those who were involved in preparing this report and steering the initiative.

(Dr. Amita Prasad)

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CONTENTS

Executive Summary

Article 26.1 of the Cartagena Protocol on Biosfety (CPB) enables taking into account Socio-Economic Considerations (SEC) in decision making with respect to Living Modified Organisms (LMOs). The report of Ad hoc Technical Experts Group (AHTEG) on Risk Assessment and Risk Management identifies key elements for SEC. Many countries have provisions for SECs in their biotechnology/ biosafery regimes and there is much divergence in these provisions, as European countries prefer a comprehensive approach and most of the other countries have opted for an approach that is related to risk analysis or limit scope of SEC. Most studies on Bt cotton in India have indicated that there are significant economic and environmental benefits from them and in case of LMOs in the pipeline there can be economic and environmental gains but there are not many studies that have done a complete socio-economic impact assessment.

The Guidelines Framework is a starting point for socio-economic assessment and it captures the key issues, variables, indicators, methods and exceptions. It is based on an extensive literature review and enables designing questionnaire and conducting socio-economic assessment. There are many methodologies for assessing impacts and gains from LMOs and most of them relate to measuring economic gains/impacts while the assessment of environmental and health impacts is relatively underdeveloped. This report illustrates how a Cost-Benefit analysis can be done using primary data to assess economic and other impacts. The findings from risk perception, willingness to pay and attitudes towards LMOs reveal an ambivalent picture about stakeholders' perception, which is a mixture of faith, doubts, positive and negative feelings, indicating that stakeholders even when they are positive about technology have concerns, rely on media and have specific views on risks and benefits.

Data survey from the field work shows that majority of the farmers are small and medium farmers and most of them use the labour of their families in agriculture. Farmers need access to good quality and assured seed and are willing to pay more for LMOs in future. The dependence and reliance on private seed providers is uniformly high and the private seed providers are the primary source of information on seeds. Farmers tend to use agrochemicals including pesticides beyond the recommended limits and are concerned about effectiveness of solutions to control pests. Despite being aware, they normally do not practice safety guidelines in handling chemicals and pesticides.

The project's findings indicate that socio-economic considerations can be used for decision making regarding LMOs. There are different types methods for of assessing the socio-economic impacts and more work in this topic is suggested.

I Introduction

Ever since their introduction in the mid 1990s use of Living Modified Organisms (LMOs) in agriculture has been on increase and more countries are cultivating GM crops now than ever before. In India, the area under Bt cotton has grown by leaps and bounds since the approval for commercial cultivation was given in 2002. Despite controversies over seed pricing, it has been the choice of cotton growers across India. Obviously the impacts of Bt cotton have been studied extensively.[1]

By now there is substantial literature on the impacts of LMOs in agriculture, including meta analysis and reviews of studies on environmental, health and safety aspects of LMOs.[2] The socio-economic (SE) impacts of LMOs have received attention in the literature but most studies focus on economic gains, changes in productivity and economic surplus for growers and consumers. At the national level, biosafety regulations and biotechnology regulations govern the research, development and testing and adoption of LMOs, based on different approaches such as substantial equivalence, precautionary principle and case by case approach. [3]

At the global level the Cartagena Protocol on Biosafety(CPB) is the most important international protocol dealing with LMOs[4]. Article 26.1 of the Cartagena Protocol on Biosafety (CPB) states: "The Parties, in reaching a decision on import under this Protocol or under its domestic measures implementing the Protocol, may take into account, consistent with their international obligations, socio-economic considerations arising from the impact of living modified organisms on the conservation and sustainable use of biological diversity, especially with regard to the value of biological diversity to indigenous and local communities."

But in giving effect to this article, which is not a mandatory article, there has been much divergence among countries while the fundamental issue of identifying elements for socio-economic considerations is a hotly debated topic in fora and meetings organised by CPB. [5]

Article 26.2 states "The Parties are encouraged to cooperate on research and information exchange on any socio-economic impacts of living modified organisms, especially on indigenous and local communities."

Technology Assessment (TA) is a standard practice undertaken by many governments to get a better understanding of overall effects of a technology. TA can be a broad exercise or a narrow one. Assessment of socio-economic and environmental impacts can help in identifying the potential negative impacts and long term consequences. Addressing Ethical, Legal and Social Implications (ELSI) is another method to assess the impacts and implications of new developments in science and technologies, particularly that of emerging technologies. However, socio-economic considerations or socio-economic assessment differs from TA and ELSI although there are overlaps. One key difference in socio-economic assessment in the context of CPB is the importance given to assessing the impacts on biodiversity and traditional communities. The purpose of including socio-economic considerations or undertaking socio-economic assessment under CPB is to aid decision making. In case of LMOs these are done often in addition to risk assessment. Risk assessment is a scientific process where as socio-economic assessment goes beyond assessing the economic benefits and costs of a LMO. Risk assessment is undertaken at different stages, while socio-economic assessment is undertaken either during the decision making or in regulatory process and/or continues after the decision to permit the adoption of LMO is taken.

Over the years UN agencies such as FAO and UNEP have helped countries to build regulatory regimes in biosafety and this has been done through, in most cases, by capacity building programmes. As most countries have ratified CPB, implementing the provisions of CPB has emerged as an important issue in biosafety and biotechnology regulation. India was a strong supporter for establishing CPB and had ratified CPB. In India, the Ministry of Environment, Forests and Climate Change (MoEFCC) is the nodal ministry for looking into issues relating to Convention of Biological Biodiversity (CBD) and CPB and is also an important player in biotechnology regulation as Review Committee on Genetic Manipulation (RCGM) and Genetic Engineering Approval Committee (GEAC) function under the auspices of MoEFCC. Hence, it is not surprising that MoEFCC is playing an important role in supporting capacity building in biosafety in a major way. MoEFCC is deeply involved in the CPB process and India has contributed significantly in enhancing the relevance and role of CPB. As a part of its mandate the MOEFCC is deeply involved in implementing Article 26.1 and in the global discussions on Article 26.1.

The Ministry of Environment, Forests and Climate Change (MoEFCC) under the Biosafety Capacity Building Project, Phase II decided to commission a research project on Socio-Economic Considerations under Article 26.1 of CPB with specific mandates on developing methodologies for Socio-Economic Assessment, Methodology for Cost-Benefit Analysis and Guidance Document.

RIS was identified as the co-ordinating agency for this research project. With the help of MOEFCC and external experts six institutions were identified as partner institutions for this project. They were

- Gujarat Institute of Development Research (GIDR), Gandhinagar, Gujarat
- Indian Agricultural Research Institute (IARI), New Delhi
- National Academy of Agricultural Research Management (NAARM), Hyderabad
- Institute for Social and Economic Change (ISEC), Bangalore
- Tamil Nadu Agricultural University (TNAU), Coimbatore, and,
- University of Agricultural Sciences (UAS), Raichur, Karnataka

Of these IARI and NAARM are research institutes under Indian Council for Agricultural Research (ICAR) while GIDR and ISEC are research centers recognised and supported by Indian Council for Social Science Research (ICSSR) and TNAU and UAS are state agricultural universities which are also recognised and supported by ICAR. The experts consulted were from *inter alia*, Department of Biotechnology, University of Hyderabad, ICAR, Institute of Economic Growth, Center for Development Studies (Thiruvananthapuram) and ISEC. They were policymakers/regulators, social scientists, agronomists and agricultural economists.

RIS is an autonomous policy research think tank under Ministry of External Affairs (MEA), Government of India and has been conducting research on CBD, CPB, and, biotechnology regulation for more than two decades. It has been working closely with Secretariat of CBD/CPB, MoEFCC and Department of Biotechnology (DBT), Government of India on Socio-Economic Assessment of LMOs. Faculty at RIS have participated in Conference of Parties/Meeting of Parties of CBD/CPB, contributed to workshops organised by CBD and MoEFCC besides taking part in online discussions organised by CBD Secretariat. The research output from RIS in this issue includes journal articles, inputs to CBD Secretariat and Policy Briefs and a special issue of its journal the Asian Biotechnology and Development Review (ABDR).[6]

The project envisaged that RIS in consultation with the institutes and other experts will develop a guidance document, a model questionnaire and final deliverables would include methodologies for SE assessment and methodology for Cost-Benefit Analysis. The questionnaires were to developed in consultation with experts and institutions and were to be tested first in the field. They were to be revised and used for collecting data based on the questionnaire. The draft questionnaire was developed after extensive discussions with experts and institutions. It was tested in the field and based on the response from stakeholders, it was revised. The revised questionnaire was used by all institutions for data collection. Minor modifications were done to make it more appropriate for the regions/ locations where data was collected. It was also translated into regional languages by the institutions for use in the field. Each institution had identified two crops and two traits and accordingly the information was collected. The traits and crops were chosen from the list provided by MoEFCC. The idea was to collect data on experience with and perceptions about Bt cotton by some institutions which would also collect data on a LMO with a specific trait. Thus the data collection covered farmers experiences with Bt cotton, aerobic rice, and, non LMO crops. Information about their expectations and willingness to pay for future LMOs with specific traits was collected through the questionnaire.

The crops and traits were chosen after examining the list of crops, traits as indicated in the pipeline survey. The Principal Investigators in the institutions chose the most relevant crops and traits, in consultation with their colleagues, taking into account the crops cultivated in the respective states/area to be covered by field work, and relevant socio-economic factors. Although there have been many studies on Bt cotton it was decided to include it as the experience of the farmers on cultivating Bt cotton and their perceptions on Bt cotton are very important for a study on SE assessment of LMOs. As the project was restricted to LMOs with single traits, stacking of genes and combining traits in a LMO was not considered. Moreover from the pipeline survey, traits that are likely to be commercialised earlier or have undergone/undergoing field trials have been given preference for assessing their Socio-Economic impacts. We are well aware of recent developments in technology, including gene editing and novel plant breeding technologies and the ongoing debate on their impacts and the regulatory issues. But given the limited mandate of this project we decided not to take them in to account in developing questionnaire, data collection and review of literature for SE assessment.

They are in nascent stages and given the constraints such as limited time and limited resources it would have made little sense to consider them along with traits and crops indicated in the pipeline survey.

Certainly, there is a need to consider them in the projects to be undertaken in the future. Taking into account we have made some observations in the conclusions and recommendations.

After collecting data and checking it for completeness, it was collated. Data analysis was done by the institutions using different methods (as explained in the reports). The institutions presented their draft findings in the workshop held on 28 April 2016. Based on the responses from invited experts and RIS team, the institutions prepared revised versions and they were submitted by second week of May 2016 and finally presented on 26 May 2016 at a workshop held at RIS.

The project reports from the six partners institutions provide many important findings on cost of cultivation, the impacts of LMO on health and environment, the perception of stakeholders on LMOs, the expectations of the farmers from LMOs and on conducting socio-economic assessment on LMOs. The reports combine data analysis with conclusions and recommendations.

We envisaged that this report from RIS should be comprehensive and be useful as a tool for policymakers and regulators. Hence it has been structured to include the key deliverables and also provide background analysis on socio-economic assessment.

This introductory chapter is followed by a chapter (Chapter 2) describing the evolution of CPB and the debates over Article 26.1 within CPB and elsewhere. It traces the discussions over SE assessment since the signing of CPB to most recent outcomes. It points out that the two dominant trends are in opposite directions, with one using SE assessment selectively and without giving it much importance in regulation while the other, mostly found in Europe, takes a comprehensive approach towards SE assessment, linking that with biodiversity conservation and sustainable development. The next chapter (Chapter 3) provides a review of literature of India's experience with LMOs in agriculture and highlights the findings from studies and informs us of the various methods used in the research to assess impacts of LMOs.

Guidelines framework is an important tool in SE assessment. Chapter 4 provides Guidelines Framework. The next chapter (Chapter 5) analyses in detail the methodological issues in SE assessment explaining the different methods used in assessing impacts, the key aspects in SE assessment and the important elements that should be considered in SE assessment. Linking the issues in SE assessment with findings from Chapter 2 and Chapter 3, it elaborates the dimensions in SE assessment.

Given the importance of understanding the Costs and Benefits of cultivating LMOs, this report illustrates a methodology for conducting Cost-Benefit Analysis, for assessing economic costs and benefits by analysing the data collected by the partner institutions.

The questionnaire is flexible enough to be used for different crops, different traits and in different contexts, with suitable modifications.

We have provided conclusions from the research project and recommendations for further work in this topic as this project is another step in bringing more clarity on giving effect to Article 26.1, Article 26.2 in a systematic manner so that decision making process can benefit from SE Assessment. Finally, although this project has been done in India, and, by institutions in India, the findings and the outcomes including the methodologies will be relevant for other countries also besides contributing to the global debate on Article 26.1.

To sum up, this report is an outcome of a research project that has combined quantitative analysis with qualitative information, taking into account, the relevant developments at the global, regional and national levels and the challenges in SE assessment. The significant outcomes are the findings from data collected by six institutions, and, the outputs (a questionnaire, a Guidance Framework, methodologies for SE assessment and example for Cost – Benefit Analysis). The outputs can form the core of SE assessment of LMOs.

Endnotes

1. See Chapter 5 for details.
2. See for example NAS (2016).
3. See Howlett and Laycock (2012).
4. See Chapter 3 for an analysis of CPB.
5. See Chapters 3 and 4 for details.
6. See www.ris.org.in for details.

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II The Cartagena Protocol on Biosafety and Socio-Economic Assessment of LMOs

2.1 The Origins of the Cartagena Protocol on Biosafety

The Cartagena Protocol on Biosafety (CPB) is a protocol negotiated, signed and ratified under the Convention on Biological Diversity (CBD). Although it is a protocol on biosafety, its objectives and mandates are closely linked to the impacts of products of biotechnology on environment, particularly on biodiversity than on the broad objectives of CBD. In the texts of CPB and CBD, the term Living Modified Organisms (LMOs) is used. In literature, it is used as a synonym for Genetically Modified Organisms (GMOs). Although for all practice purposes they are considered as equivalents, CPB in Article 3, defines a LMO as "g) 'Living modified organism' means any living organism that possesses a novel combination of genetic material obtained through the use of modern biotechnology; h) 'Living organism' means any biological entity capable of transferring or replicating genetic material, including sterile organisms, viruses and viroids; i) 'Modern biotechnology' means the application of: a. In vitro nucleic acid techniques, including recombinant deoxyribonucleic acid (DNA) and direct injection of nucleic acid into cells or organelles, or b. Fusion of cells beyond the taxonomic family, that overcome natural physiological reproductive or recombination barriers and that are not techniques used in traditional breeding and selection."

The difference is that GMO could mean any Genetically Modified Organisms, alive or dead while CPB is applicable only for LMOs. GM mosquitoes thus will be covered by the definition of LMO given in CPB. Although the scope of Article 26.1 covers all LMOs this report takes into account only LMOs used in agriculture and SE considerations related to them.

With developments like gene editing and whole genome sequencing, the questioning of (re) defining LMO/GMO for regulatory purposes becomes all the important.[1] Hence in future the distinction between GMO/ LMO and non-GMO/LMO may be different from what is perceived today. It is also likely that new terminologies may be developed to classify products developed using gene editing technologies.

The roots of CPB are in CBD. Article 19.4 of the CBD provides for Parties to "consider the need for and modalities of a protocol, including advance informed agreement (AIA), in particular, to ensure the safe transfer, handling and use of living modified organisms derived from modern biotechnology that may have an adverse effect on biological diversity and its components."

To give effect to this, the Conference of Parties (COP) to CBD held during 28 November to 9 December 1994 established an Open-ended Ad Hoc Group of Experts on Biosafety. This Group met in July 1995 and deliberated and favoured establishing an international framework on biosafety under CBD. This proposal was further discussed in the Second COP held in Jakarta in July 1995 and an Open-ended Ad Hoc Working Group on Biosafety (BSWG) was formed to "elaborate, as a priority, the modalities and elements of a protocol". The negotiations and deliberations held during the next five years resulted in Parties agreeing to adopt CPB in the COP held at Montreal in January 2000.[2] The negotiations over CPB were struck in differences between developing countries and developed countries on many issues but finally the CPB text was adopted.

CPB is the first international Protocol that comprehensively deals with biosafety aspects of Living Modified Organisms that are traded and could impact biodiversity. It also covers many aspects related to risk assessment, handling of LMOs, including advanced information and prior informed consent, and liability and redress. The negotiations over the drafting and acceptance of the Protocol indicated that developing countries were concerned about the potential adverse impacts of LMOs and wanted to ensure that they did not become dumping grounds for LMOs that are unwanted and/or harmful.

2.2 Article 26.1: Scope and Objectives

Literature on the negotiations over CPB points out that Article 26.1 was accepted after much debates over the inclusion of an article on socio-economic considerations in the Protocol. The developing nations wanted to ensure that socio-economic considerations were incorporated as a basis for decision making but developed nations argued that such considerations could not be quantified easily and hence should be left out of the Protocol. Finally, it was agreed that socio-economic considerations could be incorporated in the text of CPB provided they were added with a rider that their application was consistent with existing international obligations, specifically the obligations under trade agreements. This compromise is reflected in the Article 26.1. Moreover the article does not specify what exactly these considerations are, nor it identifies any international agreement as an example or model for them. Further, it does not specify any mechanism to identify them and operationalise such considerations in decision making.

Article 26.1 of the Protocol states:

"The Parties, in reaching a decision on import under this Protocol or under its domestic measures implementing the Protocol, may take into account, consistent with their international obligations, socio-economic considerations arising from the impact of living modified organisms on the conservation and sustainable use of biological diversity, especially with regard to the value of biological diversity to indigenous and local communities."

Article 26.2 of the Protocol states:

"The Parties are encouraged to cooperate on research and information exchange on any socio-economic impacts of living modified organisms, especially on indigenous and local communities."

According the Mackenzie, *et al.* (2003) "there must, first, be an "impact … on the conservation and sustainable use of biological diversity" as a result of or "arising from" the transboundary movement, handling, and use of the LMO concerned. The "impact" referred to may include the potential effects of the LMO on biological diversity. Hence, where the introduction of LMOs under the Protocol affects biological diversity in such a way that social or economic conditions are or may be affected, a Party can use Article 26 to justify taking such impacts on its social or economic conditions into account for purposes of making decisions on imports of LMOs or in implementing domestic measures under the Protocol. Such social or economic impacts are generally referred to as secondary or higher order effects in technology assessment literature."

It is important to understand that the CPB did not include socio-economic considerations for their own sake but within the broad objectives of CPB and CBD. Thus, socio-economic considerations should not be used as a catch-all phrase or as an instrument to be used in any decision making with respect to LMOs. To understand its scope and applications relevant articles of CBD such as Article 8 should be taken into account. In this regard the IUCN Guide states

"Possible ways of taking socio-economic considerations "into account", especially with respect to indigenous and local communities, may include, for example:

- procedures for assessing and addressing socio-economic impacts in risk assessment and management; and/or
- subjecting decisions on import of LMOs to prior public consultation processes, especially with respect to communities that will be directly affected by the import decision – for example the local community in which the LMO is destined for field trial or use, or which may be affected by any potential adverse impacts of the LMO on biodiversity" (Mackenzie, *et al.* 2003: 165).

Given the broad nature of socio-economic impacts, it is better to integrate them as part of approval/regulatory mechanism than as part of risk assessment/management. Moreover as such impacts can persists during the lifecycle of LMO, post-approval and post-marketing studies on socio-economic impacts are desirable. Hence, it is better to include them in post-approval and post-marketing assessment processes for LMOs. The prior public consultations on import of LMOs can also be part of approval/regulatory regime which can call for response/input from public, prior to decision making, but after, completing the field trials. The risk here is that the public consultation process may be maneuvered by some stakeholders and they may overwhelmingly influence the decision making process in the name of public interest. Stakeholders who support/oppose import of LMOs may do so in different pretexts. Hence, it is important that the public consultation process does not become yet another forum for endless debates. The process can be structured in such a way that no stakeholder is able to influence the process or the outcome.

Since any implementation of Article 26.1 has to be consistent with obligations under other agreements, particularly trade agreements, these two points thus circumscribe the application of Article 26.1. On the other hand Ludlow, Smyth and Falck-Zepeda (2015) argue that Article 26.1 has a specific focus and an impact indicator, i.e. impact of LMOs on conservation and sustainable use of biological diversity and value of biological diversity to indigenous and local communities. Such a narrow interpretation limits the scope of Article 26.1 and a reading of the negotiations over the drafting and finalisation of text of CPB would indicate that many Parties who were keen to include socio-economic considerations envisaged a broader interpretation for socio-economic considerations.

At the risk of over simplification we can state that there are two major approaches in taking into account socio-economic considerations. The first one is a narrow approach that often supplements the risk analysis and in this socio-economic considerations are narrowly defined or only few issues are examined in socio-economic impact assessment. The approach in Argentina is an example for this and in some cases as in USA such an impact assessment is either not mandated or is undertaken in a limited way just to meet regulatory norms.

The second approach takes into account the broader perspective and in this socio-economic considerations are linked more with environmental impacts and sustainable development than with economic gains. This approach is exemplified in the Norwegian Gene Act but is also used in many European countries. Commentators have stressed the sustainable development dimension in CPB, particularly Article 26.1.[3] These are favoured by NGOs, academics and government agencies in Europe.

2.3 Article 26.1, Article 26.2 of CPB and Compatibility with other Treaties/Agreements

The rider in the Article on meeting obligations under other international agreements and treaties ensures that socio-economic considerations cannot be used as a ground for not meeting such obligations and measures taken when such considerations are taken into decision making cannot override such obligations. 170 Countries are Parties to CPB as they have ratified it.[4] But USA and Canada have not ratified this and Canada is a Party to CBD while USA is not a party to CBD and CPB. For countries that are Parties to CPB and other international treaties/agreements the challenge is in implementing Article 26.1 taking into account this rider.

Socio-economic considerations can at the best be, a trigger in decision making and they themselves have nothing to do with obligations under other treaties. So whether the decisions taken or the resulting action would be in violation of other obligations is the real issue. Since the concept of socio-economic considerations is not well-defined one approach to understand the compatibility issue has been discussed by Ludlow, Smyth and Falck-Zepeda in their presentation made in 2015 (Ludlow, Smyth and Falck-Zepeda 2015). Taking into account the five dimensions of socio-economic considerations, i.e. economic, human health related, social, ecological, and cultural/traditional/ethical/religious, they have developed a matrix to map international obligations under the relevant agreements and Socio-economic considerations. For example, they have considered food security as a component of social dimension and identified the issues in defining the relevant SECs such as whether LMOs improve food security vs. LMOs undermine food security. On the basis of their analysis they have concluded that each nation should determine its international obligations landscape in giving effect to SECs. They point out that as different decision makers may be involved, they being under different regimes, there can be inconsistency in decisions on similar issues.

