Adopting GM crops? A Social Multi-Criteria Evaluation for the Case of Cotton Farming in Turkey

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Abstract

This paper uses social multi-criteria evaluation (SMCE) as a powerful, transparent and pluralistic methodology for analyzing a complex and conflicting problem: the decision about the approval and adoption of GM cotton farming in Turkey. At this aim, four cotton farming alternatives including business as usual (BAU), ecological farming (ECO), GMO farming (GM) and good agricultural practice (GAP) are evaluated using a set of environmental, social and economic criteria chosen based on an extensive review of cotton and GMO literatures and several in-depth interviews with key stakeholders and experts. Such an analysis showing the socioeconomic and environmental implications of different farming practices and their consequences for different constituencies provide a rich background for policymaking within a multi-layered system of governance. The paper also offers insights to public decision-makers of other potential GMO adopting countries regarding the adoption of GM crops and the allocation of public funds among alternative agricultural practices.

JEL codes: Q18, Q28, Q34, Q38, Q51, Q57, Q58

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1- Introduction

Recent debates over the genetically modified organisms (GMO) show once again the difficulties of public policy-making in cases where, as stated by Funtowicz and Ravetz (1994), facts are uncertain, values in dispute and decision stakes high. As an alternative to the traditional one-dimensional decision making framework, this paper uses social multi-criteria evaluation (SMCE) as a powerful, transparent and pluralistic methodology for analyzing a complex and conflicting problem: the decision about the approval and adoption of GM cotton farming in Turkey.

At this aim, four cotton farming alternatives including business as usual (BAU), ecological farming (ECO), GMO farming (GM) and good agricultural practice (GAP) are evaluated using a set of environmental, social and economic criteria (namely, agro-biodiversity, unintended gene flow potential, greenhouse gas emissions, market competitiveness, impact on public health, rural employment, farmers' profit, input providers' profit and current account deficit) chosen based on an extensive review of cotton and GMO literatures and several in-depth interviews with key stakeholders and experts. Such an analysis showing the socioeconomic and environmental implications of different farming practices and their consequences for different constituencies provide a rich