This approach has some merits, but the main problem is that not all agreements and not all obligations under international agreements/treatments can be considered as equals because many covenants are inspirational and countries have the right to agree to some international covenants with reservations. With respect to indigenous communities, ILO Convention 169 is the most relevant convention in terms of socio-economic considerations. Hence, in understanding the socio-economic considerations with respect to indigenous communities the relevant provisions of ILO Convention 169 and relevant articles in CBD, Nagoya Protocol on Access and Benefit Sharing should be taken into account.

2.4 Developments in the CPB Process on Article 26.1 and Article 26.2

Identifying the relevant SECs for interpreting and implementing Article 26.1 is obviously important. In this process the COP-MOPs were often used as fora to debate the relevant SECs and their role in giving effect to Article 26.1. Given the lack of consensus on what are the

SECs and the North-South divide on importance of SECs in CPB, debate has taken place in COP-MOPs and elsewhere on this. NGOs like Third World Network, organisations representing many European Governments had come out with publications promoting a broad approach to SECs stressing the risks to environment and biodiversity, the potential adverse impacts on food security and small and medium farmers and arguing for a comprehensive framework in SEC and SE assessment. For example, the Netherland's Commission on Genetic Modification (COGEM) in the report published in 2014 identified benefit to society, economics and prosperity and cultural heritage as three major criteria for identification of SECs.[5] Given the issues of co-existence between GMO plants and non-GMO plants and consumer choice and labeling being hotly debated in Europe, they also found a place in reports on SEC from European agencies. Industry groups and International Food Policy Research Institute (IFPRI) on the other hand argued for an interpretation that limited the scope of SEC and its application in decision making.[6] Their argument is that SECs should not stretched to mean anything and everything in the name of comprehensive framework and the text of Article 26.1 has limited SECs to few specific issues and hence only they should form the basis for SEC in decision making. As discussed in the Chapter on International Experience in implementing Article 26.1, countries have gone beyond these two extreme views and have given effect to Article 26.1 in many ways. Another interesting aspect is that while in the negotiations there was a clear North South divide, in implementing Article 26 the picture is more complex with countries implementing Article 26.1 to suit their national needs and regulatory frameworks.

In the COP held in 2008 it was decided that technical guidance was necessary and information on national experience should be collected. Hence a survey was organised and the results were published as a document.[7]

In the COP-MOP held at Hyderabad in 2012 the results of the survey were discussed. According to the survey, the five most important SECs are food security, health related impacts, co-existence of GMOs (and non-GMOs), impacts on market access and compliance with biosafety measures. The following were also identified as important SECs:

- Impacts on conservation and sustainable use of biodiversity;
- Economic impacts of changes in pest prevalence;
- Macroeconomic impacts;
- Farmers' rights;
- Intellectual Property;
- Consumer choice; and,
- (impact on) Indigenous and local communities.

The Parties decided to establish an Ad hoc Technical Experts Group (AHTEG).[8] In 2014, the AHTEG presented a report to COP-MOP on Socio-Economic Considerations.[9] The Group in the report listed ten general principles, identified the methodological considerations with scope, methodological approaches and factors affecting methodological approaches. It also observed the following:

Points to consider

1) Any list of elements of socio-economic considerations would be indicative and non-exhaustive.
2) Listing elements of socio-economic considerations based on existing experiences and as contained in the document that summarised the online discussions would contribute to the future development of guidelines on socio-economic considerations.
3) Elements of socio-economic considerations may be classified using the dimensions below.

4) Elements of socio-economic considerations could fall into more than one dimension.

5) Human health-related and ecological dimensions that are not addressed in risk assessment may be addressed when taking socio-economic considerations into account.

Dimensions:

(a) Economic: e.g. impact on income;

(b) Social: e.g. impact on food security;

(c) Ecological: e.g. impact on ecosystem functions;

(d) Cultural/traditional/religious/ethical: e.g. impact on seed saving and exchange practices;

(e) Human health-related: e.g. impact on nutritional status.

This approach by the Group is a sensible approach as it eschews a too broad perspective, nor advocates a too narrow perspective. Further it has emphasised the key dimensions in SECs while acknowledging that any list of such elements would be indicate and non-exhaustive. It recognises the need for future development of guidelines in SECs. The final report should hence be considered as an important step in bringing conceptual clarity in SECs. As more countries give effect to Article 26.1 and with countries revising their regulatory regimes, there could be more debate on implementing Article 26.1.

However, it should be pointed out that there is no consensus on the AHTEG Report. That lack of consensus is not surprising. The COP-MOP took note of the Report in the seventh meeting held in 2014 in Korea. By decision BS-VII/13, the Parties extended the AHTEG and determined that it should continue its future work in a step wise approach on : "At its seventh meeting, the COP-MOP took note of the report of the Ad Hoc Technical Expert Group on Socio-economic Considerations (AHTEG). In decision BS-VII/13, Parties extended the AHTEG and determined that it should work, in a stepwise approach, on: (i)

Table 2.1: Countries having SECs-related Legislations/Framework in Place

Africa	Americas and Caribbean	Asia-Pacific and Oceania	Europe
Burkina Faso	Argentina	Australia	Austria
Cameroon	Belize	Indonesia	France
Ethiopia	Brazil	Malaysia	Italy
Ghana	Canada	New Zealand	Latvia
Kenya	Colombia	Philippines	Norway
Madagascar	Costa Rica	Republic of Korea	
Mali	Cuba		
Mauritius	Honduras		
Namibia	Mexico		
Nigeria	Panama		
Senegal	Peru		
South Africa	Saint Kitts and Nevis		
Tanzania	Uruguay		
Togo	Venezuela		
Zambia			
Zimbabwe			

Source: Compiled by authors based on various sources viz. UNEP CBD BCH documents, Chaturvedi et al (2011), Chaturvedi *et al.* (2012), Spok (2010), Zepeda *et al*. (2010), Benimelis and Myhr (2016).

the further development of conceptual clarity on socio-economic considerations arising from the impact of living modified organisms on the conservation and sustainable use of biological diversity, and (ii) developing an outline for guidance with a view to making progress towards achieving operational objective 1.7 of the Strategic Plan and its outcomes."

In view of this, it can be expected that AHTEG's work will be along these lines. The forthcoming COP-MOP may give further directions on the work on SE considerations. Thus despite consensus the work relating to interpreting and implementing Article 26.1 will continue within CBD and elsewhere. In fact this document itself is a contribution to that.

Article 26.2 states "The Parties are encouraged to cooperate on research and information exchange on any socio-economic impacts of living modified organisms, especially on indigenous and local communities."

The CPB Secretariat is engaged in promoting sharing of research and information on SE impacts of LMOs. The Biosafety Clearing House (BCH) enables parties and others to share research and information. CPB Secretariat also organises workshops on this topic. In addition under different capacity building programmes, such activities are promoted. In India, MoEFCC being the national focal point, has been organising programmes on biosafety, risk assessment and safe handling of LMOs, for participants from different countries in Asia-Pacific.

Table 2.2: SECs Taken into Account in Biosafety Decision-Making

Social dimension • Social acceptability • Social utility • Changes in land use • Changes in communities' rights • Distribution of benefits with future generations • Equity issues • Food sovereignty • Food security • Gender impacts • IPRs and patents • Livelihood of communities • Sustainable development	**Economic dimension** • Access and cost for GM technology • Changes in agricultural production systems • Changes in agricultural productivity • Changes in small and marginal farmers income • Change in export trends • Change in economic value of traditional varieties • Change in industrialisation trends • Change in traditional markets • Crop loss • Employment loss/gain • Impact on small business development • Impact on organic agriculture
Cultural/ethical/religious dimension • Cultural aspects and practices • Erosion of indigenous technology and knowledge • Ethical and moral concerns • Impact on traditional crops and products • Religious concerns • Traceability and labeling issue	**Ecological-related dimension** • Loss of genetic diversity • Agro-diversity loss • Farmers' varieties loss • Development of weed resistance • Changes in energy use patterns • Changes in herbicide use • Changes in insecticide use • Greenhouse gas emission • Soil contamination/erosion • Impact on environment
Health dimension • Food safety • Nutritional needs • Public health impact	

Source: Chaturvedi *et al.* (2012), Binimelis and Myhr (2016).

2.5 SEC Related Laws/Regulations at National Level

Of the total of 41 countries, which already have established legal/institutional frameworks in place for incorporating SECs into decision making process, 16 countries are from Africa followed by 14 American and Caribbean countries; 6 Asia-Pacific and Oceania countries and 5 European countries (Table 2.1).

The analysis of existing legal and institutional frameworks incorporating SECs in the countries has revealed that within the dimensions enumerated by the AHTEG-SEC, the following socio-economic issues have taken into account within the legal or institutional frameworks of the countries (Table 2.2).

2.6 Approaches towards incorporating SECs into Biosafety Decision-Making

When it comes to the matter of extent to which the SECs have been taken into decision-making procedure, it is found that there are two sets of countries existing today. First set of countries are those who have taken a very broad stand while defining elements of SECs; while the second set of countries are those which have taken a rather limited narrow stand.

Countries such as Norway, Ethiopia, Mali, Nigeria, Senegal, Togo Tanzania, Zambia, Cameroon, and Malaysia fall into the first set of countries which have very detailed guidelines regarding incorporating SECs. On the other hand, in the second set, countries such as Argentina, Mexico, Zimbabwe, New Zealand, Australia and Canada have a limited or narrow take on SECs.

Norway is a classic case of having a very comprehensive definition of SECs for incorporation into decision-making process. The Norwegian Gene Technology Act 1993 regulates the production and use of LMOs in Norway. It has provisions for ensuring that the production and use of LMOs take place in an ethical and socially justifiable way, in harmony with the principle of sustainable development and without detrimental effects on health and the environment. Many African countries also have a very comprehensive SECs-related provisions embedded in the decision-making process. In Ethiopia, there is a constitutional provision that require that health, environmental well-being and the general socio-economic conditions of the country be protected from risks that may arise from modified organisms.

There are regional frameworks also for the incorporation of socio-economic considerations in the decision making. European Union (EU) has the most advanced regional framework for the socio- economic analysis. The EC Directive 90/220/EEC provides for an approval process and labeling and packing requirements for all GM food, which aims to avoid the adverse effects on human health and the environment that could result from a release of LMOs into the environment or food chain. Like the EU, the African Union and the Andean Community also provide regional approaches for the socio-economic analysis. Article 1 of the African Model Law on Biosafety clearly states that the objective of this model law is to contribute to ensuring an adequate level of safety for the protection of biological diversity, human and animal health, socio-economic conditions and ethical values in the making, safe transfer, handling and use of genetically modified organisms and products of genetically modified organisms resulting from modern biotechnology. It defines socio-economic conditions as 'the economic, social or cultural conditions, livelihoods, knowledge, innovations, practices and technologies of indigenous and local communities including the national economy.' The New Partnership for Africa's Development (NEPAD) has initiated the African Biosafety Network of Expertise (ABNE) through its African Biosciences Initiative in Africa. The main objective of ABNE is the provision of biosafety resources for African regulators in decision making on safe use, deployment and management of biotech products that are locally developed, imported and adopted in Africa.[10]

The Andean Community's (composed of five countries, namely Bolivia, Colombia, Ecuador, Peru and Venezuela) Regional Biosafety Strategy adopted in 2002 does not displace or substitute existing laws. However, the Regional Strategy may develop and propose resolutions to the Andean Council of Foreign Ministers and Andean Community Commission for approval.[11] The importance of the Regional Biosafety Strategy is that it does consider socio-economic considerations that may be adopted by member countries that are developing their own laws and regulations but does not provide any guidance on implementation.[12]

Conclusion

Article 26.1 enables taking socio-economic considerations into decision making. It has been interpreted and implemented in many ways. Efforts by Conference of Parties and CBD Secretariat have enabled a better and shared understanding of Article 26.1 while activities under Article 26.2 are promoted by CBD Secretariat and different countries including India.

Endnotes

1. See Greenpeace (2015).
2. See http://www.biosafetyprotocol.be/history.html for an overview.
3. Segger, Perron-Welch, Frison (eds) (2013).
4. https://www.cbd.int/doc/lists/cpb-ratifications.pdf
5. COGEM (2014).
6. E.g. https://croplife.org/wp-content/uploads/pdf_files/Socio-economic-Considerations-in-Decision-making-on-LMOs-MOP-6.pdf
7. See p125 of Ludlow (2015) for details.
8. http://bch.cbd.int/onlineconferences/portal_art26/se_main.shtml
9. https://www.cbd.int
10. See also Summary of OnLine discussions held in 2013 in https://www.cbd.int
11. Chaturvedi *et al.* (2011).
12. ibid.

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III Literature Review of Studies on Socio-Economic Assessment of GM Crops in India

3.1 Introduction

There have been many studies, related to socio-economic assessment of GM crops in India, conducted over a period of time. However, most of these studies have been *ex-post* in nature for Bt Cotton, which is the only crop approved for commercialisation in India since 2002. *Ex-ante* studies on crops yet to be approved for commercialisation have been very limited.

3.2 Meta Analysis Of The Studies

Meta analysis of these studies show that majority of these studies have been undertaken the economic impact of LMOs. The parameters selected for the study focussed on yield gain, productivity increase, net profit gain, reduction in insecticide use and labour use.

There are several important points that have emerged from these studies. The first and foremost is that the benefits are contingent on the agronomic environment, biotic and abiotic stresses, farming practices and socio-economic milieu of the producing communities.

Most of the studies on Bt Cotton (Table 3.1) estimated that there were higher gross margins per hectare on Bt plots, varying spatially among sub-regions and states. This can be due to higher yield, lower input cost or savings on insecticides and labour, etc. Few studies also concluded that in some areas the farmers did not benefit at all from the introduction of Bt seeds. Still further, few studies also criticised the results of pro-Bt studies by claiming that more reliable date from trials conducted by public state university showed that yields were higher for non-Bt germplasm than for the Bt hybrids.

Various reviews meta-analyses of the performance of GM crops worldwide (including India) done by Raney (2006), Qaim (2009), Tripp (2009), Smale *et al.* (2009), Finger *et al*. (2011), Areal *et al.* (2013), Klümper and Qaim (2014), Racovita *et al.* (2014), Fisher *et al.* (2011) have shown that due to adoption of GM crops, there were reductions in yield damage by insects, reductions in insecticide applications for target insect pests, decreases in management time and increases in gross (in some cases net) margins.

However, it is important to address the issue of uncontrolled confounding variables, biases, and other methodological limitations that field researchers face in defining adoption and effects of GM crops (Smale *et al.* 2009).

Klümper and Qaim (2014) analysed findings of 147 studies of HR soybean, maize, and cotton and *Bt* maize and cotton in 19 countries. They found that profit increased by an average of 69 per cent for adopters of those crops, largely because of the increased yields (21.5 per cent) and decreased insecticide costs (39 per cent). Another meta-analysis of findings of studies of the same crops in 16 countries reported that production costs were greater for GM varieties than for non-GM varieties but that gross margins were higher on the average for the GM varieties, in large part because of their greater yields (Areal *et al.*, 2013).

Raney (2006) reviewed studies conducted in Argentina, China, India, Mexico, and South Africa and concluded that GM cotton, maize, and soybean provide economic gains to adopting farmers in these countries; however, the effect was highly variable and depended on national institutional capacity to help poorer farmers to gain access to suitable innovations.

Ex-ante studies on socio-economic impact of introducing the transgenic crops on the farmers have been done by various researchers in the following crops (see the Table 3.2):

- Insect resistant Bt Eggplant (Bt Brinjal)
- Drought and salt tolerant Rice
- Tobacco streak virus resistant Groundnut and Sunflower
- Late blight Disease resistant Potato

Most of these *ex-ante* studies have projected that the use of GM crops will result in net profits to the farmers at all levels. These will be due to higher yield, lower input cost or savings on insecticides and labour, etc. Though there are also a few studies which counter these claims and argue that the use of GM or LMO will not lead to any substantial benefits to farmers more so to the small and marginal farmers.

Table 3.1: *Ex-post* studies on Bt Cotton in India

Indian Study Done By	Criteria/Focus	Methodology
Ashok *et al.* (as mentioned in N. Lalitha and P.K. Vishwanathan Edited Book "India's Tryst with Bt Cotton", 2015)	Economic and Environmental Impact	Economic analysis and impact quotient
Haque *et al.* (2015)	Productivity	Cob-Douglas method
Ranganatahan and Gaurav (2013)	Yield (kg/ ha) Price (Rs/ quintal) Revenue (Rs/ ha)	Variance Decomposition Analysis
Kumar *et al*. (2011)	Yield gain (reduction in crop damage from FSB infestation) Reduction in application of insecticide use Benefits to Brinjal farmers (reduction in insecticide use, reduction in labour) Benefit to consumers (reduced price due to higher volume produced)	Multi-stage stratified random sampling

Mal, Manjunatha, Bauer, and Ahmed (2011)	Environmental impact (insecticide use) Yield (kg) Fertiliser used (kg) Labour used (days)	Data Envelopment Approach (Cobb Douglas production function)
Rao and Dev (2009)	% change in yields (pest infestation) Net income in Bt cotton vs non Bt (revenue- rental value of land, fertiliser, pesticide family labour, etc) (Rs/acre) Poverty Reduction (Employment Days)	Multi-stage stratified random sampling
Sadashivappa and Qaim (2009)	Total Cost (manure, fertiliser, labour, insecticide, irrigation) Revenue (Yield (kg/acre), output price(Rs/kg)) Profit (Revenue – cost)	Stratified Random Sampling Procedure
Krishna, Zilberman and Qaim (2009)	Yield (Quintal/acre) Cost (Manure, fertiliser, Labour, Insecticide, Irrigation) (Rs/ acre)	Tobit Model and Cobb Douglas production function
Kolady and Lesser (2008)	Yield (Quintals/Acre) Factors influencing yield (Fertiliser use Pesticides use Irrigation use Labour use)	Weibull Production Function
Peshin *et al.* (2007)	Input use (fertiliser use, seed, pesticide) {Kg/ha} Productivity (Insect pest losses caused by bollworm) {q/ha} Yield Pesticide cost (Rs/ha)	No Methodology given
Krishna and Qaim (2007)	Cost (Seed, insecticide, labour cost, harvesting cost) {Rs/acre} Yield (quintals/acre) Gross Revenue (Rs/acre) Gross Margin (Rs/acre)	Partial Equilibrium
Stephen, Bennett, and Ismael (2007)	Output (Yield Comparison (Quintals/acre) Total Cost (Seed use, Fertiliser use, insecticides for bollworm control, Irrigation use, Labour use) (Rs/acre) Gross Margin (Revenue - Total cost)	One way ANOVA table

Narayanamoorthy and Kalamkar (2006)	Total Cost (seed cost, insecticide, fertiliser, manure, labour, harvesting cost) {Kg/ Acre} Revenue (yield (Kg/ Acre), output price (Rs/kg)) Net Revenue (Revenue – Total Cost)	Linear Regression
Qaim, Subramanian, Naik and Zilberman (2006)	Cost of Production across social categories Impact on employment across social categories	Multi-stage random sampling procedure
Rao and Dev (2006)	Yield and pesticide use Cost and Returns Cotton Quality	Multi-stage stratified random sampling
Vasantha and Namboodari (2006)	Cost (Seed, insecticide, fertilisers, manure, labour, harvesting) Revenue (Yield, output price) Gross margin	Regression Analysis
Naik, Qaim, Subramanium, and Zilberman (2005)	Insecticide Savings (insecticide use) Reduction in losses due to pests Output (Production)	Multi Stage area random sampling.
Kambhampati, Morse, Bennett and Ismael (2005)	Cost of cultivation (labour, seed cost, fertiliser, pesticide, irrigation cost) Cotton yield (Kg/Ha)	No Methodology given
Jana (2005)	Expenditure (seed use, manure, inorganic fertiliser use, insecticide use, irrigation use, labour) (Rs/Acre) Yield (Kg/Acre)	Descriptive Statistics and Statistical Tests
Stephen, Bennett and Ismael (2005)	Total Cost (Seed use + insecticide use) [Rs/ Ha] Revenue (cotton yield + price of cotton) [tonnes/ ha + Rs/ tonne] Gross Margin (Revenue – Total Cost) [Rs/Ha]	General Linear Model Approach
Qayyum and Sakkhari (2005)	Yield	440 farms; No methodology given

Bennett, Kambhampati, Morse and Ismael (2006)	Pesticide use Pesticide cost Yield	No methodology given
Shiva and Jafri (2004)	Yield per acre Staple size Seed cost Income	Field study in Maharashtra, MP, AP and Karnataka
Qaim and Zilberman (2003)	Yield (quintal/ acre) Pesticide Use Investment in Bt and non Bt (Rs/acre)	157 farms; Cobb-Douglas Production Function
Sahai and Rahman (2003)	Yields	No methodology given
Arunachalam and Ravi (2003)		Quoting other studies; critical of methodology adopted by Qaim and Zilberman (2003) study
Naik (2001)		Domestic Resource Cost Coefficient

Source: Compiled by partner institutions.

Table 3.2: *Ex-Ante* Studies on GM Crops in India

Sl. No.	Study done by	Crop	Sample and Methodology	Findings
1	Ramasamy, Selvaraj, and Norton (2007)	Drought and salinity tolerant Rice	-Secondary Data: South Zone (TN, AP, Karnataka), North Zone (Punjab, Haryana, UP), East Zone (WB), West Zone (MP, Maharashtra) -Farm level Data: 150 rice farmers from TN and Chhattisgarh -Economic surplus method	-Yield gap w.r.t. experimental yield (Max. yield gap was noticed in UP with 3728 kg per hectare, which accounts for 56.5% of the experimental yield) -Adoption of drought and salinity resistant transgenic is projected to bring additional income to farmers, despite an increase in seed cost. -The cost of rice seed is projected to be about 15.5% higher than for the existing high yielding varieties and the level of use of other inputs should remain about the same. (Labour, Fertiliser, Pesticide) -Yield of rice would be 25% higher as compared to existing varieties under stress conditions. -Farmers would incur Rs. 7997 per hectare in cost of cultivation, while the total return would be Rs. 26114 per hectare

2	Selvaraj, Ramasamy and Norton (2007)	Tobacco streak virus resistant in Groundnut and Sunflower	-Interview with survey questionnaire of 80 groundnut and 30 sunflower growers and 16 scientists from AP, Karnataka and Gujarat -Economic surplus method and cost benefit analysis	-Adoption of transgenic TSR resistant groundnut would bring 90% higher profits to the farmers despite an increase in the cost of seeds of 20% compared to existing varieties. -There would be 8% reduction in labour use due to reduction in application of fungicides. -Farmers would incur Rs. 3573 per hectare in cost of cultivation of TSV resistant groundnut, compared to Rs. 3651 for existing varieties. -Total returns would be Rs. 38556 per hectare in case of TSVR groundnut, compared to Rs. 26792 for existing varieties. -Adoption of transgenic TSVR sunflower would bring 150% higher profits per hectare despite increase in seed cost of 20%. There would be reduction of labour use of 9% due to 50% reduction in application of fungicides. -Yield of TSVR sunflower would be 20% higher than existing varieties such as Ganga Cauvery, Kargil and Suntech 120. -Cultivation of TSVR groundnut and sunflower would bring benefits in terms of high yield, low production cost and high income.
3	Selvaraj, Ramasamy and Norton (2007)	Late blight resistant Potato	-Farm survey of 30 potato growers and 4 scientists in CPRI, Shimla. -Economic surplus method and cost benefit analysis	-Yield of LBR potato would be 25% higher, reduced pesticide application costs by INR 1100; reduction in labour use by 11% due to reduced application of fungicides. -Farmers would incur Rs. 73246 per hectare in cost of cultivation of LBR potato, as compared to Rs. 68893 for existing varieties due to higher seed costs (20% more) for the GM potato, but total returns would be Rs. 190000 per hectare in case of LBR potato as compared to Rs. 127000 for existing varieties.

4	Krishna and Qaim (2007)	Bt Eggplant (Bt Brinjal)	-Field trial data carried out by Mahyco in several locations (8) in several states. -Interviews of 360 Brinjal farmers in three leading Brinjal-producing states in India (AP, WB, and Karnataka) -Consumer surveys (645 households from five locations)	-Bt technology allowed for significant insecticide reductions; amounts of insecticides used against SFB were reduced by 80%, which translated into a 42% reduction in total insecticide quantities. -Yields of Bt hybrids were double than those of non-Bt counterparts; yield advantage w.r.t. other popular hybrids and OPVs was even more pronounced. -Typical farmer applies 30 insecticide sprays during a single Brinjal crop of 180 days. Repeated application of pesticides results in harmful buildup of residues. -With the expected insecticide reductions through Bt Brinjal technology in the Centre/ South (35%) and East (48%), health cost savings would be around Rs. 50/acre and Rs. 470/acre respectively. -The widespread adoption of Bt technology will lead to a decrease in market prices for Brinjal (by 15%). Lower prices, in turn, will lead to higher consumption of Brinjal with positive nutrition effects in low-income consuming households (by 4%).
5	Kolady and Lesser (2005)	Bt Eggplant (Bt Brinjal)	-290 farmer families in 4 districts of Maharashtra -Bivariate probit model	-Use of Bt seeds for controlling the insect's attack is considered to be cost effective compared to chemical alternatives -The conditional probability of adopting Bt hybrid, given that the famer is already adopted hybrid Brinjal is very high at 85%.; whereas there is a negative correlation between past adoption of hybrid and expected adoption of Bt OPV.

6	Kumar, Lakshmi and Wankhade (2011)	Bt Eggplant (Bt Brinjal)	-Data on production and prices of Brinjal at all-India level and for selected regions covering farmers growing Brinjal in the major states such as West Bengal, Gujarat, Eastern UP and Bihar and Karnataka -Economic surplus method used to estimate potential economic benefits of Bt Brinjal -Economic gains simulated under three adoption scenarios (15%, 30% and 60%)	-Higher yield would accrue due to reduction in crop damage from SFB infestation (yield gain of Bt hybrids was 37.3 % over non-Bt hybrids and 54.9 % over popular hybrids); reduction in cost due to savings in insecticide-use to control SFB (reduction by 41.8%). There will also be better quality of produce which will have better market acceptability and will provide a premium price. -Consumers will also benefit from better quality produce which will be free from SFB infestation and residues of chemicals; they will get it at lower rate (3-15% less); and they will have more access to brinjal due to higher production volume. -Likely gains for total economy have been estimated between Rs. 577 crore to Rs. 2387 crore annually at different adoption level. -In terms of regional distribution effects, the major share of welfare gains would accrue in the eastern states (WB, Odisha, Bihar), where most of the brinjal is produced and insect-pest problem is severe. -Development of Bt OPV will improve access to resource poor farmers to technology; who might not adopt more expensive Bt Hybrids due to income constraints.
7	Krishna and Qaim (2007)	Bt Eggplant (Bt Brinjal)	-Farm survey; 360 brinjal farmers were visited and interviewed in three major brinjal-producing states of India (AP, Karnataka, WB). -Contingent valuation method used to elicit brinjal farmers WTP (willingness to pay) for Bt hybrid seeds.	-Considerable reduction in insecticides. The average quality of insecticides used on the Bt plots was 2.82 kg/acre, 45% less than on non-Bt plots. -While the mean yield of Bt brinjal was 221 quintal/acre, it was only 102 quintal/acre for the non-Bt counterparts. -In Karnataka, 90% of the sampled farmers use hybrid seeds, in AP 38%, while in WB, accounting for more than 25% of the total brinjal area, adoption is less than 1%. -The low hybrid adoption in WB is due to the high incidence of bacterial wilt, against which local OPVs are partly more resistant, and a less developed seed marketing network. -The farmers mean WTP for Bt hybrids was found to be more than 4 times the current price of conventional hybrids.

8	Andow (2010)	Bt Eggplant (Bt Brinjal)	-Farm Survey in West Bengal, AP and Karnataka -Economic surplus model	-The agronomic performance and efficacy experiments for hybrid Bt brinjal are designed for large-scale commercial brinjal production systems, and do not reflect the production systems used by small-scale resource-poor farmers. The data are probably appropriate for about 4% of brinjal production in India. -Yield gaps are prevalent between experimentally estimated yield and average farmer yield. The yield benefit of hybrid Bt brinjal estimated from the controlled MST and LST experiments should be multiplied by 0.54 to estimate the yield benefit for the average large-scale commercial farmer. This also reduces the estimated benefit to small-scale resource-poor farmers. -The expected maximum potential yield benefit from hybrid Bt brinjal is probably ≤43.7 q/ha for large-scale commercial farmers and ≤7.2 q/ha for small-scale resource-poor farmers; about 16 % of the time hybrid Bt brinjal is not expected to out-yield non-Bt brinjal. -Insecticide use might decline in large-scale commercial Bt brinjal production systems by an average of 6.5 applications. However, other factors may modulate this substantially, and new secondary pests will result in more insecticide use. It is not possible to estimate how insecticide use might change if Bt brinjal were used by small-scale resource-poor farmers. -Hybrid Bt brinjal may improve net returns of large-scale commercial farmers by at most Rs.2 3,439/ha and of small-scale resource-poor farmers by at most Rs. 3,250/ha. In comparison, brinjal IPM has improved net returns of small-scale resource-poor farmers by Rs. 66,794/ha. -The estimated economic surplus for brinjal IPM is significantly larger than for hybrid Bt brinjal. Farmers are expected to receive 63% of the surplus from brinjal IPM but only 10% of the surplus from hybrid Bt brinjal. Increased public investment, greater promotion, and strengthened public policy for brinjal IPM relative to those for hybrid Bt brinjal will result in greater social benefits in India and a major increase in profitability for small-scale resource-poor farmers.

Source: Compiled by RIS project team.

4.3 Conclusion

There have been concerns regarding these studies such as:

- The studies have used different methodologies while carrying out their economic assessment. Finding the one best methodology is a challenge.
- No one study has taken into consideration the various many socio-economic factors/ parameters under its ambit. The factor of gender has not come up in any of the studies; though the farm labour was mentioned in general terms.
- Some of the assumptions/methodology taken in the *ex-ante* studies has been challenged such as assumption on price difference between Bt or non-Bt seeds or the yield gap.
- There do not seem to have a uniform set of definitions, sample selection or parameters across the studies which lead to sometimes counter results.

Stone (2012) had pointed out that with Bt cotton, the convention of routinely ignoring the effects of selection bias and cultivation bias benefits researchers, and industry, but this did not help in drawing meaningful conclusions about the relative performance of GM technology. Both supporters and opponents of Bt Cotton technology in India claim that their arguments are based on 'facts' and these 'facts' are repeatedly used to endorse their claims.

To this objection by Stone, Herring (2013) retorted by stating that Stone had contradicted himself by quoting peer-reviewed literature where it was clearly shown that there had been impressive level of measured contributions to yield increases owing to GM technology. To this, Stone (2013) replied that the estimates quoted by the studies are largely uncited, unverifiable and suspicious claims. He also said that many of the studies showing favorable results for GM crops were authored by employees of biotech firms themselves.

From the claims and counter-claims, it is evident that there has been a need for undertaking a public socio-economic assessment study which is expected to be unbiased and neutral.

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IV Guidelines Framework for Socio-Economic Assessment of LMOs

4.1 Introduction

Based on the project document approved by MoEF&CC this guidelines framework has been prepared for use in SE assessment of LMOs. For Indian context of the traits that are researched for development of LMO crops, this guidance document shall have bearing on both yield-determinant attributes (traits) and agri-ecosystem stress (both biotic and abiotic) mitigation traits. The stress due to limitation of natural resources such as water (drought/water logging), soil (aberrant pH and sodicity) and temperature (both above and below crop threshold) are taken up for breeding for tolerant crop varieties through genetic engineering approach.

This framework is based on an extensive analysis of literature and findings from studies as described in the chapter on Survey of Literature. We have listed 11 key objectives that have been discussed in the literature. Although assessing SE impacts from the perspectives of labour and women in GM crops has not been discussed much in the literature we have included them as they are important in SE Assessment. This guidelines framework should be read and used along with the questionnaire, methodologies for SE Assessment.

4.2 Guidelines Framework

The framework for the guidelines based on the analysis of various ex-post and ex-ante studies on GM crops, and, the views expressed in the surveys conducted by CBD Secretariat. The framework is only indicative and when SE assessment is being undertaken this can be used as a guideline. The framework will be useful in determining the scope of data collection, applying relevant methodologies. We have identified key socio-economic dimensions that should be considered in decision making regarding LMOs.

As the impacts on small and medium farmers are likely to be different from that of farmers holding large areas of land we have listed them as a separate category. In their case it is important to assess the net gain *vis-a-vis* the net gain from cultivation of conventional, i.e. non-LMO crops/varieties. Another aspect that has to be investigated is whether the net gain is commensurate with the increase in cost of inputs and whether that is significant enough for them to switch over to or opt for LMOs.

In case of impact on labour, studies show that in case of Bt cotton the demand for labour including female labour increases in operations related to picking and demand for labour for spraying is reduced as the number of sprays and quantity sprayed are lesser than that of the conventional crops. Thus, it is important to assess the overall impact on labour, in terms of earnings, cost, and health impacts.

With respect to impact on women labourers literature shows that herbicide tolerant (HT) LMOs are likely to reduce the demand for labour, as labour needed for weeding is reduced. However, the demand for women labour in the entire cropping cycle has to be assessed. The income lost to them on account of reduced demand for women labour on account of weeding *vis a' vis* the positive impacts on them in terms of health has to be estimated so that the assessment is comprehensive.

The objectives listed here cover economic, social and environmental aspects and depending upon the objective relevant variables, principles, methodology and exceptions can be added. Hence, this guidelines framework should be treated as an evolving document.

Framework for the Guidelines

Sl. No.	Objectives	Variables/ Parameters	Principles	Methodology
1	Assessing increase in yield/ productivity in LMO crops that have yield-determinant traits	Yield gain (kg/ha); Yield gain (reduction in crop damage from pest/insect infestation)	Increase in yield per hectare; yield gain due to reduction in crop damage from pest/ insect infestation	Partial Equilibrium; Linear Regression; Multi-stage stratified random sampling; Cobb-Douglas Production Function; Economic Surplus Model (for *ex-ante* Studies)
2	Assessing reduction in use of pesticide in LMO crops that have pest tolerating trait gene (s).	Pesticide quantity use Frequency of Pesticide use Residues of pesticides in output/soil samples		Partial Equilibrium; Linear Regression; Multi-stage stratified random sampling; Cobb-Douglas Production Function; Economic Surplus Model (for *ex-ante* Studies)
3	Assessing health benefits of farming families and farm labour force	Health check-ups; Medicines; Sickness and loss of days/loss in earnings Effects of changes in residues of pesticides in output/soil samples	Decrease in ailments measured through reduction in duration of sickness, reduction in expenditure on medicine/treatment for such ailments;	Partial Equilibrium; Linear Regression; Multi-stage stratified random sampling; Cobb-Douglas Production Function; Economic Surplus Model (for *ex-ante* Studies)
4	Analyse economic gains for farmers	Pesticide cost; Labour cost (used for spraying and weeding) Fertiliser cost Irrigation cost Medicines cost (These are costs that the grower would have incurred had s/he not opted for LMO with the trait(s)	Less investment in buying insecticides, Less labour cost per season; fertiliser; Changes in irrigation and medicines costs	Partial Equilibrium; Linear Regression; Multi-stage stratified random sampling; Cobb-Douglas Production Function; Economic Surplus Model (for *ex-ante* Studies)

5	Assessing Consumer Benefits	Product price; Safe product due to less risk due to harmful chemical residues	Reduced Cost and Safer Products	Partial Equilibrium; Linear Regression; Multi-stage stratified random sampling; Cobb-Douglas Production Function; Economic Surplus Model (for *ex-ante* Studies) Survey
6	Assessing impact of seed prices on overall costs and changes in yield	Seed cost comparison; Willingness to Pay Value addition on account of trait Value in terms of life of the new LMO technology	Variable claims for seed cost difference Cost difference vs. changes in gains and savings Value for farmer from the trait/seed Seed saving/reuse rate and changes in costs	Partial Equilibrium; Linear Regression; Multi-stage stratified random sampling; Cobb-Douglas Production Function; Economic Surplus Model (for *ex-ante* Studies)
7	Assessing economic gains for small and medium farmers	Net gain on account of savings in costs and increase in yield vs. increase in seed cost and additional cost of increased use of major inputs (fertilisers, irrigation,agro-chemicals) and other factors	Comparing with non-GM varieties, Cost-Benefit Analysis	Partial Equilibrium; Linear Regression; Multi-stage stratified random sampling; Cobb-Douglas Production Function; Economic Surplus Model (for *ex-ante* Studies)
8	Assessing long term gains for farmers	Increase in returns over a period, sustaining the increase and gains. Impact on factor productivity in the relevant cropping system. This can be assessed if relevant methodologies are available and reliable base line data is also available	Long term Cost-Benefit Analysis	Longitudinal studies; Survey
9	Assessing environmental benefits	Residues of Toxic Pesticide in environment; reduction in use of pesticides	Soil quality, residues of toxics in output, reduction in use of pesticides over a period	Testing soil samples and outputs' changes in types of pesticides used; measuring impacts on humans and non-humans
10	Assessing impact on labour (from perspective of labour)	Employment (Man days) / Economic Loss of the commodity	Less labour used for insecticide spraying or weeding purpose and income loss; cost of labour vs. income in other options for labour	Survey; employment pattern and income; labour usage time and income; changes in employment and costs/benefits
11	Assessing impact on women (from women labours/ farm labour perspective)	Employment (days of work); income ; income from non-farm activity/other options	Quantum of womens' labour in terms of days/hours for different tasks; reduction in wages; wages in non-farm labour activity;	Survey; employment pattern and income; labour usage time and income; changes in employment and costs/benefits

V

Methodologies for Socio-Economic Assessment

5.1 Introduction

Socio-Economic Assessment (SEA) can be comprehensive by assessing various socio-economic parameters including analysis of alternatives.[1] SEA is often used to assess the impacts of projects, particularly projects relating to utilisation of natural resources and impacts of new technologies.[2]

SEA can be narrow or a focussed exercise that would provide outputs to meet specific needs in decision making. In the context of SEA regarding LMOs, Article 26.1 is the guiding article. In this report in Chapter 3 and in the reports from the institutions, various methods that have been used in assessments have been highlighted with their respective merits and limitations. The objective of a methodology is to use methods, data and other information to arrive at a conclusion or a finding. But as SEA can be conducted at different stages of the life cycle of a LMO the methodologies for SEA can be different for different stages. In this report we primarily discuss the methodologies for SEA for decision making for LMO with a specific trait to be released or used widely in agriculture, i.e. for approval for use by farmers. The reports from the partner institutions based on the questionnaires relate to this stage as they are based on the experiences of farmers on cultivating a LMO, their willingness to pay/accept a LMO with different traits and the framework of the research conducted under the GEF-UNEP Project pertains to SEA at this stage.

The methodologies should involve many stakeholders and should integrate quantitative analysis and qualitative information and provide a clear picture for decision making in terms of indicators, preferred choices and on the basis of other indicators and parameters as sought by the decision making. The methodologies should be theoretically strong and amenable for use in different contexts.

5.2 Impact Assessment: Methods and Contexts

In this section we briefly discuss the various methods in assessing economic impacts and their application in SEA.[3] Impact assessment of interventions in agriculture such as introduction of new technologies, increase in use of resources, infrastructure projects is done through *ex-ante* or *ex-post* approach. *Ex-ante* studies try to estimate the potential impacts of an innovation while *ex-post* studies assess the effects of an innovation after its diffusion or adoption. In Chapter 3 the results from various such studies have been described. In general most ex-ante studies agree that Bt cotton has resulted in significant economic gains and environmental benefits, while ex-post studies on LMO traits/crops to be introduced have projected economic gains and environmental benefits. The studies done at micro/farm level are necessary but not sufficient to assess the overall impacts. So many times scholars do a meta analysis of such studies to synthesise the findings and come

Table 5.1: Framework for Socio-Economic Assessment

	Approaches	Ex-ante	Ex-post
Micro	Adoption	Simulation	Logit/probit, tobit, heckman, double hurdle
	Impact	Simulation, Ex-ante economic surplus analysis	Randomised Contol Trail (RCT), PSM (Propensity Score Matching), DD (Double Difference), Instrumental variable (IV)
Macro	Adoption	Systematic review, Simulation	Systematic review
	Impact	Systematic review, Economic surplus using model using DREAM model	Systematic review

Source: Project Report submitted by NAARM, P 13.

to general conclusions, often with caveats.[4] Such a meta analysis also indicates what else should be examined in future studies. Studies on macro effects indicate the impacts at the macro level, often at the level of a nation or a region while sectoral level studies indicate the impact at the market for a single product in a single country and these studies are done as part of broader impacts of an innovation in a value chain or how innovation in one crop impacts other sectors in terms of increase in trade, economic gain and productivity.

To assess the impact of cultivation of a LMO, through indicators such as yield increase, a baseline scenario and an impact scenario should be undertaken. Baseline scenario is the situation without the cultivation of LMO and impact scenario is the situation with the cultivation of LMO. Impact measured in terms of an indicator can be described as below:

Impact = value of indicator in impact scenario – value of indicator in baseline scenario.

Baseline scenario can be accessed through primary data collection or from available data while impact scenario can be *ex-ante* or ex-post. Farm surveys and data collection from adopters and non-adopters can be used to assess the impact in terms of indicator. In case of a LMO that is yet to be commercialised, for ex-ante studies, data from field trials can be used. But caution should be exercised in using them as they are controlled field experiments and the situation under actual farming could be different. Ideally speaking reliance on primary data should be preferred. Since farmers have years of experience in cultivation before switching over, data prior to switching over can be compared with data after switching over if both are available.

For economic impact analysis at different levels many models are in vogue. These common approaches used in economic impact analysis are indicated in Table 5.1.

Economic surplus models have been used to assess the welfare gains from introducing a technology. Benefit-Cost Ratio, Net present Value (NPV) and Internal Rate of Return (IRR) are used in such exercises. This is relevant to estimate the aggregate welfare effects and this is used to assess what difference a technology could make in terms of welfare. For assessing the distribution of costs and benefits among different groups such as producers, consumers, in terms of producer surplus and consumer surplus, partial equilibrium models are used. To study wider impacts especially when there are cross-sectoral impacts, computable general equilibrium (CGE) models are used. They are comprehensive and useful when there are effects across sectors with feedback effects.

Ex-ante assessments can be used to estimate the impacts of various scenarios associated with changes inputs, costs, outputs and yield and scenario analysis can be used to estimate the welfare effects of different technological options/products. Scenario analysis is useful in finding out the potential effects of different

Table 5.2: Common approaches for assessing the impact of biotechnology applications

Level	Scope	Impact evaluated	Indicators used	Time frame	Approach/ model
Micro	Farm (family village)	Agronomic	Yield, cost of production factors	ex-ante	Effects on production function
				ex-post	
		Socio-economic	Workload, family income, health of workers, additional time	ex-ante	Household approach
				ex-post	
Sector	Market of a single product in a single country	Economic	BCR	ex-ante	Dynamic Research Evaluation for Management (DREAM)
			Internal rate of return		Scenario analysis
			Net present value	ex-post	Aggregate economic welfare analysis (single market partial equilibrium models)
			Distribution of benefits between operators of the production chain		Economic surplus models
Macro	Market of many products in a single country Market of a single product in many countries Multicommodity market in many countries	Economic	International price of products	ex-ante	Partial equilibrium models (few commodities) Computable general equilibrium (CGE) models (across commodities and sectors) (DREAM) multimarket analysis
			Distribution of benefits between regions or countries (adopters/non-adopters)		
			Distribution of benefits between society categories	ex-post	

Source: FAO (2009), P6.

policies and hence can be used to take measures accordingly. Dynamic Research Evaluation for Management (DREAM) software is useful to assess economic surplus as the *ex-ante* model can generate aggregates of economic consequences, with the introduction of a technology or without it, in single or multiple markets.[5]

Many studies on economic impacts of LMOs in use have used ex-ante and *ex-post* methods and the details of the same are available in Chapter 3.

An important constraint in using models to assess economic impacts is the availability and quality of data. For *ex-ante* assessment usually primary data is needed while ex-post analysis can be done by using secondary data but for many topics in ex-post analysis primary data is required. In case of using secondary data in *ex-post* and *ex-ante* due attention should be given to limitations of analysis, comparability of data across studies, impacts studied and models used, and, the period for which data is collected/analysed. Hence, whether it is a meta analysis or ex-post analysis or ex-ante analysis, reliance of secondary data should be undertaken with an understanding of the limitations. Often quality of primary data may not be uniform and the purpose for which data is collected should be taken into account.

Economic impact studies on cultivation of LMOs whether ex-post or *ex-ante* can be done only when the time period is specified since impacts may change over a period. Ideally speaking the assessments should cover at least, one year period or two cropping seasons.

In the literature on LMOs studying the economic impacts of LMOs has got the maximum attention for obvious reasons. In case of India obviously it is Bt cotton that has been studied the most. Meta analysis by and large, have confirmed that there have been economic gains but there is no consensus on whether the economic impacts could be attributed solely to the traits or whether it could be concluded that the traits have been the primary reason for yield increase. According to a recent report from National Academy of Sciences (NAS), "To assess whether and how much current and future GE traits themselves contribute to overall farm yield changes, research should be conducted that isolates effects of the diverse environmental and genetic factors that contribute to yield. In future experimental survey studies that compare crop varieties with Bt traits and those varieties without the traits, it is important to assess how much of the difference in yield is due to decreased insect damage and how much may be due to other biological or social factors" (NAS, 2016: p.27)

To sum up in assessing economic impacts of LMOs many methods have been used and these methods have been used to study impacts at different levels (micro, macro, sectors, across-sectors and across time periods). Primary data is more reliable but caution is needed when comparing primary data collected in different contexts. For decision makers these studies provide guidance in understanding the impacts and the impacts of alternative technological interventions/policies and at different levels/sectors.

5.3 Comprehensive Socio-Economic Assessment: Methods, Contexts

Economic impact studies are important but not sufficient to assess the socio-economic impacts of LMOs. SEA is also required as studies reveal that technologies are not scale neutral, gender neutral and different stakeholders get impacted differently and in the long run unanticipated issues/impacts emerge (e.g. adverse environmental consequences, increase in pest resistance) and the economic gains tend to vary significantly. Another issue is that despite the efforts for diffusion of a technology, adoption varies across different groups and there are non-economic factors such as, access to knowledge, perceptions about risks and benefits and availability of support from technology providers/government that influence adoption of a technology.[6] In this section we review briefly the various approaches and methods in SEA.

Sustainable Livelihoods Approach (SLA): SLA is a comprehensive approach that assesses the impact of an innovation on the livelihoods of different stakeholders, by evaluating how that innovation impacts the vulnerability, the need for different types of resources/capital and the resulting impact on the overall welfare. It thus gauges the non-economic impacts also and uses quantitative and qualitative research methods, often as an interdisciplinary research exercise. As it uses conventional impact analysis with qualitative assessment and takes into account the subjective factors, assessments by stakeholders and the values of the stakeholders it can provide a better picture of the impacts. Literature indicates that SLA has been used to assess how different interventions/projects/innovations have impacted the lives of different stakeholders/ communities. In case of using SLA for assessing impacts of LMO we could not find any single study. Perhaps it is possible to use SLA but it has not been tested so far in assessing impacts of LMOs.

The environmental impacts of LMOs are to be considered as part of SEA. Given the importance of biodiversity conservation and sustainable use in CPB, SEA should give adequate attention to assessing the impact of LMOs on biodiversity. The impacts can be direct impacts such as gene transfer to wild relatives, gene transfer to conventional crops i.e. non-LMOs cultivated, potential for inducing weediness, effects on non-target organisms including beneficial organisms, changes in the distribution of different species in the eco-system/ cultivation landscape, changes in the soil quality and impact on water quality.

It is true that during field trials some of these are assessed but as those trials are conducted on experimental sites, the data from them cannot be extrapolated to farm conditions in all regions. Another issue is that whether the regulatory regimes systematically assess environmental impacts over a long terms or whether the assessment is for the short term testing period only. Long term studies are necessary but there are many constraints in conducting long term studies on environmental impacts of LMOs in agriculture.

Brooks and Barfoot (2015) highlight the positive environmental impacts of GM crops measured in terms of reduction in pesticide use and argue "The adoption of GM insect resistant and herbicide tolerant technology has reduced pesticide spraying by 553 million kg (8.6 per cent) and, as a result, decreased the environmental impact associated with herbicide and insecticide use on these crops (as measured by the indicator the Environmental Impact Quotient (EIQ)) by 19.1 per cent. The technology has also facilitated important cuts in fuel use and tillage changes, resulting in a significant reduction in the release of greenhouse gas emissions from the GM cropping area. In 2013, this was equivalent to removing 12.4 million cars from the roads."

In fact many studies have pointed out that use of LMOs has reduced the overall use of herbicide and insecticide and thereby contributed positively to protection of environment although critics have challenged such claims. According to a recent report from NAS the evidence is mixed but there is little evidence to link GE crops with adverse agronomic or environmental problems (NAS, 2016: P99). It also pointed out that usage of pesticides in terms of quantity (in kgs), does not necessarily predict environmental effects. It should be pointed out despite fears about gene transfer to wild relatives evidence is lacking to prove them. Given the impacts of LMOs with different traits on the environment, studies have to be designed taking into account the trait, the quantity and quality of chemicals uses, and the estimated impact on target organisms. As pointed by NAS report and other studies so far there is no indication that LMOs harm biodiversity or result in reduction of biodiversity. However, displacement of traditional varieties and cultivars and impact on *in situ* conservation cannot be ruled out.

5.4 Methodologies for SEA

In the previous sections we discussed the various methods to assess different components of SEA. Based upon them methodologies for SEA can be developed. As discussed in the previous chapters, there is no consensus on the key elements of SEC and countries have adopted different strategies to implement Article 26.1. The reports of the AHTEG and the discussions organised by CBD Secretariat have helped in identifying the key elements in SEC. According to The Netherlands Commission on Genetic Modification (COGEM) any SEA framework should consider the following:[7]

- Quantitative and qualitative effects
- Reversible and Irreversible effects
- Distribution of effects
- Uncertainties with regard to effects
- The possibilities and limitations of ex-ante or ex-post studies
- The possibilities and limitations of various types of analyses
- Value to society

Further COGEM has identified the following as building blocks for assessing the impacts of LMOs:

- Economy and Prosperity
- Health and Welfare
- Food Supply and Food Security
- Cultural Heritage
- Freedom of Choice and Co-Existence
- Safety
- Biodiversity
- Environmental Quality

Of these safety is taken care by the risk analysis while cultural heritage is not a relevant factor in most instances. While biodiversity and environmental quality are important. Regarding freedom of choice and co-existence these are issues that could have different meanings in different countries. Health and welfare is certainly important but including welfare in SEA is not desirable as it is difficult to define welfare or develop indicators to measure impacts on welfare. Economy and prosperity can be classified as economy and as discussed there are many methods to measure economic impacts.

Interestingly COGEM states "The rejection of GM crop on the basis of arguments other than safety, while these arguments will apply the same extent to conventional crops that are not subject to these criteria could be seen as (unjustly) creating an uneven playing field". (COGEM, 2014: P29). Hence SEA should have legitimacy and should not be seen as a measure inherently biased against LMOs.

The issue with COGEM and most of the suggestions from Europe on SEA is that they stretch the limits of SEA and make the process more complex by including values and norms that are difficult to measure and assessing the impacts on LMOs on these norms and values is not easy. With respect to food supply and food security, assessing the impacts of LMO cultivation on food supply is feasible and there are methods that could indicate the impacts on food supply under different scenarios and how changes in food supply can create impacts in other sectors. The traits in LMOs do not directly result in enhanced yield and contribute to increase in yield by reducing damage caused by insects and by making the plants resilient. Hence, food supply when considered in quantitative terms is acceptable as an indicator in SEA. But food security is a complex subject and there is no universally accepted definition of food security. Further there are methodological issues in measuring food security.

In our view the reports of AHTEG and COGEM are useful in identifying the key elements for SEA. But the contextual understanding is more important for conducting SEA. Co-existence of LMO and non-LMO is a major issue in Europe but it is not so in India. Hence in doing SEA at the national level the key elements have to be identified and SEA should cover biodiversity conservation and use and impacts on traditional/indigenous communities to reflect the concerns expressed in CBD and CPB.

5.5 Conclusion

Most methodologies for SEA focus on economic indicators while some have integrated socio-economic factors. In this report we have highlighted indicators and methodologies in different chapters and they also figure in the reports from institutions. The challenge lies in developing comprehensive methodologies for SEA and in this the report of AHTEG can be very relevant.

Endnotes

1. See for example http://echa.europa.eu/support/socio-economic-analysis-in-reach/examples-of-sea-and-analyses-of-alternatives
2. For example see Rutz and Jansenn (2014).
3. For an overview see FAO (2009), Ludlow, Smyth, and Falck-Zepeda (eds.) (2014).
4. See for example NAS (2016)
5. See http://www.ifpri.org/dream.htm
6. See the project reports for examples.
7. COGEM (2014).

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VI Cost-Benefit Analysis of LMOS

6.1 Introduction

Cost benefit analysis has a long history in project evaluation. We can make use either Economic Cost Benefit Analysis or Social cost Benefit analysis. In view of the data constraints on the Social costs and benefits in LMOs it is ideal to use the Economic Cost Benefit Analysis.

Economic Cost Benefit Analysis

Cost benefit analysis takes in to consideration the series of investment costs and working costs incurred on a project in the initial year, say, I(0) to t^{th} year and similarly the stream of benefits that the project generates. The stream of costs and benefits over time are aggregated to arrive the benefit cost (B:C) ratio.

B:C ratio =Total benefits/ Total costs.

This method does not take into account the costs and benefits in real terms as the investments made in previous years have higher value in the present time. Hence, a discounted cash flow stream of costs and returns are arrived by choosing an appropriate discount factor.

Discounted Cash Flow (DCF)

A discounted cash flow (DCF) is a valuation method used to estimate the attractiveness of an investment opportunity. DCF analysis uses the future cash flow projections of costs and benefits and discounts them using an appropriate rate of discount to arrive at a present value estimate, which is used to evaluate the potential for investment in LMO. Calculated as:

$$DCF = \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \ldots + \frac{CF_n}{(1+r)^n}$$

CF= Cash flow of costs/benefits due to LMO

r = discount count is normally taken at 15 per cent for Agricultural projects as suggested by the World Bank or we can take the rate of interest at which capital is borrowed. World bank has suggested 15 per cent as the discount factor for agricultural projects which is applicable for LMOs

Benefit Cost Ratio = Net present value of Benefit/ Net present value of the costs

Costs and Benefits

All investment made in developing the LMO, licencing fee, land, building, irrigation structure and machinery at market/current value are amortised based on the life span of the asset. We may use the depreciation on these investment to arrive at the investment cost each year.

All working cost incurred at market prices each year such as cost on seed, fertliser, plant protection chemicals, labour, maintenance of machinery and cost incurred on borrowing money and sale of produce are considered. The returns realised by sale of produce at market prices are considered as benefits. By making of costs and benefits a flow stream of costs and returns for each year is arrived and are discounted to workout the C:B ratio.

6.2 Economic Evaluation

The economic evaluation will stress three aspects, employment, yield and the change in farmer incomes.

Employment

The field study by the Institute of Social and Economic Change (ISEC) compared the use of seeds of aerobic rice with those of conventional rice. The employment effects of the two kinds of rice are given below (Table 6.1).

Conventional rice uses the same amount of hired labour and slightly less family labour and so slightly less total labour for the *Kharif* crop than does aerobic rice. But aerobic rice uses considerably more labour for the *rabi* crop, almost twice as much hired labour and 50 per cent more of total labour. Furthermore, aerobic rice uses more family labour than does conventional rice for both the *kharif* and *rabi* crops. In addition, the greater use of hired labour by aerobic rice for the *rabi* crop consists of more of both male and female labour. Most of the family labour used by both aerobic and conventional rice and for both the *Kharif* and *rabi* crops is male labour, comparatively little female family labour is used. Over the two crops, aerobic rice uses about 50 per cent more labour, 40 per cent more of hired labour and 25 per cent of family labour.

Labour

We now discuss labour use in brinjal cultivation based on data collected by TNAU. This compares two varieties of seeds for brinjal cultivation, one is called variety and the other is called hybrid. The pattern of use is similar for the *kharif* and *rabi* crops so we give the data for only the *kharif* crop.

There are no significant differences in total labour use between the variety and the hybrid (Table 6.2). However, the hybrid uses more female labour than does variety and most of this is hired labour.

We next analyse the use of labour in Bt cotton cultivation. The UAS, Raichur has compared Bt cotton with non-Bt cotton whereas

Table 6.1: Employment Effects (Days)

	Aerobic		Conventional	
	Kharif	*Rabi*	*Kharif*	*Rabi*
Hired Labour	31.4	44.8	31.2	22.3
Self labour	15.6	20.5	14.2	14.8

Source: Data collected by ISEC.

Table 6.2: Brinjal Labour Use (days/Ha)

	Variety			Hybrid		
	Male	Female	Total	Male	Female	Total
Hired	154.0	816.0	970.0	82.6	918.5	1001.1
Family	118.5	87.6	206.1	156.8	53.0	209.8
Total	272.5	903.6	1176.1	239.4	971.5	1210.9

the ISEC study considers only Bt cotton. The data from UAS, Raichur reveals that Bt cotton uses about 15 per cent more labour than does non Bt cotton (Table 6.3). However, the use of labour in cotton cultivation in areas studied by ISEC is considerably less, about 15 per cent less.

Yield

We now consider the difference in yield between aerobic rice and conventional rice.

The yield of conventional rice is more for the *Kharif* crop and less for the *rabi* crop (Table 6.4). But the average yield between the two crops is more for the conventional crop. However, the quantity of by products is more for aerobic in *Kharif* and less in *rabi*. The average between the two crops is almost equal.

However, the picture is very different in the case of brinjal. The yield of the hybrid is 166 per cent higher in the *Kharif* season and 176 per cent higher in the *rabi* season (Table 6.5).

6.3 Income and Rate of Return

Income accruing to farmers

Income can be measured in two ways. One is the revenue they receive from sales of the output less what they pay out for the inputs they purchase. But farmers use family labour and they could have earned an income by hiring out this labour to other farmers. So one should include this foregone as a cost. So the net return is the revenue minus the paid out costs and minus the value of family labour used at the going rate. Both the cash profit and the net profit that takes into account family labour are lower for aerobic rice (Table 6.6).

The lower return for aerobic rice would be justified if the benefits in the drought year are high enough. To carry out this calculation one would need to know how much higher the income is in a drought year by growing aerobic rice. This higher income must be multiplied

Table 6.3: Use of labour in Cotton Cultivation (Days per acre)

	Bt Cotton	Non Bt Cotton	
	UAS Raichur	ISEC	UAS Raichur
Hired Labour	56.2	32.4	49.5
Family labour	6.7		

Table 6.4: Yield (kg/ha)

	Aerobic		Conventional	
	Kharif	*Rabi*	*Kharif*	*Rabi*
Main	21.4	20.5	24.6	19.5
By-product	12.6	9.6	10.4	13.2

Source: Data from ISEC.

Table 6.5: Yield (Kg/ha)

	Variety	Hybrid	Relative Productivity (Column 2/Column 1)
Kharif	17590	46920	266.7
Rabi	18900	52160	276.0

by the probability of drought occurring. In other words the higher income in a drought year multiplied by the probability of a drought year occurring must be higher than the income difference in a normal year.

We now calculate the difference in returns from brinjal cultivation. Hybrid cultivation provides a substantially higher income than does variety cultivation (Table 6.7). The returns from hybrid are higher by 46 per cent in the *Kharif* season and 73 per cent in the *rabi* season on a cash basis. Taking account of family labour they are higher by 72 per cent in the *Kharif* season and 129 per cent in the *rabi* season.

Rates of return from the different crops

The rate of return was calculated as the net profit divided by total costs and multiplied by 100.

Analysis of Results and Conclusion

The chapter has illustrated concretely how the principles underlying the cost-benefit assessment could be applied. It concentrated in the economic analysis as the studies provided most information on these indicators. But it did provide some pointers on how a social analysis could also be undertaken. Income by different farm sizes could be calculated. The incomes earned by smaller farmers could be compared to the rural poverty line. The effects on women employment were examined.

Gender

We next examine employment effects by gender. In the case of brinjal cultivation in area studied by TNAU , total employment in hybrid cultivation is very similar to that in variety cultivation. But employment of women is higher by 7.5 per cent in hybrid cultivation

Table 6.6: Income from Rice Cultivation

	Aerobic		Conventional		Relative Income	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
Cash Profit	11785	10409	11789	11911	1.0	0.87
Net Profit	7578	6180	8000	7126	0.95	0.94

Note: Net profit is calculated by subtracting for family labour.

Source: Data collected by ISEC, Bangalore.

Table 6.7: Costs and Income from Brinjal (Rs/Ha)

	Variety		Hybrid		Relative Return	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
Gross Return	598.4	528.1	787.3	741.7		
Paid Costs	332.9	328.4	398.7	396.1		
Costs	398.8	399.2	443.3	447.0		
Cash Return	265.5	199.6	388.6	345.6	1.46	1.73
Net Return	199.6	128.8	344.0	294.7	1.72	2.29

Source: Data collected by TNAU.

Table 6.8: Rate of Return

Institution	Crop (s)	Rate of Return
GIDR	Castor	21.1
	Groundnut	18.4
UAS, Raichur	Bt Cotton	38.1
	Cotton	18.4
	Pigeon Pea	17.5
ISEC	Aerobic Rice (*Kharif*)	46.8
	Aerobic Rice (*Rabi*)	38.9
	Conventional (*Kharif*)	54.9
	Conventional (*Rabi*)	116.8

whereas employment of men decreases by 12.1 per cent. Most of this additional employment is of hired women and not family women. As far as rice cultivation is concerned, there is not much difference in employment by gender between aerobic and conventional rice. In the *Kharif* season there is not much difference in employment per acre between aerobic rice and conventional rice. In the *rabi* season both aerobic and conventional rice use more male labour than female labour. No general conclusion can be drawn as to whether conventional seed cultivation requires more or less labour than newer varieties.

Health Benefits

In general, the studies paint a picture of considerable neglect or unawareness of the need for precaution in using chemicals. However, the costs of this neglect seem to be minor both in terms of days of work lost or in terms of treatment costs. This might partly explain the neglect of safety measures.

The GIDR study found that 11 farmers only responded to the question and they had incurred a total cost of Rs. 4560, namely and average of about Rs. 400, almost equally split between medicines, physician costs and travel costs. This compares with net income of more than Rs. 7000 per hectare for castor and Rs. 8000 per hectare for groundnut. The 20 farmers reporting loss of working days lost 111 full working days and equivalent to 31 days loss of partial days. More brinjal farmers, about 50 per cent in Telengana suffered adverse health effects. The average expenditure incurred was Rs. 3038, which is only about 1 per cent of the per hectare income of over Rs. 3 ,00,000. Bt cotton farmers in area studied by ISEC suffered about 3 days of lost labour and the cost of treatment incurred was about Rs. 1000 per episode. As far as aerobic farmers are concerned between 2 to 8 per cent suffered from the three main diseases and the average days lost was about 3 and average expenditure of treatment was Rs. 100. Health effects do not seem to be a major factor in the socio-economic assessment.

Environment

Information on effects of various seeds on soil quality or water quantity and quality was not elicited in the questionnaires. Usually more than 60 per cent of the farmers disagreed with the statements that GM crops will cause humans and cattle as they carry genes from different species, or their entry into the food chain will cause health risk or that cultivation of GM crops will harm agro-biodiversity.

Return by Farm Size

We first consider returns by farm size. We present below income gains by farm size. Income here is revenue minus cash costs incurred.

Table 6.9 Distribution of Income Gains by Farm Size : Bt Cotton

	Income (per acre) (1)	Operated Area by HH (2)	Income by HH (1 x 2)
Marginal	11229	1.63	18303
Small	23746	4.04	95934
Medium	26036	7.07	202300
Large	11691	18.06	211139
Distribution of Income Gains by Farm Size : Aerobic Rice			
	Income (per acre) (1)	Operated Area by HH (2)	Income by HH (1 x 2)
Marginal	8809	1.63	14359
Small	11788	3.78	44559
Medium	19969	8.5	169737

Note: HH is Household

Source: Data from ISEC

Per acre returns for Bt Cotton are U-shaped increasing initially then decreasing (Table 6.9). The question naturally rises as to why per acre returns decrease after a point. If there are problems of managing large farms then one could expect farmers with farms larger than the optimum size to subdivide their farm and rent out a portion. But, of course there may be problems in renting out land.

Since the cultivated area is higher for larger farms income increases with size. This leads to very unequal incomes. The current poverty line for a rural family of 7 is 81,760. Income for farmers with the smallest size is about 25 per cent of poverty line. But for others it is more. For aerobic rice income per acre rises leading to very unequal incomes between households. Again income for marginal and small farmers is less than the household poverty line.

VII Knowledge of LMOs, Risk Perceptions and Willingness to Pay

7.1 Introduction

Rapid advances in molecular biology enabled scientists to understand life processes at molecular level and also to intervene in the processes to evolve new technological innovations in the form of products such as GM seed. Innovations, apart from having advantages also tend to have the potential to cause harm to human, non-life forms and environment. It is because of these features that we have to understand the knowledge underlying the technologies and the consequences of their applications in the real world. Genetically Modified Organisms (GMOs) and Living Modified Organisms (LMOs) have necessitated the need to understand the nature of the technology and the control over the technology for the deployment of technology. In terms of the nature of technology there are some uncertainties and risks associated with their deployment. In order to understand risks and their management, several probabilistic models have been developed. Probabilistic models are based on the belief that measurement and quantification of description, explanation helps us in predicting the future events accuracy. Probabilistic models are based on observable, and quantifiable data over time and across space. Each of the models is based on certain assumptions regarding relevant parameters. Probabilistic models do provide some idea of the probability (ranging from zero to one) of occurrence of a harmful event but the models do not factor in all factors some of which are not measurable and predictable. Assessment of risk by construction probabilistic models, stochastic models, expert judgments. Probabilistic models based the positivist science approach phenomena with *a priori* concepts. Probabilistic models are not *conclusive* models. Hence, there is a need to look at the cultural belief systems which perceive risks.

7.2 Culture and Agriculture

Historically all human societies have been interacting with nature to gather and/or produce food and products of use value and/or exchange value through accumulation of knowledge and techniques. This interaction resulted in the simultaneous transformation of nature and social world of human species. Domestication of plants and animals and their *in situ* conservation, metal tools created conditions for the practice agriculture on a more permanent basis in contrast to nomadic food gathering. Adaptation to the climate and agronomic conditions led to variations in the systems of beliefs about nature. As part of the beliefs empirical observations relating to seasons, patterns of rain fall, wind direction and variations in temperature in a given period of time have been codified in the form of calendars (oral/written) which also indicated appropriate time for sowing and other practices related to agriculture. Farming communities across the country consulted the traditional calendars which, as mentioned earlier, are based on several decades of empirical observations regarding rain fall patterns, wind patterns and temperature trends. In India, the traditional calendars were used extensively perform various agricultural operations (the idea of *Karthes* in the Indian traditional calendar system). Communities developed plurality of knowledge systems across time and space. The green revolution, based on inorganic chemical fertilisers and pesticides, relegated the traditional calendars and traditional knowledge to a background. The green revolution is based on a belief system that takes for granted irrigation, energy requirements, fertilisers and pesticides (mostly inorganic synthetic) altered the belief system and did not replace the traditional one with a new one.

7.3 The Notion of Risk

In the process of interacting with nature human societies have learnt to distinguish, for example, what is edible and what is not, what is health promoting food and what is harmful food and accordingly acted either to promote or ignore certain types of food from vegetable sources and animal sources. These distinctions and preferences have become part of cultural repertoire and has been transmitted to successive generations. For example, food has become a cultural marker. As a corollary what is considered as not edible and not health promoting have been considered to be potentially harmful and hence to be avoided. Perceiving risk has become a part of beliefs and values about nature. Recently, it has been termed as cultural cognition of risk, which refers to a tendency of persons to form perceptions of risk and related facts that in consonance with the beliefs and values of the group to which one belongs.

It should be mentioned here that as the present study on LMOs deals with GM seed including GM food crops, understanding the meaning that people attach to what is considered food and what place livestock have in the farming system in India are important. Seed and livestock are bio-cultural resources as they have been selected, bred and conserved *in situ.* India until the 1960s practised organic farming which was replaced by green revolution and of late attempts are being made to usher in gene revolution.

7.4 Regulation of Technology

No technology is risk-free. Modern agricultural biotechnology is no exception. In order to minimise risk or eliminate risk modern biotechnology has to be regulated. Regulation is needed for the following reasons: 1) Equity; 2) justice; and 3) cultural compatibility.

Equity essentially means equitable access to technology and gains of technological development. For example, the operational part of this value of equity is that the GM seed must be available at a cost that a small farmer can afford to procure. There must be equitable access to complete information about new technologies and the inputs associated with new technologies. Equity will promote inclusive growth in the society.

Justice means fairness. It should be ensured that the technology does not pose risk for the health of people and environment. Justice also includes recognising usefulness of the knowledge produced by the communities over time.

Cultural compatibility implies relevant, preferred and appropriate activities, objects and events that are compatible with the values and system of meanings of a given group or society. Notions of what is accepted as food and what is prohibited as food are mediated by culture.

7.5 Farmers' Knowledge about LMOs

The findings of the research field studies by the six partner institutions indicate that the majority of the farmers are not aware of what is Genetic modification. However, this did not prevent the farmers in the states of Gujarat, Telangana state, Karnataka and Tamil Nadu covered in the study to adopt Bt cotton which is a genetically modified crop. Though Bt cotton helped farmers to protect cotton crop from Bollworm they also expressed concerns regarding the safety and its implications for traditional knowledge and biodiversity.

7.6 Risk Perception

To understand risk perceptions respondents were asked to provide degree of their agreement/disagreement on an ordinal scale to 18 categorical statement that is related to certain possible risks. All the research teams have used the same statements. The farmers in the sample survey in all the states as mentioned above were receptive to GM seed with a desired trait also expressed some concerns. The responses given in the perception surveys conducted by the six partner institutions are presented in this section (Tables 7.1 to 7.18).

Farmers who have had the experience of cultivating Bt cotton seem to perceive that adoption of GM seeds will reduce the cost of cultivation and cultivation of GM crops will ensure food security for the rapidly growing population. However, the farmers seem to have little idea of the consequences for farm practices that may occur when one makes a shift from genetically modified cash crop such as cotton to a genetically modified food crop.

As mentioned above though the farmers were willing to adopt GM food crops they have concerns relating to cultural dimension. Farmers, consumers, seed dealers, scientists and academicians interviewed by the research teams were apprehensive of the threats that introduction of GM crops can pose for traditional knowledge regarding crop plants, seed system and livestock and, biodiversity in general, which are bio-cultural resources that the communities conserved over several centuries. Another concern that was expressed was regarding the freedom to exercise one's option to choose a traditional variety of food crop may not exist ones the GM food crops are introduced as the transgene may flow into the traditional variety. The educated sections interviewed by the research teams do not seem to see any risk for human health in consuming GM food.

The majority of the farmers expressed concern over the monopoly control over GM technology which has implications for equitable access to technology as the technology is proprietary one. The company that controls the technology may exercise control over price. In the majority of the states where the study was conducted farmers felt that the GM technology may benefit large farmers. The majority of the farmers expressed the view that GM technology would undermine indigenous knowledge. Tables 7.1 to 7.17 illustrate the concerns in relation to adoption of GM crops that farmers expressed in terms of percentage vis-a-vis the sample size (N).

Table 7.1: Entry of GM food in food chain will cause health risk

Organisation	Strongly agree	Agree	Somewhat agree	Disagree	Strongly disagree
GIDR (Gujarat) N: 203	8.0	24	2	41	25
UAS, Raichur (Karnataka) N: 25	--	--	8.0	20.0	72.0
ISEC (Karnataka) N: aerobic farmers: 50 N: Bt cotton farmers: 100	0.0/ 0.0	2.0/ 4.0	16.0/ 33.0	70.0/ 49.0	12.0/ 8.0
IARI (Punjab and Haryana)	2.7	38.6	46.8	11.8	0

Table 7.2: Cultivation of GM crops will harm agro-biodiversity

Organisation	Strongly agree	Agree	Somewhat agree	Disagree	Strongly disagree
GIDR (Gujarat)	5.0	13.0	6	55	21
UAS, Raichur , (Karnataka)	---	36.0	24.0	24.0	16.0
ISEC (Karnataka) Aerobic rice farmers/Bt cotton farmers	0.0/ 1.0	4.0/ 12.0	8.0/ 28.0	80.0/ 43.0	8.0/ 8.0
TNAU (Tamil Nadu)Maize farmersBrinjal farmers	0.0 11.4	70.0 63.0	3.3 10.0	26.6 15.0	0.0 0.0
IARI (Punjab and Haryana)	1.4	34.1	48.6	11.4	4.5

On the issue of safety concerns, farmers across surveyed regions have expressed mixed perceptions (Tables 7.1, 7.2, 7.6, 7.12 and 7.13). From these tables, it is reflected that generally farmers from the North Indian states hold a view that GM crops are harmful to human and environment health, whereas the farmers from the South Indian states have shown their disagreement to the perception that the GM crops are harmful for human and environment health.

However, it is interesting to note that majority of the farmers from all the surveyed regions have agreed to the statement that a rigorous scientific testing is done prior to the relapse of any GM crop (Table 7.3). But, they are apprehensive of the genetic engineering scientists in sharing the data about harmful effects of GMOs (Table 7.4) and they perceive that the information on biotechnology provided by the mass media is trustworthy (Table 7.17). This is a matter of concern and calls for an effective communication strategy so as to allay any apprehension about safety of GM crops.

Table 7.3: Rigorous scientific testing is done prior to release of GM crops

Organisation	Strongly agree	Agree	Somewhat agree	Disagree	Strongly disagree
GIDR (Gujarat)	26.0	44.0	24.0	4.0	2.0
UAS, Raichur (Karnataka)	88.0	12.0	--	--	--
ISEC (Karnataka)Aerobic rice farmers/Bt cotton farmers	16.0/ 0.0	26.0/ 11.0	48.0/ 18.0	10.0/ 23.0	2.0/ 38.0
IARI (Punjab and Haryana)	5.9	74.5	8.2	5.9	5.5

Table 7.4: Genetic engineering scientists tend to conceal data about harmful effects of GMOs

Organisation	Strongly agree	Agree	Somewhat agree	Disagree	Strongly disagree
GIDR (Gujarat)	5.0	17.0	44.0	27.0	6.0
UAS, Raichur (Karnataka)	-	-	-	16.0	84.0
ISEC (Karnataka)Aerobic rice farmers/Bt cotton farmers	4.0/ 1.0	12.0/ 8.0	62.0/ 28.0	18.0/ 9.0	4.0/ 2.0
IARI (Punjab and Haryana)	0	7.3	28.6	33.6	30.5

Table 7.5: Promotion of GM technology will cripple indigenous knowledge system

Organisation	Strongly agree	Agree	Somewhat agree	Disagree	Strongly disagree
GIDR (Gujarat)	15.0	44.0	9.0	27.0	5.0
ISEC (Karnataka)Aerobic rice farmers/Bt cotton farmers	8.0/ 4.0	10.0/ 6.0	56.0/ 12.0	26.0/ 19.0	0.0/ 48.0
IARI (Punjab and Haryana)	0.9	68.2	9.1	15.5	6.4

Table 7.6: Prevalence of secondary pests will increase

Organisation	Strongly agree	Agree	Somewhat agree	Disagree	Strongly disagree
GIDR (Gujarat)	6.0	25.0	33.0	33.0	2.0
UAS, Raichur (Karnataka)	60.0	16.0	24.0	---	----
ISEC (Karnataka)Aerobic rice farmersBt cotton farmers	4.0	26.0	18.0	52.0	0.0
TNAU (Tamil Nadu)Maize farmers N: 60/Brinjal farmers N: 60	66.0/ 75.0	10.0/ 20.0	18.0/ 5.0	5.0/ 0.0	0.0/ 0.0
IARI (Punjab and Haryana)	4.5	4.5	39.5	15	5

Table 7.7 The production and trade of GM seeds will increase the monopoly of big companies in the seed market

Organisation	Strongly agree	Agree	Somewhat agree	Disagree	Strongly disagree
GIDR (Gujarat)	21.0	47.0	29.0	2.0	0.0
UAS, Raichur (Karnataka)	28.0	52.0	20.0	---	----
ISEC (Karnataka)Aerobic rice farmers/Bt cotton farmers	2.0/ 3.0	10.0/ 8.0	60.0/ 46.0	26.0/ 31.0	2.0/ 4.0
TNAU (Tamil Nadu) Maize farmers/Brinjal farmers	73.3/ 63.3	15.0/ 21.0	11.0/ 11.0	0.0/ 4.0	0.0/ 0.0
IARI (Punjab and Haryana)	3.2	34.5	3.2	47.3	11.8

From the survey, it was found that majority of the farmers across the surveyed regions held the perception that GM crops will be beneficial for farmers (Table 7.9) and disagree to the statement that only large farmers will be benefitted by GM technology (Table 7.8). They subscribe to the view that adoption of GM seeds will reduce the cost of cultivation (Table 7.10), and to the statement that the cultivation of GM crops will ensure food security for the rapidly growing population (Table 7.11) and however, the GM technology is required for few crops (Table 7.14).

7.8 Only the large farmers will be befitted by genetic engineering technology

Organisation	Strongly agree	Agree	Somewhat agree	Disagree	Strongly disagree
GIDR (Gujarat)	6.0	33.0	21.0	30.0	11.0
UAS, Raichur (Karnataka)	---	----	24.0	24.0	52.0
ISEC (Karnataka)Aerobic rice farmers/Bt cotton farmers	2.0/ 2.0	18.0/ 7.0	32.0/ 28.0	36.0/ 31.0	12.0/ 21.0
TNAU (Tamil Nadu) Maize farmers/Brinjal farmers	0.0/ 0.0	0.0/ 0.0	1.0/ 0.0	50.0/ 86.6	50.0/ 13.4
IARI (Punjab and Haryana)	9	54.1	3.6	31.4	10

Table 7.9: GM crops like Bt Cotton will be beneficial for farmers

Organisation	Strongly agree	Agree	Somewhat agree	Disagree	Strongly disagree
GIDR (Gujarat)	14	64	13	6	2
UAS, Raichur (Karnataka)	100	0	0	0	0
ISEC (Karnataka) Aerobic rice farmers/Bt cotton farmers	14/-	54/-	30/-	0/-	2/-
TNAU (Tamil Nadu) Maize farmers/Brinjal farmers	19/21	33/26	8/13	0/0	0/0
IARI (Punjab and Haryana)	13.2	75.9	6.4	3.6	0.9

On fear of monopolization, majority of the farmers across all regions agree to the statement that the production and trade of GM seeds will increase the monopoly of big companies in the seed market (Table 7.7) and also to the view that the promotion of GM technology will cripple the indigenous knowledge system (Table 7.5) and the promotion of GM crops will pose a serious threat to GI-marked high value crops such as Basmati rice (Table 7.15).

Table 7.10: Adoption of GM Seeds will reduce the cost of cultivation

Organisation	Strongly agree	Agree	Somewhat agree	Disagree	Strongly disagree
GIDR (Gujarat)	6	35	30	24	4
U A S , Raichur (Karnataka)	64	0	16	20	0
ISEC (Karnataka) Aerobic rice farmers/Bt cotton farmers	24/53	26/30	46/15	0/1	4/0
TNAU (Tamil Nadu) Maize farmers/Brinjal farmers	41/39	11/15	8/5	0/1	0/0
IARI (Punjab and Haryana)	5.0	76.8	6.4	13.6	2.7

Table 7.11: Cultivation of GM crops will ensure food security for the rapidly growing population

Organisation	Strongly agree	Agree	Somewhat agree	Disagree	Strongly disagree
GIDR (Gujarat)	6	41	36	14	2
U A S, Raichur (Karnataka)	68	12	20	0	0
ISEC (Karnataka) Aerobic rice farmers/Bt cotton farmers	10/28	38/24	48/28	0/19	0/0
IARI (Punjab and Haryana)	1.4	86.8	0.9	9.1	1.8

Table 7.12: Cultivation of GM crops will be risly as pollen flow from GM plants will contaminate other neighboring crops

Organisation	Strongly agree	Agree	Somewhat agree	Disagree	Strongly disagree
GIDR (Gujarat)	4	19	26	41	9
U A S , Raichur (Karnataka)	0	28	40	12	20
ISEC (Karnataka) Aerobic rice farmers/Bt cotton farmers	0/-	4/-	24/-	72/-	0
IARI (Punjab and Haryana)	0	15	75	10	0

Table 7.13: Since GM crops carry genes from different species they will cause harm to the human and cattle

Organisation	Strongly agree	Agree	Somewhat agree	Disagree	Strongly disagree
GIDR (Gujarat)	8	22	2	48	19
U A S , Raichur (Karnataka)	0	0	0	0	100
ISEC (Karnataka) Aerobic ricefarmers/Bt cotton farmers	0/-	0/-	16/-	80/-	4/-
IARI (Punjab and Haryana)	4.5	22.7	61.4	11.4	0

Table 7.14: GM technology is required for few crops

Organisation	Strongly agree	Agree	Somewhat agree	Disagree	Strongly disagree
GIDR (Gujarat)	10	48	15	22	4
TNAU (Tamil Nadu) Maize farmersBrinjal farmers	38/45	11/11	4/4	7/0	0/0
IARI (Punjab and Haryana)	9	21.4	26.8	42.3	8.6

Table 7.15: Promotion of GM crops will pose a serious threat to GI marked high value crops (eg. Basmati rice)

Organisation	Strongly agree	Agree	Somewhat agree	Disagree	Strongly disagree
GIDR (Gujarat)	7	49	32	10	1
IARI (Punjab and Haryana)	5	72.9	10	11.4	5.4

Table 7.16: GM foods should be labelled for the benefit of consumers

Organisation	Strongly agree	Agree	Somewhat agree	Disagree	Strongly disagree
GIDR (Gujarat)	31	63	6	0	0
UAS, Raichur (Karnataka)	100	0	0	0	0
ISEC (Karnataka) Aerobic rice farmers/Bt cotton farmers	8/16	40/39	46/27	6/5	0/1
TNAU (Tamil Nadu) Maize farmersBrinjal farmers	44/36	8/13	8/4	0/2	0/5
IARI (Punjab and Haryana)	9.1	48.6	42.3	0	0

Table 7.17: Information on biotechnology provided by mass media sources is trustworthy

Organisation	Strongly agree	Agree	Somewhat agree	Disagree	Strongly disagree
GIDR (Gujarat)	17	28	38	12	6
ISEC (Karnataka) Aerobic rice farmers/ Bt cotton farmers	10/3	20/28	66/28	2/22	2/5
TNAU (Tamil Nadu) Maize farmers/ Brinjal farmers	1/4	4/12	50/41	5/3	0/0
IARI (Punjab and Haryana)	7.3	45.5	42.3	5	0

On the issue of labeling, majority of the respondents supported the stance that the GM foods should be labeled for the benefit of consumers (Table 7.16). This will be an important step in letting the consumers make an informed choice.

7.7 Willingness to pay

The farmers across states included in the study drew the attention of the researchers regarding escalating costs of inputs and constraints relating to the quality of seed, and returns on investment. In this context the farmers are receptive to adopt new seed with desired trait(s) and associated practices. In Gujarat the majority of castor farmers and groundnut farmers included in the study were willing to adopt a GM crop with new trait for the sake of experience. The majority of the farmers in all the states covered in the study were also willing to pay more for the new seed with a desired trait than what they were paying for the seed they used earlier. The extent of payment ranged from 10 per cent to 50 per cent. Their willingness to pay more is related to the expected output. The expected output by using the new seed with a desired trait ranged from one and a half times to two times the output that they got. In other words, farmers' willingness to pay more for the seed with a desired trait is subject to assurance of higher output and hence conditional.

7.5 Conclusion

The above excerpts from the reports presented by research collaborators in different regions has shed some light on the knowledge about LMOs, perceptions regarding risks and their willingness to pay for a technology that ensures better returns on their investment.

Research carried out in the states included in the study indicates that the farmers do want to improve their crops by using new technologies including GM technologies. The majority of the farmers in the studies carried out in different regions of the country are willing to pay more than what they were paying to the seed they were using earlier. However, they also expect to get more returns on their investment. They expect to gain between 10 to 50 per cent more than what they were getting from their output earlier.

It is this situation that calls for regulation to ensure equity and inclusivity. As the paying capacity of the farmers vary there is a need to make sure that farmers of all sections including small and marginal farmers have access to GM technology and information regarding farm practices associated with the new technology. As the GM technology is a proprietary technology controlled by seed companies may dictate the price of the seed. In this context, there is a need to intervene the government either at the center or at the state level to fix a reasonably affordable price for the GM seed. To recall, when the Bt cotton seed was introduced in the then state of Andhra Pradesh in the year 2006, the government had to invoke the provisions of the MRTP Act to make the company to reduce the price of Bt seed. Regarding knowledge of LMOs it is clear that in regions where Bt cotton was cultivated the farmers have some knowledge about LMOs. However, the farmers also expressed concerns regarding risks. As part of risk perceptions, avoiding economic risks were expressed in terms of more returns on investment. In normal times avoidance of risk is ensured by institutional mechanisms such as crop insurance even if the farmers continue to use against existing varieties and hybrids. The insurance mechanism has to be strengthened. Further, there is a need to put in place surveillance mechanism at local levels to check the quality of the seed. Farmers also expressed risks which relate to culture. As mentioned in the introductory section, seed and livestock are bio-cultural resources that farming communities historically selected species, bred them and conserved them *in situ.* As mentioned above though there is willingness to adopt GM seed, concerns were expressed regarding undesirable consequences for the seed system, and biodiversity that the communities have conserved over time. It should be mentioned that biodiversity which has been conserved in a region by various communities- farmers, practitioners of traditional medicine, communities engaged in animal husbandry horticulturalists and others is part of the bio-cultural heritage of a region. To minimise risks there is a need for a broad-based and democratic regulatory framework that is based on values of equity, justice, and ethics. There is an urgent need to create critical awareness among farmers, and consumers regarding GM technology and GM seed so that they can make informed choices regarding GM technology.

The questionnaire should attempt to elicit information from farmers and other stakeholders on the interrelated dimensions, namely, economic, social, health, environmental and cultural/ethical which includes values like equity and justice.

Conclusions and Recommendations

A. This project on developing guidelines and methodologies for socio-economic assessment of LMOs was coordinated by RIS and executed in collaboration with six partner institutions (IAR, GIDR. UAS, TNAU, ISEC, NAARM). An extensive field survey in six Indian states (Haryana, Punjab, Gujarat, Telangana, Karnataka and Tamil Nadu) with a total of about 1500 sample size was undertaken as part of this project. The sample included farmers, breeders, scientists/researchers, retailers, and consumers . The crops and traits were selected from among the crops and traits mentioned in the Base Paper on Pipeline Crops and Traits of the MoEF&CC. The following Table (Table 8.1) depicts the institutions, selected crops and traits and states covered.

B. The methodologies used by the parner institutions in executing this project is shown in the Table 8.2.

C. This project has resulted in many important findings regarding benefits from LMOs, cost of cultivation and economic gains, farmers' experiences with and expectations from LMOs and their perceptions about risks from LMOs. The major conclusions from the analysis of field data are:

- Farmers covered by sampling are mostly small and medium farmers, with most of them in their forties, fifties and sixties. The representation of younger age groups in this is low. This may indicate that the younger generation is not keen on farming, but a clear conclusion cannot be drawn given the limited sample size and area covered.
- Farming is heavily impacted by rising costs, pest problems and non availability of superior technologies. The economics of increasing costs and the non commensurate increase

Table 8.1: Selected Crops, Traits, States

Institution	Crops	Traits	States
GIDR	Castor and Groundnut	Fungus/Bacterial and Nitrogen Use	Gujarat
IARI	Mustard and Wheat	Aphid Resistance and Herbicide Tolerance	Haryana and Punjab
TNAU	Brinjal and Maize	Insecticide Resistance and Herbicide Tolerance	Tamil Nadu
ISEC	Bt Cotton and Aerobic Paddy	Insect Resistance and Drought/salinity Tolerant	Karnataka
NAARM	Maize and Brinjal	Herbicide Tolerance and Insect Resistance	Telangana
UAS	Pigeon Pea and Black Gram	Insect Resistance and Fungal Resistance	Karnataka

in output or economic gains deserves further extensive analysis. In case of new technologies this could be a disincentive for adoption.

- Farmers reliance on private sector for seeds is increasing and they are the main sources of information, advice and often, the source of credit for buying seeds. Reliable good quality seed is desired by most by farmers who are willing to pay a premium for it.
- LMO cultivation has reduced pesticide use and there by improved health, resulting in lesser expenditure on health. But farmers use more than the recommended quantity of chemicals and pesticides, which are often handled without adequate caution. Awareness of caution and proper use does not necessarily translate into practice. Farmers are concerned about secondary pests and emerging threats that could affect production in future. They expect that effective technological solutions will be developed and adopted.
- While there are some concerns about risk of LMOs, farmers expect that future LMOs will have traits needed by them and are willing to pay more for them.
- There are also concerns about the negative impacts and many of the farmers do not espouse full faith in the scientists when it comes to trustworthiness. The findings on knowledge, risk perception and attitudes present a mixed picture of farmers' perception and call for re-think in communication strategies. There is a need to engage with stakeholders and a top down approach will not work. Instead the factors influencing farmers' perceptions and the reasons for ambivalences have to be studied and also the sources of information relied by stakeholders have to be examined as to why stakeholders find them trustworthy.
- The studies on economics of farming and output indicate besides addressing structural issues, attention should be paid to extension, training and support for farmers for adopting new technologies.
- The major constraints mentioned by the farmers are viz. high cost of input, high incidence of pests, climatic risks, lack of quality input, shortage of water, weed menace, unavailability of labour.
- The criterion enabling decision-making by farmers while seleting any variety are namely yield, pest resistance, germination potential, cost of seed, inputs requirements, safety to human and cattle, crop duration etc.

D The main conclusions from research done as part of the project, on literature review on LMOs, SE aspects of LMOs, developments in CPB on Article 26., 26.2 and giving effect to Article 26.1 and 26.2, are as below:

- The studies in India on LMOs indicate that there have been significant gains on account of use of LMOs and similar gains can be expected from LMOs in future. But very few studies have been done on socio-economic impacts of LMOs or on environmental/health impacts of LMOs.
- Developments in technology may necessitate a revision in terminology regarding LMO and this has implications for CPB, particularly Article 26.1. 26.2. For example gene editing is more sophisticated and widely applicable than genetic engineering technologies used in developing LMOs/GMOs. In future products can be developed with inserting foreign gene and the very idea of 'genetic modification' may have to be looked afresh for risk

Table 8.2: Methodologies Used

Institution	Methodology
IARI	• Multi-stage Random Sampling (Selection of sample) • Check-list (Awareness and Knowledge; Adoption) • Psychometry (Risk Perception) • Factor Analysis (Risk Perception) • Semantic Differential (Risk Perception) • Matrix Ranking (Preference) • Focus Group Discussion (Preference) • Garret Ranking (Preference) • Logit Regression (Willingness for Adoption) • Benefit Cost Ratio (Change in Yield and Income) • Questionnaire Survey • Interviews
TNAU	• Multi-stage Sampling (Selection of sample) • Partial Budget Analysis (Measurement of cost and benefits associated with the introduction of new technology) • Choice Experiment Approach (Farmers' crop variety preference and Willingness to Pay) • Economic Surplus Model (Welfare and distributional impact of technology) • Questionnaire Survey • Interviews
ISEC	• Multi-stage Random Sampling (Selection of sample) • Descriptive Analysis • Economics of Costs and Returns • Ranking Technique
UAS	• Multi-stage Random Sampling (Selection of sample) • Tabular Analysis • Functional Analysis • Garret Ranking • Questionnaire Survey • Interviews
NAARM	• Multi-stage Random Sampling (Selection of sample) • Perception Frequency (Adoption) • Logit/probit (Willingness for Adoption) • Simulation • Scenario • Questionnaire Survey • Interviews
GIDR	• Multi-stage Random Sampling (Selection of sample) • Descriptive Analysis • Cross Tabulation • Linear Regression • T-Test • Cost-Benefit Analysis (Change in Yield and Income) • Scenario • Questionnaire Survey • Interviews

assessment and regulatory purposes. Although no foreign gene might have been inserted, the genetic components of a product might have been changed and these may be nearly identical to the ones which have not undergone gene editing. So old approaches such as substantial equivalence may have to be revised and recalibrated in light of technological development. We may need more clarity on defining LMOs and differentiating LMOs and GMOs from products developed through gene editing and other novel technologies.

- The debates in CPB on SE considerations and framework for SE assessment have reached an important phase. Even if there is no consensus on frameworks for SE assessments, a shared understanding is emerging. Still there is little understanding on SE assessment in different phases in life cycle of LMO.
- The diversity in implementing Article 26.1 is remarkable but in most cases the laws/provisions/rules limit the use of SE considerations or use it more as a procedural norm than as a mandatory norm. The approach in Europe is towards a comprehensive framework for socio-economic assessment and this cannot be recommended as a good model for other countries.
- By now the literature on methods and approaches in socio-economic assessment is substantial and it is possible to develop methodologies from this and other sources. Methods for assessing non- economic impacts are available and have been tested.
- Given the wider implications of new and emerging technologies such as gene editing and novel plant breeding technologies, more research on their implications for biodiversity is necessary and this calls for studies on ethical, legal and social implications of these technologies.

Recommendations

- The findings from field survey indicate the need for more research on some disturbing trends as identified on increasing costs, diminishing returns and also on farmers needs and access to technology.
- Regarding seeds, the high dependency and reliance on private sector should be addressed and alternative channels should be established and supported.
- Similarly extension and support from government departments should be revitalised and strengthened.
- Training on safe handling of chemicals and pesticides is needed and so is the question of nudging the users towards good practices.
- Enough attention should be paid to farmers' perceptions on risks, benefits and attitudes towards LMOs. Economic gain need not translate into unquestioned acceptance of positive claims made on LMOs, nor should willingness to pay more be considered as full endorsement for LMOs.
- The less requirement for labour for certain farm tasks such as weeding may happen due to introduction of some tarits such as HT. This can be used as an opportunity to shift the labour from farm to non-farm sectors. This can also mean more safe and quality time available for family and leisure.
- Communication strategies are needed to address the fears and concerns of farmers and other stakeholders and also to provide them reliable and credible information through different channels.

- Accessibility and affordability of LMO seeds deserves attention. The willingness to pay more for LMO seeds should not be taken as an indication of capacity to pay at all times. Hence seed policy and IP policy and practice should be revisited to ensure that access to LMO seeds is not unduly constrained on account of high prices. Open Pollinated Varieties in LMOs can be considered with more innovation from public sector with respect to LMOs in agriculture.
- More research on SE assessment and biotechnology regulation and the interface among biosafety, risk assessment, technology regulation and SE assessment should be studied so that the regulatory frame can be strengthened, and made more credible and acceptable.
- Technology assessment studies including the socio-economic assessment of futuristic emerging biotechnologies such as gene editing, gene stacking, synthetic biology, and GM insects etc would have different challenges and concerns. Therefore, it would require a modified assessment framework to be developed in due course.
- Studies on SE assessment of these technologies should be conducted as these are likely to be commercialised soon. For instance GM mosquitoes have been approved for use in some contexts. EU and USA are now having a relook at the current regulatory regime for biotechnology in view of the developments in technology and their experience with them over two decades. It is suggested that MoEF&CC and other relevant departments support research on SE assessment of these technologies and their implications for regulation of biotechnology.

Annexure 1

MODEL QUESTIONNAIRE

Prepared for the Project

"Developing Guidelines and Methodologies for Socio-Economic Assessment of LMOs"

Reference Period: Schedule Number:

Reference Crop	Trait

PART I

A. General Information

Village		Name of the Investigator	
Tehsil/Taluk		Date of Interview	
District/Block		State	

B. Details of the Respondent:

Name of the respondent:	Contact. No:	
Respondent's age:	Gender: (Male =1; Female=2)	
Number of years of education:		
Caste:________ SC=1; ST=2; OBC=3; Others=4;		
Sources of Income (Rs / Annum):	Agriculture and allied activities:	
	Others:	
Number of years of farming experience		
Number of years of experience of LMO crop cultivation:		
Number of years of experience of conventional crop cultivation:		

C. Details of Household Members and labour utilisation (Including respondent)

Category	Total No of persons	Working in own farm		Working in other farms	
		No. of hrs/day	No. of months/ annum	No. of hrs/ day	No. of months/annum
Male (>16 years)					
Female (>16 Years)					
Children (<16 years)					

D. Land related Information (area in acres)

Type of Land	Irrigated	Rainfed	Source of Irrigation*	Rental Value (Rs/acre)	Soil type
Total owned land					
Leased-in					
Leased -out					
Uncultivated land					
Total					

*Open well =1, Tube well=2, Tank =3, Canal = 4, Others=5

E. Farm Assets

Assets	Qty./No.	Year of purchase/ construction	Purchase/ construction value (Rs.)	Annual repair and maintenance cost (Rs.)	Annual Rental Value (Rs.)
Well/tube-well					
Pump sets					
Drip system/irrigation systems					
Tractor and tractor drawn implements					
Farm sheds					
Drying Yards					
Plough					
Sprayer					
Small tools (sickle, hoe, machete, etc.)					
Cattle shed					
Cattle					
Buffalo					
Goat/ Sheep					
Others					

F. Details of cropping pattern

Season/Crop	Area (acre)		Source of irrigation Code*	Total Production (qtl)		Quantity Sold (qtl)		Average Price (Rs/qtl)		Cost of cultivation in Rs.
	Irrigated	Rainfed		Main	Byproduct	Main	Byproduct	Main	Byproduct	
Kharif										
Rabi										
Summer										
Annuals / Perennials										

Source Code (major source)*: Open well =1; Tube well =2; Canal =3; Tank =4; Others =5.

G. Details of area and production for the reference crop (________________) during the last 2 years

Year	Area (acres)			Production (qtls)			Price			Remarks
	Kharif	*Rabi*	Summer	*Kharif*	*Rabi*	Summer	*Kharif*	*Rabi*	Summer	
2012-13										
2013-14										
2014-15										

H. Credit Details

Name of the agency	Amount (Rs.)	Purpose of loan	Rate of interest per annum (%)	Month of borrowing	Time of repayment	Amount Paid (Rs.)	Outstanding loan amount (Rs.)
Commercial Banks							
Cooperatives							
Private Banks							
Traders/money Lenders/ friends/relatives							

I. Major constraints faced in the cultivation of reference crop____________________

Sl. No.	Particulars	Yes/ No	Severiety of the problem (Low =1;Medium=2; High=3)
1	Problematic soils (salinity/alkalinity)		
2	Quality of seed		
3	Avaliability of labour		
4	Incidence of pests and diseases		
5	Weeds		
6	Water stress		
7	Cost of inputs		
8	Others (Specify)		
9	Others (Specify)		

Area (acres):
Variety: LMOs
Season:*Kharif*

Crop duration: Days

Wage rate (Rs./day):

Male:
Female:

J. Cost of Cultivation for reference crop (For whole area)

Sl. No.	Operations	Bullock power (Rs.)		Machine power (Rs.)		Human labour				Inputs		Remarks
						Total no. of family labour		Total no. hired labour				
		Hired	Owned	Hired	Owned	M	F	M	F	qty.(kg).	Value (Rs.)	
a	Land Preparation											
b	Seed/seedling											
c	Sowing											
d	Irrigation (acre-inches)											
e	Weeding											
f	Intercropping											
g	FYM ,Organic/Bio-fertilisers											

h	Urea (N)											
i	Phosphorus (P)											
j	Potash (K)											
k	Complex ferti:_________											
l	Other ferti_________											
m	Micro Nutrients											
n	Weedicide											
o	Insecticide											
p	Pesticide											
q	Harvesting											
r	Threshing											
s	Bagging, transportation & marketing cost											
t	Others											

K. Cost of Cultivation for reference crop (For whole area)

Area (acres): Variety: LMOs Season:Summer/*Rabi*	Crop duration: Days	Wage rate (Rs./day):	Male: Female:									
RemarksInputsHuman labourMachine power (Rs.)Bullock power (Rs.) OperationsSl. No.												
Value (Rs.)qty.(kg.)Total no. hired labour Total no. of family labour												

OwnedHiredOwnedHired FMFM Land Preparationa Seed/seedling b Sowing c Irrigation (acre-inches)d Weedinge												
	Intercropping											
	FYM ,Organic/Bio-fertilisers											
	Urea (N)											
	Phosphorus (P)											
	Potash (K)											
	Complex ferti:__________											
	Other ferti_________											
	Micro Nutrients											
	Weedicide											
	Insecticide											
	Pesticide											
	Harvesting											
	Threshing											
	Bagging, transportation & marketing cost											
	Others											

L. Cost of Cultivation for conventional crop (For whole area)

Area (acres): Variety:Conventional Season:*Kharif*	Crop duration: Days	Wage rate (Rs./day):	Male: Female:									
RemarksInputsHuman labourMachine power (Rs.)Bullock power (Rs.) OperationsSl. No.												
Value (Rs.)qty.(kg.)Total no. hired labour Total no. of family labour												
OwnedHiredOwnedHired FMFM Land Preparationa Seed/seedling b Sowing c Irrigation (acre-inches)d Weedinge												
	Intercropping											
	FYM ,Organic/Bio-fertilisers											
	Urea (N)											
	Phosphorus (P)											
	Potash (K)											
	Complex ferti:_________											
	Other ferti_________											
	Micro Nutrients											
	Weedicide											
	Insecticide											
	Pesticide											
	Harvesting											
	Threshing											
	Bagging, transportation & marketing cost											
	Others											

M. Cost of Cultivation for conventional crop (For whole area)

Area (acres): Variety: conventional Season:Summer/ *Rabi*	Crop duration: Days	W a g e rate (Rs./ day):	Male: Female:									
R e m a r k s I n p u t s H u m a n labourMachine power (Rs.)Bullock power (Rs.)OperationsSl. No.												
Value (Rs.)qty.(kg.)Total no. hired labour Total no. of family labour												
OwnedHiredOwnedHired FMFM Land Preparationa Seed/seedling b Sowing c Irrigation (acre-inches)d Weedinge												
	Intercropping											
	FYM ,Organic/Bio-fertilisers											
	Urea (N)											
	Phosphorus (P)											
	Potash (K)											
	Complex ferti:_________											
	Other ferti_________											
	Micro Nutrients											
	Weedicide											
	Insecticide											
	Pesticide											
	Harvesting											
	Threshing											
	Bagging, transportation & marketing cost											
	Others											

PART II

TRAIT RELATED INFORMATION

A. Details of seed for the reference crop _______________

S.No	Particulars	Variety 1 : ……	Variety 2: ……	Variety 3: ……	Variety 4: ……
1	Own=1;Purchased=2				
2	Qty. of seed purchased (Kg.)				
3	Price (Rs./kg)				
4	Sources of purchase				
5	How many years have you been buying seeds (of any kind) from this source?				
6	What is the location of the source of the seed: within the village=1;taluka/town=2;others=3				
7	Distance from the source (Km)				
8	Germination quality Low=1;High=2				
9	Who decides the variety to be sown: self=1,head of the HH=2, joint/collective =3; Government=4;University/KVK=5; Prívate company=6; other= 7(specify)				
10	Which year did you first plant this variety?				
11	Area planted in the first year.				
12	Mention previously cultivated variety and the year				
13	Reasons for cultivating this variety				
15	Did the seller persuade you to buy any variety other than you wanted? Yes=1; No=2				
16	Whether technical advise was provided by the seed seller? Yes=1; No=2				
17	Did you purchase seed on credit =1 or cash=2 ?				
18	What other inputs do you buy at this shop/source?				

B.WEED MANAGEMENT

B.1. Incidence of weed for the reference crop

Name of the weed	Frequency of Incidence (every season=1;once in a year=2)	Severity of incidence (low=1;médium=2;high=3)	Stage of incidence#	Estimated yield loss (%)	Remarks
Kharif					
Rabi					
Summer					

seedling/sowing=1; vegetative stage=2;flowering=3;grain formation=4

B.2. CONTROL OF WEEDS

B.2.1. Cultural Method

Summer Ploughing							
Wage Rate (Rs.)Total LabourRate per hour (Rs.)HoursOwned /hiredMachinery/Animal Power FemaleMale FemaleMale Inter Cultural Operations (manual/machine weeding) *Kharif*							
Rabi							
Summer							

B.2.2. Chemical method

Herbicide#	Control which weeds	No. of Spray	Qty. (ltr/kg.)	Value (Rs.)	Labour charge (Rs.)	Sprayer Hiring (Rs.)	Nature of herbicide*
Kharif							
Rabi							
Summer							

#Write the chemical name and trade name; * Pre emergence/Post emergence

B.2.3. Biological method

Name of the biological agent	No. of release	Time of release	Qty.	Value (Rs.)	Labour charge (Rs.)	Remarks
Kharif						
Rabi						
Summer						

C. INSECT PESTS AND DISEASE MANAGEMENT

C.1. Incidence of Pests and Diseases for the reference crop

Name of the pest and diseases	Frequency of Incidence (every season=1;once in a year=2)	Severity of incidence (low=1;médium=2;high=3)	Stage of incidence #	Estimated yield loss (%)	Resistant varieties	Remarks
Pest						
Kharif						
Rabi						
Summer						
Disease						
Kharif						
Rabi						
Summer						

seedling=1; vegetative stage=2;flowering=3;grain formation=4

C.2 PEST AND DISEASE CONTROL

C.2.1. Cultural Method

A. Did you adopt summer ploughing for control of pest and diseases? Yes/ No, If yes fill the table B.2.1.A

B. Mechanical (pick and destroy, cut and burn, etc.)					
Machinery/Animal Power	Owned /hired	Hours	Rate per hour (Rs.)	Total Labour (days)	Wage Rate (Rs.)
	Male	Female	Male	Female	
Kharif					
Rabi					
Summer					

C.2.2. Chemical method

Insecticide/ fungicide /nematicide #	Control which insect pests / diseases	No. of Spray	Qty. (ltr./kg.)	Value (Rs.)	Labour charge (Rs.)	Sprayer Hiring (Rs.)	Nature of chemical *
Kharif							
Rabi							
Summer							

#Write the chemical name and trade name; * Contact=1, systemic =2 and others (specify)=3

C.2.3. Biological method

Name of the biological agent	Method of application#	No. of release	Time of release	Qty	Value (Rs.)	Labour charge (Rs.)	Remarks
Kharif							
Rabi							
Summer							

seed treatment=1; soil application=2; others(specify)=3

D. WATER MANAGEMENT

D.1. Water Use

Particulars Groundwater Area (acres) Number of irrigation per week Number of hours per irrigation	Crop 1:…………..	Crop 2:……………..	Remarks										
	Conventional	LMOs	Conventional	LMOs									
	K	R	S	K	R	S	K	R	S	K	R	S	
Discharge of wáter (inches)													
Water charges (Rs.)													
Surface wáter (canal/tank)													
Area (acres)													
Number of irrigation per week													
Water charges (Rs.)													

PART III

FARMERS AND CONSUMERS PERCEPTION ABOUT LMOs/GMOs

ι. If a new variety with desired trait (drought tolerant/insect resistant) release_______ , would you be willing to pay for this seed: Yes/No
If yes. How much?

α. < 10% of what you paid last season
β. 10-25% of what you paid last season
χ. 25-50% of what you paid last season
δ. > 50% of what you paid last season

ιι. What other crop traits you prefer ?____________

ιιι. Why did you choose your primary seed source? __________
(1 No other choice, 2. reasonable price, 3. Good quality, 4. nearness, 5. Trust the source, 6. Available on credit 7. Technical advice, 8.Others)

ιϖ. Apart from your primary source of seed, which other sources of seed do you know of? ----------------

ϖ. For the past how many years have you been experiencing the present problem (trait related) which is constraining the production or productivity?

ϖι. What price should be fixed for LMO crop output with desirable traits

(α) Same as that of existing crop (b) 1.25 times more (c) 1.5 times more (d) 2 times more

ϖιι. Do you apply yourself Pesticides (insecticides, fungicides) or Herbicides? (Yes/ No):______

ϖιιι. If you or the person applying the chemicals experiences any health problem during or after insecticide sprays, please give details.

Health Impairment	Frequency of illness (No. per year)	Working days, fully lost due to illness (per year)*	Working days, partially lost due to illness (per year)*	Average reduction in working hours per days	No. of times sought treatment for illness(per year)	Cost of medicine (Rs./year)	Fee paid to physician (Rs/visit)	Travel cost to meet Physician (Rs/visit)
1.Nausea								
2.Stomach Pain								
3.Diarrhoea								
4.Severe cold								
5.Asthma								
6.Other respiratory problems								

7.Coughing								
8.Eye irritation								
9.Blurred vision								
10.General Weakness								
11.Fever								
12.Sleeplessness								
13.Wounds								
14.Skin irritation								
15.Others (Specify)								

*Working days lost by the household, which also includes time spent by the family members in treating the illness.

- Did you receive training on how to use pesticides or herbicides? (Yes/ No)
- If yes, from whom? Specify:_________
- Do you or your farm labourers use gloves, cover mouth and nose, and protective clothing when applying? (Yes/ No)
- Do you or your farm labourers wear boots when applying chemicals? (Yes/ No)
- Do you or your farm labourers wear spectacles? (Yes/ No)
- Do you or your farm labourers follow wind direction while spraying? (Yes/No)
- How do you dispose chemicals/containers?:________
- Do you or your farm labourers eat and drink while applying chemicals? (Yes/ No)
- Do you or your farm labourers smoke while applying chemicals? (Yes/ No)
- Do you or your farm labourers wash hands/bathing after applying chemicals? (Yes/ No)
- Do you use more=1, less=2, recommended doses=3 of herbicides and pesticides? Indicate ….
- Access to extension services

a. Did you receive any advice/training in the past two seasons from any service provider (agricultural extension services) for crop production? (Yes/No) ______

b. If Yes, please provide the details below

Service Provider	Frequency of seeking information#	Total number of visits in past one year
Government agency		
Universities/KVKs		
Input dealers		
Farmer group member		
NGO		
Other fellow farmers		
Project/program/volunteer providers		
Other (specify)		

Regularly=1,Occasionally=2,Rarely=3,Never=4

I. Do you seek information about market prices before you plant? (Yes/No)______

II. Do you seek information about market preferences before you plant? (Yes/No) ____

III. Knowledge about LMOs (Farmers' Perspective)

1	Do you know about genetically modified crops?	Yes / No
2	If yes , what GM crop you heard about?	
3	Have you ever cultivated Bt cotton (GMO)?	Yes/ no
4	If yes, did GM cotton give higher yield than other hybrids? What is the increase in yield per acre (%) ?	Yes/ no
5	If yes, did GM cultivation led to increase in your income or profit? By what percentage?	Yes/No
6	Do you find quality differences of reference crop(____________) is better than conventional variety If yes, provide details : (whole or broken grain/weight/color of grain or seed/ nutrition quality)	
7	Do you percieve any environmental risks in growing GM crops? List out:	Yes/No

Knowledge about LMOs (Consumers' Perspective)

1	Do you know about genetically modified foods/crops?	Yes / No
2	If yes , what GM food/crops you heard about?	
3	Have you ever eaten any GM food?	Yes/ no
4	If yes, what GM food have you eaten?	
5	If no, would you prefer eating any GM food?	Yes/No
6	If yes, why would you prefer eating any GM food?	
7	If no, why would you not prefer eating any GM food?	
7	Would you prefer any eating any GM food if it is cheaper?	Yes/No
8	Would you prefer any eating any GM food if it is healthier?	Yes/No
9	Would you want GM food to be labelled?	Yes/No
10	Do you think GM good is harmful to health?	Yes/No
11	Do you find the media reports trustworthy?	Yes/No

Risk Perception about GMOs:

How do you perceive about GM crops like Bt cotton being promoted in India? Given below are statements related to GM crops. Kindly mark the level of your agreement or disagreement with respect to each statement by putting a tick mark in the appropriate cell.

S.No.	Statements	Strongly Agree	Agree	Somewhat Agree	Disagree	Strongly Disagree
	GM crops like Bt cotton will be beneficial for farmers					
	Adoption of GM seeds will reduce the cost of cultivation.					
	Cultivation of GM crops will ensure food security for the rapidly growing population (for aerobic rice only).					
	Cultivation of GM cotton will be risky as pollen flow from GM plants will contaminate other neighbouring crops.					
	Since GM crops carry genes from different species they will cause harm to the human and cattle.					
	Entry of GM food in food chain will cause health risk					
	Cultivation of GM crops will harm agro-biodiversity.					

	The production and trade of GM seeds will increase the monopoly of big companies in the seed market.					
	Rigorous scientific testing is done prior to release of GM crops					
	Genetic engineering scientists tend to conceal data about harmful effects of GM crops					
	Only the large farmers will be benefitted by genetic engineering technology.					
	Promotion of GM technology will cripple indigenous knowledge system.					
	Genetically modified foods should be labelled for the benefit of consumers.					
	Information on biotechnology provided by mass media sources is trustworthy					
	Prevalence of secondary pests will increase					
	GM technology is required for few crops					
	Promotion of GM crops will pose a serious threat to GI marked high value crops (e.g. Basmati rice)					
	Deployment of GM crops will raise the cost of cultivation					

Annexure 2

Summary of Reports from Six Partner Institutions

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GIDR: Executive Summary

Profile of farmers: The average age of the castor, ground nut and all farmers are 44, 46 and 45 years. This also has implications as the younger generation is relatively less involved in agriculture.

1. Only 12.3 per cent of the total farmers are illiterates and their number is relatively more among the castor growers.
2. Of the 1170 household members, 653 members or 56 per cent of the household are engaged in farming. Implicitly the rest are engaged in some other activity. Of the 653 persons engaged in farming, 57 and 43 per cent are male and female respectively.
3. The average size of the household of the sample farmers is 5.7 members.
4. 604 persons are working in their own farm. Out of this, 59 per cent are male. 66.3, 1.0, and 4.6 per cent of the 604 persons are also engaged in animal husbandry, work as labourer in other farms and engaged in other than farm related activities.
5. In castor while overall 253.7 person days of labour was involved, male members were engaged for 263.5 days compared to 241.3 person days for females. In groundnut cultivation, females were engaged for 223.17 person days compared to 239.12 person days for males.
6. Of the total 203 farmers chosen for the study, 55.7, 37.9 and 6.4 constitute the small, medium and large landholders, respectively.
7. 92.5 per cent of the total income comes from agriculture and the rest from other sources.

Irrigation status of farmers

Totally 95 per cent of the land is irrigated. Tube well irrigates 81 per cent of the area and 17.6 per cent is irrigated by open wells. 1.2 per cent is irrigated by other sources.

Farm assets

65 per cent farmers own only one type of irrigation structure perhaps due to the cost involved. 25.5 per cent own two irrigation structures and 9.6 per cent farmers have three irrigation structures.

44 and 60 per cent of the farmers own tractors and farmsheds respectively.
Castor is cultivated in sandy, reddish and fertile soil, groundnut is grown more in reddish fertile and black soil.

Labour use in castor and groundnut cultivation:

A total of 28924 person days have been used in cultivation by the chosen farmers. Of this 47 per cent has been contributed by the family labour. Females constitute 33 per cent of the total labour force. Hired labour constitutes 25 per cent of the total labour force. Farmers report an yield of 23 quintals in castor and 15 quintals in groundnut.

Indebtedness:
Timely availability of loan is essential for farmers as majority of farmers have indicated taking loans for buying seeds. If the farmers are unable to get timely loan, they may miss the season or may not be able to get their choice of seeds. This can also push the farmers in vulnerable situations.
Farmers depend on formal sources for their loan needs and particularly on co-operative more than the commercial banks.

Weed:
Farmers report occurrence of weed, pests and diseases as major constraints in cultivation. Majority of both castor and ground nut farmers indicated the problem to be medium and high in severity of incidence. More number of farmers have reported damage due to weeds at the sowing and vegetative stage. Implicitly, it may mean that farmers may have to sow again or the yield could be less if weeds are not attended to at the right time. Labour availability at the right time may be important for farmers.

Production scenarios without, with and along with remedial measures for salinity/drought issue

In the presence of the salinity/drought issue, castor farmers were expecting a yield of 6.2 quintal on the lower end and 8.9 quintal on the higher side. Groundnut farmers were expecting 4.6 and 7.3 quintals on the either end of the production scenario. It appears from the responses, farmers do not expect that remedial measures for the salinity and drought issue would restore their yield to the level in the absence of the problem. Thus castor farmers expect a yield level of 10.6 and 14 quintals and groundnut farmers expect 7.8 and 11.4 quintal, which is much lower than the yield without the salinity/drought issue.

Pesticide use: Groundnut farmers reported using more number of sprays which is a concern from health and environment point of view. Though farmers reported using recommended dose of pesticides, the self safety measures needs to be improved. Presently only a few farmers have reported illness due to mild poisoning of pesticides. As majority of the farmers are spraying the pesticide by themselves, there could be more cases which are not reported by farmers as these are mild symptoms. The long term health implications could be different.

Knowledge about GMOs: The analysis shows that farmers are favourably inclined to use LMOs in future to improve the production. The past experience of Bt cotton users indicate that though they received higher income, they also incurred higher costs. In order to cut down the avoidable costs, extension services are required. A number of farmers believed that scientists tend to conceal the data. Majority of the farmers also believed that information on GM in mass media is trust worthy. Hence, government will have to carefully weigh the information that gets passed on to the farmers in the vernacular languages.

Overall, this report has discussed the farming practices, cost incurred and the farmers' perception about GMOs. Farmers have favourable opinion about GMOs. More extension services towards appropriate adoption along with suitable farming practices will lead to favourable economic and environmental impact of the technology.

ISEC Executive Summary

The Agricultural Development and Rural Transformation Centre (ADRTC) of the Institute for Social and Economic Change (ISEC), Bangalore associated with The Research and Information Systems for Developing Countries (RIS), New Delhi for the project for developing guidelines and methodologies for "Socio-Economic Assessment of LMOs" in different parts of the country. The ADRTC conducted primary survey of aerobic rice farmers and Bt Cotton growers in two districts of Karnataka state. The district of Mandya which has high aerobic rice area and Haveri which claimed very high Bt Cotton area were identified for survey. The sample covered 50 aerobic rice cultivating farmers belonging to 2 talukas of Mandya and another 100 Bt Cotton sample farmers spread over 7 talukas of Haveri district. The trait emphasis was drought tolerance of aerobic rice and insect resistance trait of Bt Cotton. The study aimed to address the specific objectives: socio-economic profile of GM crop farmers; analyse the cost of cultivation of GM crops in comparison to traditional crops; input management followed by the GM crop farmers; and perception of farmers as well as scientists, cotton traders and input dealers about GM crops. The data was collected for the period from July, 2014 to June,2015 through a questionnaire designed exclusively to meet the objectives.

The excerpts of the survey of aerobic rice farmers of Mandya district and Bt cotton farmers of Haveri district are as under:

Aerobic Rice

- The important indication of the survey was that age and education are not a limiting factor among the farming community to accept and cultivate aerobic rice. Nevertheless, to some extent, the size of operational holding mattered. This can be evidenced on the result that aerobic rice was more popular among small and marginal farmers.

- Majority of the farmers who had adopted aerobic rice have decades of experience in cultivation of conventional crops. The experience in cultivating of aerobic rice was around 2 years as aerobic rice was introduced very recently about 3 to 4 years back. The productivity remained constant at 21 to 22 quintals per acre for the last two years.

- With regard to cost of cultivation of aerobic rice, it can be mentioned that the farmers had obtained slightly higher productivity than conventional rice leading to higher gross returns. But still, the net return from aerobic rice worked out less than conventional rice for the reason that cost of cultivating aerobic rice was higher by 10 to 12 per cent of conventional rice. The situation remained same for *Kharif* rice and *Rabi* rice. The expenditure on labour was highest among other expenses.

- The drought tolerance trait of aerobic rice was amply visible in terms of water saving. The management of inputs like seeds, fertilizers, plant protection chemicals were not according to recommendations. This resulted not only in increased cost of cultivation, but also had negative effect on the yield level.

- Around a quarter of the aerobic rice farmers did not know about Genetically Modified (GM) crops. However, they showed their willingness to continue aerobic rice even at increased seed cost. A large number aerobic rice farmers perceived and agreed that GM crops are beneficial to farmers. Some of them had perceived the benefits very strongly. Many of the aerobic rice farmers felt that the cost of cultivation of aerobic rice is higher than conventional rice. The farmers had divided opinions about issues such as health hazard to human beings and harming agro-diversity. The aerobic rice farmers have the perception that Ragi is more profitable crop than aerobic rice.

- The aerobic farmers were not out rightly rejecting to cultivate aerobic rice. They have been finding ways and means such as shifting from one variety to other, taking technological advises from available sources.

Bt Cotton

- The important indication of the survey was that age and education are not a limiting factor among the farming community to accept and cultivate Bt Cotton. Nevertheless, small and medium farmers had taken more interest in cultivating Bt Cotton than marginal and large farmers.

- The sample farmers were cultivating Bt Cotton since 2005 and hence some farmers have more than a decade years of experience in Bt cotton cultivation. The average was around 6 to 7 years. The adoption of Bt Cotton among the farmers of Haveri district is so wide spread that the survey team could hardly identify farmers cultivating conventional cotton in Haveri district.

- Since there were no conventional cotton crop growers in Haveri district and Bt Cotton crop was grown only in *Kharif* season the cost of cultivation could not be compared. Labour cost was the highest among all other items of cost of cultivation in Bt Cotton.

- The insect's resistance trait of Bt Cotton was not fully achieved as fields of Bt Cotton farmers were not devoid of insects. The management of inputs like seeds, fertilisers, plant protection chemicals were not according to recommendations. This resulted not only in increased cost of cultivation, but also had negative effect on the yield level.

- Almost all the Bt cotton farmers were aware about Genetically modified (GM) crops and they were ready to continue. They strongly perceived that GM crops reduce cost of cultivation. The farmers had divided opinions about issues such as health hazard to human beings and harming agro-diversity.

Based on both the surveys it can be concluded that the sample farmers are not out rightly rejecting to cultivate aerobic rice or Bt cotton. They have been finding ways and means such as shifting from one variety to other, taking technological advises from available sources. Dissemination of proper and authentic knowledge about GM crops through training and demonstration would go a long in convincing farming community to GM crops in lieu of conventional crops. It is extremely essential that the GM crops in agriculture is offered to farmers as a package. The package may be on similar lines of System of Rice Intensification (SRI) method that was offered to the farmers. Concurrent assessment of the implemented package for GM crop is also essential.

IARI- Executive summary

Genetic engineering has played a significant role in technological breakthrough. The unprecedented success of Bt cotton in India is a remarkable example, where an innovation has diffused at a much faster rate than any other farm innovation. However, the debate on application of genetic engineering for improvement of crops is intense and non-conclusive. Among many reasons, socio-economic implications are being considered vital as agriculture is the mainstay of livelihood. Realising the need for adequate emphasis on such issues, Paragraph 1 of Article 26 of the Cartagena Protocol on Biosafety provides that Parties may take socio-economic considerations into account in decision-making on living modified organisms. There is need for a clear understanding of socio-economic issues relevant for living modified organisms and to suggest the methodological framework for socio-economic assessment

Considering the importance of aphid management in mustard, the trait selected for the study was aphid resistance in mustard. Similarly, herbicide tolerance in wheat was selected due to weed menace in wheat.

The study was conducted with following objectives:

a. To identify the socio-economic, cultural and ecological concerns related to living modified organisms

b. To devise and validate survey instrument for analyzing the concerns related to living modified organisms

The study was conducted in Punjab and Haryana which have witnessed not only the adoption of Green revolution technologies and their consequences but also Bt cotton cultivation. Among the predominantly growing districts; Mansa and Bhatinda districts from Punjab and Sirsa, Hissar, and Fatehabad from Haryana were selected randomly. With multistage sampling 220 farmer respondents were selected for testing the questionnaire.

At the outset, stakeholders' workshop and focus group discussions were held, which revealed lack of understanding about GM technology; Bt cotton has been successful; Other biotech crops acceptable if profitable; Scientists' verdict about safety is important; Openness in experimentations and trails of biotech crops; Emphasis on Public awareness and Educational campaign; Deployment of biotech crops through govt agencies; If deployed by private agencies alone, they should own the responsibility of prompt and consistent advisory for the farmers; and the cost should be reasonable

Cost of input with highest Garret score of 69.6 was found to be the major constraint followed by high incidence of Pest and climatic risks.

With the highest mean score of 9.67 the yield potential and efficacy in management of pests were considered as the first and foremost criteria for selection of any Bt. hybrid followed by the germination potential; cost of seed; plant type; input requirement; suitability to farm , safety to human and cattle, irrigation intensiveness and crop duration .

With adoption of Bt cotton, there was drastic fall (about 32 per cent) in number of pesticide spray and cost on spray also reduced significantly. The yield increased by nearly 36 per cent, while the benefit cost ratio increased by about 22 per cent.

Though Bt cotton performed exceptionally on parameters like no incidence of American bollworm, high yield, less number and cost of sprays, and suitability to heavy soils; the non-Bt hybrids were preferred to Bt cotton hybrids with respect to germination potential, ease of use, less susceptibility to stresses like physiological disorder, moisture stress, incidence of secondary pests; and input intensiveness.

Number of family members engaged in farming, social participation and social network were the major variables having a bearing on adoption decision among farmers.

Factor analysis revealed that the major domains of risks were related seed systems, resource systems, openness in innovation generation, and regulations systems.

A majority of the farmers purchased every year and travels 4 to 8 Km for seed procurement. Seed also influences seed procurement. Fellow farmers are the major source of information.

A majority of respondents of in both states did not have knowledge about genetic modification of the crop, while all of them have cultivated Bt Cotton and perceived that it has led to increase in yield and income. Most of the respondents have opined that adoption of Bt cotton has lead to increased input use. Many of the respondents have pointed out higher yield and pest resistance as major traits required. Very few respondent have opined that GM crops are harmful to human (12.5 per cent in Punjab and 3 per cent in Haryana) and animals (11.7 per cent in Punjab and 18 per cent in Haryana).

The schedule was found effective in capturing the hypothesised variables related to socio-economic perspective. Scope could be broaden to include more stakeholders for covering legal, ethics and governance, issues.

NAARM -Executive summary

Article 26.1 of the Cartagena Protocol opened the possibility of including socio-economic considerations as part of the decision making process. Important issues to consider are that implementation of this article has a **limited scope** to those factors affecting biodiversity especially regarding its value to indigenous and local communities. Introduction of broader socio-economic considerations into GMO biosafety analysis and the decision-making process needs deep understanding as there are many approaches for development and implementation of methodologies for estimation of costs, benefits, risks and tradeoffs in terms of technology use, safety, gains in knowledge and regulatory impact. It is certainly prudent for countries to consider all of these issues, starting from the most basic question of why each country wants to include socio-economic considerations into their technology decision-making processes. The debate on expanded use of genetically modified (GM) crops in the developing has included the main clause of socioeconomic considerations in regulatory process through which these crops are approved. Currently, several developing countries are exploring the option of including such considerations in their decision making process. Analysing and defining the process of socio-economic condition is still unclear even to

social scientists and they are groping to find some empirical way to standardise the methodology. A strong technology-assessment methodology must reflect the understanding of all the stakeholders in the value chain of the commodity. These methodology and Implementation strategy is expected to serves as a valuable and timely guide for implementing the socioeconomic assessment of LM technologies as part of the biosafety approval process.

In India, so far the guidelines and methodologies for socio-economic evaluation of LMOs for environmental release for cultivation and entry into the food chain of animals / humans have not been developed and tested. This study will be one of the pioneer to develop such frame work. But given the diversity of India in terms of social, cultural, environmental, and agriculture, the task has been gigantic. RIS has therefore partnered with six other institutions as partners. ICAR-NAARM is one of the partners who is entrusted to work in Telangana region to fulfil the objectives of the project. The study has been conducted in Nalagonda District of Telangana where both the crops viz. Maize and Brinjal is grown in the district. In the selected district based on the prominence of Maize and Brinjal, two Mandals (Block) was selected based on the prominence of both the crop. The advice of KVK Kampasagar was sought in this stage so as to get maximum farmers. From the sampling frame of the villages in two different categories, following villages were selected randomly in next stage. Simple random sampling techniques was used while selecting farmers at the last stage for selection of the farmers. The data was collected on the schedule prepared in consultation with all the partners. Simple frequency table and averages were estimated for the population. Where ever required some graphical analysis was carried out and probit analysis was used for ex-ante adoption studies.

The average age of farmers growing brinjal and maize was 41.1 and 42, respectively. About 38.4 per cent of brinjal farmers were illiterate while only 20 per cent of maize farmers were illiterate. The average household size of brinjal farm household was 4.5 while it was 3.9 in case of maize farm household. The household level illiteracy was higher in case of maize farm households (13.6 per cent) compared to brinjal farm households (8.0 per cent). Only 36.4 per cent of the male member in the brinjal household are engaged full time in their own farm while 65.26 per cent of the female members are engaged full time in their own fields.

Most of the farmers stated that they follow the recommended practices. The average total land holding of brinjal farmers is 1.75 ha and maize farmer is 1.71 ha. The average productivity reported by brinjal farmers were around 517 Q/ha and maize farmers 33.26 Q/ha in 2014-15.

Brinjal farmers preferred to buy hybrids seedlings (64.0 per cent) over buyng seeds and preparing nursery (28.8 per cent) from private dealers. In maize farmers grow mainly hybrids and 75 per cent of them get seeds from private dealers. The major pesticide used is corazen against pests in rice and other vegetables including brinjal. Caldon is used in Brinjal crop against Shoot and fruit borer, Jassid, Whitefly, major pest of Brinjal. However, many farmers use these pesticide on the recommendation of retailer. Carbofuran is one of the most toxic carbamate insecticides but reported to be used maxium in the maize cluster. Farmers in in brinjal cluster do not use any herbicides for weed control. In maize Atrazine (85.6 per cent) and Paraquat (52.8 per cent) are commonly used. Being an advance district in adoption of agri-technology, Use of different type of fertiliser is higher. The major constraints were insect attack (22.4 per cent) in brinjal and in maize insect and weeds were the major constraints.

Total variable cost of Brinjal and maize was about Rs. 91,188 and 28,966 per hectare, respectively. The major portion of this is expended in Insecticides (about 16.94 per cent) in brinjal and 14.24 per cent in weeding (including cost of herbicide, its application and manual weeding). Sensitive analysis reflects that there should also be yield advantage in both brinjal and maize, if benefit cost ratio is to be maintained at present level, assuming that the cost of seeds of GM crop will be more as compared to conventional crops. Farmers were explained about the desired LMO (pest and weed tolerant trait for brinjal and maize, respectively) and asked about their willingness to pay for the seed. About 63.2 per cent and 41.6 per cent of brinjal and maize farmers, respectively, willing to pay more than 50 per cent of seed cost as it not only would give better economic return (tangible) but also improve their lifestyle and reduce cost of health related problems. Presently, Brinjal farmers had reported that they mainly face itchy/water eyes (48 per cent) and maize farmers had faced dizziness (37.6 per cent). Besides, only 5.6 per cent of the brinjal farmers and 6.4 per cent of maize farmers had received training on pesticide application. The source of information was also limited to farmers in both the crops.

Review of literature showed different methods for the sampling used in field research that examines the adoption and impact of Genetically Modified Organisms. The levels include farmer, consumer, trade, and industry. Here we present salient notes from the assessment of farmers. Review indicated that, on average GMO crops provide economic advantages for adopting farmers. There are several methodological limitations associated with these studies which have been identified in most cases by the authors themselves. These limitations have implications for findings and for policy formulation. The majority of studies reviewed used primary field data collected from farmers, farm records, or field trials conducted by researchers. Few ex-ante studies use field data and an econometric estimation to then project potential economic impacts. Most studies focused on Bt cotton.

It is important to point out that the issues, methods, and analysis are intricately interconnected. The issues will determine the methods, which will be limited by the way in which the assessment is conducted within the regulatory system. If the assessment is conducted before deliberate release (ex-ante), there is no adoption to measure and thus no data to be collected on adopters.

This will reduce the portfolio of methods that can be used for the socio-economic assessment. If the assessment is done after deliberate release (ex-post) then the issue becomes designing appropriate data collection approaches that explicitly consider avoiding sampling and statistical bias.
From the study conducted in Nalagonda, we find that the average age of farmers in maize cluster and brinjal cluster were about 41.1 and 42.2. More than 98 per cent of respondent's primary source of income is agriculture. Female labour is more prominent in owned farm and other farms. Majority of farmers are marginal farmers (< 1 ha). Maize is easily infested with different weeds due to many reasons. However, the losses due to these weeds in maize are very high (about 14.26 per cent of cost of cultivation). Weed management is very difficult in early stages of crop. Labour availability is constrained. Therefore, the need for weed tolerant crops are required. LMOs can be one such alternative.

In Brinjal, the major insect is fruit borer. The loss due to this insect is as high as 60 per cent. Insecticides are to be applied at proper time (Flowering stage). Lack of awareness and timely availability of proper insecticide at proper time is the major constraints. Cost of insecticide and its application is also very high (22.5 per cent of cost of cultivation). Corazen, Messile, Caldon, Carbaryl, Copperoxychloride, Fipronil, and Monocrotophos are the major insecticides used in Brinjal crop as advised by the retail chemical store keeper. The need for crops that can have high resistant to such insect attack is the need.

Due to small area under brinjal and maize cultivation farmers seems to be overstated yields and yield attributes. The variability observed was also high for both the crops. Besides variable cost of cultivation was estimated around Rs. 91,118 for brinjal and Rs. 28,897 for maize. Returns to Fixed Farm Resources were nearly three lakhs per hectare and twelve thousand per hectare fro brinjal and maize, respectively. Sensitive analysis reflects that there should also be yield advantage in both brinjal and maize, if benefit cost ratio is to be maintained at present level, assuming that the cost of seeds of GM crop will be more as compared to conventional crops.

Farmers really wanted and alternative crop varieties (HYV, Hybrid, GM etc) in different crops and willing to pay more for seed provided that crop would increase the profitability of the farming. These can be done either by reducing the cost of cultivation or by increasing the yield. Farmers are presently suffering from different health related problem due to use of heavy use of insecticide as they are not aware about the method to use these chamicals. Moreover, they are spending time and money for the treatments. Many farmers feel that GM crops can be useful. Farmers opinion study showed that they are ready to adopt new technologies that would enhance profitability and reduce labour requirement. They also feel that before introducing such crops they should be made aware properly so that they can take all precautions that are needed to raise a genetically modified crop. Some of them had reported offline that they burnt the finger in Bt Cotton when it was introduced without proper awareness. Farmers also are in the opinion that the new varieties (GMOs, LMOs) should have proper environmental safety precautions and government should be very strict in that.

TNAU- Executive Summary

Convention on Biological Diversity (CBD) adopted a decision on socio-economic considerationsto develop conceptual clarity on socio-economic considerations arising from the impact of livingmodified organisms on the conservation and sustainable use of biological diversity in the contextof paragraph 1 of Article 26 of the Cartagena Protocol on Biosafety (CPB). In the above context,the Ministry of Environment and Forests (MoEF) funded a research project on socio-economicimpacts of Living Modified Organisms (LMOs) which is coordinated by Research andInformation System for Developing Countries (RIS), Government of India, in association withselected institutions and Universities. The study involves validating questionnaires, conductingfield survey, organizing and participating in workshops and development of guidelines andmethodologies for socio-economic assessment of LMOs for selected crops in Tamil Nadu. Accordingly TNAU is involved in socio-economic assessment of maize and brinjal forinsecticide resistance and herbicide tolerance with the following specific objectives.

- To participate in all the project related activities including, developing, testing and validating questionnaires, for socio-economic assessment of LMOs in agriculture
- To finalise the sampling procedure for field survey of farmers for data collection on the identified crop and trait
- To compile, tabulate and analysis of the data with appropriate methodologies for socioeconomic assessment of LMOs.
- To prepare of the final report on the guidelines and methodologies for socio-economic assessment of the respective agricultural LMO products.

Selection of Crops and Traits

Maize is the most widely distributed crops of the world. It is cultivated in tropics, sub-tropics andtemperate regions. Maize is an important cereal in many developed and developing countries of the world. It is widely used for animal feed and industrial raw material in the developed countries where as the developing countries use it in general for feed. Maize is one of the important industrial crops in Tamil Nadu which is utilised for food and non-food purposes. Its value chain is diverse from food to poultry feed to different industrial applications. Brinjal is one of the major vegetable crops consumed in Tamil Nadu and in India. Accordingly TNAU is involved in socio-economic assessment of maize for insecticide resistance and herbicide tolerance and Brinjal for insecticide resistance.

Field Survey and Data Collection

Field survey was designed based on the maximum area of the selected crop cultivated in the state. Accordingly the district wise triennium areas of the selected crops were collected. Salam District grows maximum area of irrigated maize and Brinjal and hence Salam District was selected for the study.

Developing Questionnaires

Developing testing and validating questionnaires for conducting field survey is part of the project. Accordingly TNAU submitted draft questionnaire to RIS for approval. After several revisions and contributions from other participating institutes the final questionnaire was developed. The final questionnaire was used as the survey tool for field survey for data collection for socioeconomic assessment of LMOs.

Trait valuation

The process of identifying and describing the benefits due to the trait which a crop variety possesses and attaching a value to it is complex. The major problems faced by the maize farmers in the state are the incidence of weeds and pests like stem borer. The study attempts to investigate whether the proposed Bt variety with traits that reduce the incidence of pests and weeds in the maize crop would be economically beneficial to the farmers. There are many methods in the literature to value the trait depending upon the data availability and also the stage of the introduction of the trait such as ex-ante or ex-post. In the present study the trait valuation is attempted in an ex-ante situation with no data on the performance of the proposed traits in the identified crops. Researchers have adopted different approaches in assessing a trait value. Selection of particular method depends on the nature of data available, trait(s) in consideration, purpose for which valuation is done, etc. The methods include Partial Budget Analysis (PBA), Choice Experiment Approach, Distributional Impact of GM Technology through Economic Surplus Model and decomposition model. In the present study, considering the data availability partial budget analysis was applied to arrive at trait valuation, with suitable assumptions.

Salient Findings

Maize

Among the selected maize farmers, 60 per cent the area was cultivated with maize in *Kharif* and 67 per cent of the area was cultivated in *Rabi*. The average yield per hectare of maize is 77.75 quintals in *Kharif* and 80.50 quintals in *Rabi*. The major constraints in maize cultivation included rising cost of inputs, incidence of weeds, low price for the output and lack of availability of labour. Average Price Received for maize grains was Rs 11.16 / kg in *kharif* and Rs. 12.25 / kg in *Rabi*. Major components in cost of cultivation were labour and inorganic fertilizer. The important Maize varieties grown included NK 6240, Gargil 900, CP 818, NK 6668, Pioneer 3546, CP 828, Pioneer 828, AP 244. Average quantity of seeds used in *Kharif* and *Rabi* seasons are 19.92 kg and 19 kg respectively per hectare of maize. Choice of varieties was based on its high yield, good germination and also for its quality grains and higher grains filling. Weed incidence was reported in every season with medium intensity during vegetative and flowering stage. The yield loss perceived was 11-20 per cent both in *Kharif* and *Rabi* seasons. Farmers used Atrazine (pre- emergence) and 2,4D (post-emergence) for weed control, with average quantity and price being Atrazine: 1.32 kg & Rs. 378.10 (*Kharif*) 1.23 kg & Rs. 363 (*Rabi*) and 2,4-D: 1.29 kg & Rs. 382.50 (*Kharif*) 1.20 kg & Rs. 360.83 (*Rabi*). The major pests of maize was stem borer, cob worm and stem fly (low to medium severity). 78.33 per cent of farmers resorted to chemical method of control. For Chemical Management of pests in Maize farmers used different chemicals such as Monocrotophos (Phoskill), Cartap hydrochloride (Caldan 50 SP), Indoxacarp (plithora), Chlorantraniliprole 18.5 per cent SC (coragen), Thiodicarb 75 per cent WP (Larvin), Emamectin benzoate (Elpida). The average quantity and price of the pesticides used for stem borer management is 481.66 Ml per hectare and Rs. 829 per hectare (*Kharif*); 510.83 Ml per hectare and Rs. 729.66 per hectare (*Rabi*). GM Trait valuation: Net change in income per hectare due to new traits in GM Maize (*Kharif*) varies from 5028.62 to 13705.52 [with an assumed yield increase from 5 to 15 per cent and 20 per cent increase in seed cost]. Net change in income per hectare due to new traits in BT. Maize (*Rabi*) varies from 5549.05 to 15410.31 [for yield increase from 5 per cent to 15 per cent and 20 per cent increase in seed cost]

Brinjal

Among the selected maize farmers, 18 per cent the area was cultivated with brinjal in *Kharif* and 26 per cent of the area was cultivated in *Rabi*. The average yield of brinjal per hectare was 18 tons in *Kharif* and 19 tons in *Rabi*. The major constraints in brinjal cultivation included rising cost of inputs, incidence of weeds, low price for the output and lack of availability of labour. Average quantity of seeds used in *Kharif* and *Rabi* seasons are 365.71 g per hectare and 370.10g respectively. Choice of varieties was based on its high yield, good germination and quality fruits. Weed incidence was reported in every season with medium intensity during vegetative & flowering stage and farmers attributed 11-20 per cent (both *Kharif* and *Rabi*) yield loss due to weeds. Weedicides used for chemical management of weeds included Pendimethalin and Oxyfluorfen (pre- emergence) and Quizalofop ethyl (post-emergence). The Average Quantity & price of the pre- emergence herbicides was 2110.24ml & Rs. 1674.42 (*Kharif*) and 2185.40 ml & Rs. 1740.05 (*Rabi*). The Average Quantity & price of the Post-emergence herbicides was 879.04 ml & Rs. 1420.09 (*Kharif*) and 865.83 ml & Rs. 1274.20 (*Rabi*). Major pests in brinjal are shoot and fruit borer, leaf hopper, epilachna beetle and red spider mites (high severity). All the farmers resorted to chemical method of pest control. The chemicals used for pest control include Triazophos 40 EC, Novaluron, Cartap hydrochloride, Spinosad 45 SC etc. The average quantity and price of the pesticides used for shoot and fruit borer management was 6034.35 Ml per hectare and Rs. 33801.89 per hectare (*Kharif*) and 6047.43 Ml per hectare and Rs. 38092.57 per hectare (*rabi*) GM Trait valuation in GM brinjal variety: Net change in income per hectare due to new traits in GM brinjal variety in *Kharif* season varies from Rs. 63667.80 to Rs. 123508.98 [with an assumed yield increase from 5 to 15 per cent and 20 per cent increase in seed cost]. Net change in income per hectare due to new traits in GM brinjal variety in *Rabi* season varies from 64440.53 to 117247.13 [for yield increase from 5 per cent to 15 per cent and 20 per cent increase in seed cost] GM Trait valuation in GM brinjal hybrid: Net change in income per hectare due to new traits in GM brinjal variety in *Kharif* season varies from Rs. 72653.48 to Rs. 151385.24 [with an assumed yield increase from 5 to 15 per cent and 20 per cent increase in seed cost]. Net change in income per hectare due to new traits in GM brinjal variety in *Rabi* season varies from Rs. 74666.31 to Rs. 148837.83 [for yield increase from 5 per cent to 15 per cent and 20 per cent increase in seed cost]

Farmer Knowledge and Risk Perception about LMOs

All the farmers in both the crops are willing to cultivate LMO with desired traits. They are willing to pay upto 25 per cent extra cost for GM seed in Maize and 30 per cent in case of Brinjal. Most of the farmers expect 25 per cent increase in yield in case of Maize and 50 per cent increase in yield in case of Brinjal.

Majority of farmers did not experience any health problem during insecticide spray and about 30 per cent of farmers received training on use of pesticides from KVK/research institutes. None of the farmers in both the crops used any kind of gloves, Protective clothing/boots while spraying. But farmers consider Wind direction while spraying chemicals. Most of the farmers disposed chemical containers by throwing away. Farmers usually did not eat while spraying but they used to drink water. All the farmers washed hands after applying chemicals. Majority of the farmers used recommended dose of insecticides and herbicides.

Knowledge about LMOs

All the Maize farmers and 93 per cent of Brinjal farmers were aware about GM crops (Cotton). More than 90 per cent of both the farmers have cultivated Bt Cotton and all of them were of the opinion that GM Cotton gave higher yield. Most of the farmers felt around 25 per cent increase in income due to GM Cotton cultivation. All the Maize farmers need GM hybrid and 75 per cent of Brinjal farmers desired to have a GM trait in a variety. Both the Category of farmers desired to have GM trait against Sucking and Lepidopteral pest and herbicide tolerance. Farmers in general did not have any idea on adverse effect of GM crops on human, on livestocks or on environment. All the Maize farmers and 77 per cent of Brinjal farmers were willing to adopt proposed GM crop with desired trait.

UAS, Raichur- Executive summary

World's population is increasing with alarming space and the growth of food production is becoming stagnant. The industrial developmental activities and urbanisation are swallowing fertile and productive lands which results in decreased availability of land for the farming. The challenge for more populous nations like China and India is to increase the food productivity with the available arable and fertile land.

Traditional breeding and agronomic practices have made tremendous changes in the food grain production scenario of India and brought the country from ship to mouth existence to self sufficient state through green revolution in 70s, however, now it is difficult to increase food production further only by traditional means. Now the biotechnology tools *viz*., DNA Marker Technology, Genomics and Transgenic Technology are imperative to complement with the traditional breeding techniques to achieve this herculean task of attaining nutritional and food security for ever growing population of the country.

The living organisms which possess a novel combination of genetic material obtained through the use of modern biotechnology are referred to as Living Modified Organism (LMOs) or Genetically Modified Organism (GMOs). The LMOs of major economic crops, specifically soybean, maize, rape (canola) and cotton, were first grown commercially in 1996. Since 1996, when farmers first commercially planted LMOs, the area under these crops has raised more than hundredfold from 1.7 m ha to 181.5 m ha (from 1996 to 2014). Currently, the global area of LMO crops continued to increase for the 19th year at a sustained growth rate of 3 to 4 per cent or 6.3 million hectares (~16 million acres), reaching 181.5 million hectares or 448 million acres around the world. Biotech crops have set a precedent in that the LMO crop area has grown impressively every single year for the past 19 years, with a remarkable 100-fold increase since the commercialisation began in 1996. Thus, LMO crops are considered as the fastest adopted crop technology in the history of modern agriculture (James, 2014).

According to recent data India has the fourth largest area planted under Genetically Modified (GM) crops mainly the *Bt* cotton. Farmers in India planted a total 11.6 million hectares (m ha) under LMOs/GMOs in 2014, behind the corresponding areas for Argentina (24.3 m h), Brazil (42.2 m ha) and the US (73.1 m ha). The LMO crop acreage in India far surpassed China's 3.9 m h, while equalling that of Canada's 11.6 m ha. Significantly, the entire 11.57 m ha LMO crop area in India consisted of *Bt* cotton. Nearly 96 per cent of the country's cotton area is now covered by *Bt* hybrids. *Bt* technology has helped India to treble its cotton output from 13 million bales in 2002 (when it was introduced) to 40 million bales in 2014.

Intellectuals across the world are coming together to discuss the next steps to fight global hunger and malnutrition, at the same time transgenic crop solutions are being find out for various traits such as drought tolerance, nitrogen use efficiency and yield improvement. By adoption of biotechnology, some countries have been able to have many breakthroughs like deployment of insect resistant crops by various countries has increased the productivity and reduced the pesticides usage which interns lower the damages to the environment. Furthermore, biotechnology has also increased areas under forest cover, as the need for deforestation has reduced significantly. Hence, in our country also we need to extend GM technology to more crops, and also encourage PPPs, so that our farmers benefit from competition and faster commercialisation.

In the light of the above background, the present study was executed to assess the socio-economic implications of LMOs i.e. *Bt* cotton in comparison to traditional or pigeonpea i.e. pigeonpea (because of non availability of non-GM variety of cotton, the traditional crop of the region was taken for comparison) in Hyderabad Karnataka region.

Objectives

- To assess increase in yield / productivity
- To assess the reduction in use of insecticides / pesticides
- To assess the health benefits of LMOs
- To analyze the economic gains for farmers
- To assess the impact of seed prices on overall cost and changes in yield
- To assess the impact of LMOs on labour (men & women)

The results of the present study would be useful in finding out the facts in the existing situations in the cultivation of LMOs i.e. *Bt* cotton and pigeonpea i.e. pigeonpea and their impact on income and employment in agriculture. It would also help the scientists / researchers to know the perception of farmers about LMOs and to know the GM technology knowledge level among the stakeholders. Also help the planners and policy makers in identifying the problems in the LMO crop cultivation and to find out possible remedies for the same.

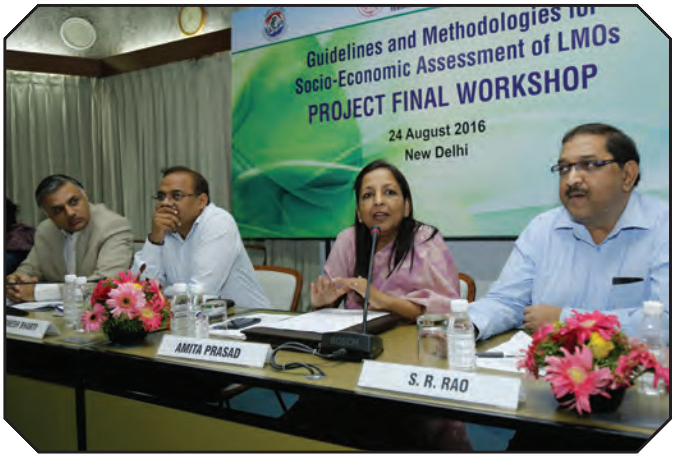
This study was conducted in Central and Northern Dry zone of Karnataka. The data for the study was collected from different stakeholders related to LMOs crop cultivation *viz.*, farmers, farm labourers, traders / input dealers and academicians / researchers. The source of data is a primary source from all the stakeholders collected through the personal interview with pre defined schedule.

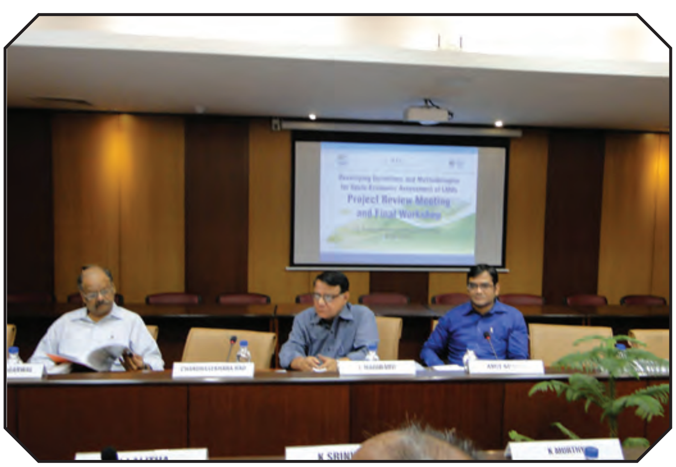
The data collected through these investigations were analyzed on the computer and compiled in simple tabular form. The statistical tools, such as the total numbers, averages, percentages, ratios and Garrett Ranking were used to arrive at the results.

Major findings of the study

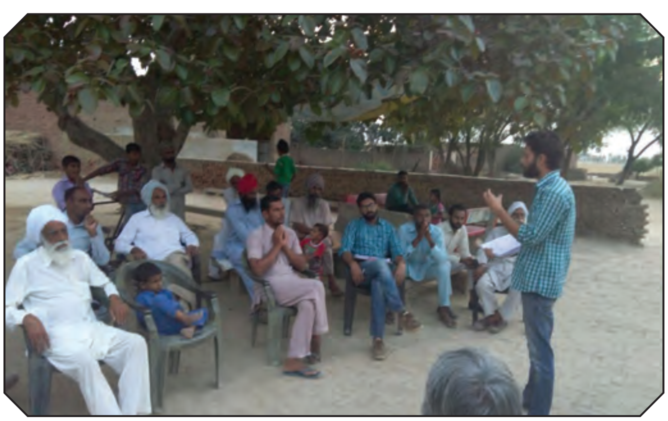
1. Most of the farmers in the study area have adopted LMO crop recently *i.e.* less than 5 years (70 per cent) and only some farmers are cultivating LMO crop (Bt cotton) since from 8 years (30 per cent).
2. From the study it is clearly understood that the cost incurred on inputs is high (Rs. 7869.40) in LMO crop (Bt cotton) as compared to non-Bt cotton (Rs. 4447.09) and pigeonpea (Rs. 5586.19).
3. The study clearly indicated that LMO crop provides more employment opportunity for both men and women labourers as compared to pigeonpea.
4. It was observed that the area under LMO crop in the study area is increasing despite the decline in the yield level or productivity of crop over the years.
5. The extent of application of plant protection chemicals was relatively higher in case of pigeonpea as compared to LMO crop.
6. The cost of cultivation incurred per acre in Bt cotton (Rs. 32695.28) was marginally higher than non-Bt cotton (Rs.28491.48) and pigeonpea (Rs.19845.98) the net returns accrued was also higher in Bt cotton, which was mainly due to higher level of yield.
7. The returns to per rupee of investment worked out to be higher in the case of Bt cotton (1.38) as compared to non-Bt cotton (1.18) and pigeonpea (1.17).
8. From the study it was observed that farmers have good opinion about the LMOs and they are ready to accept if *Bt* came in their pigeonpea provided it's should be scientifically proved that it's not harmful to them and their live stock.

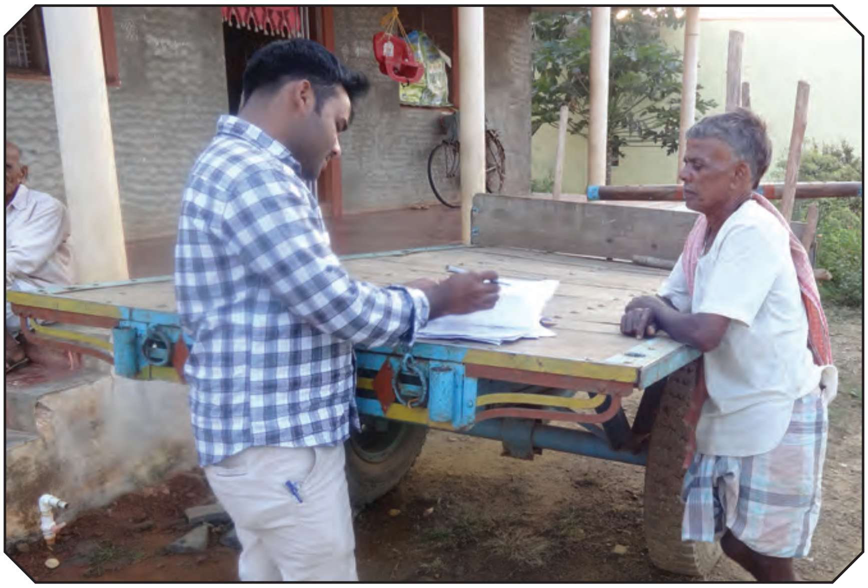
Glimpses of the Project Meetings and Field Surveys






TAKEHOLDERS' WORKSHOP
ON
-ECONOMIC CONSIDERATIONS FOR GENETICALLY MODIFIED CROPS
MAY 26, 2015
ORGANISED BY
DEPTT. OF EXTENSION EDUCATION, PAU, LUDHIANA
DIVISION OF EXTENSION EDUCATION ICAR-IARI, NEW DELHI





प्रकृतिः रक्षति रक्षिता

Nature Protects if She is Protected

Ministry of Environment, Forest and Climate Change
Government of India

PROJECT PARTNERS

RIS
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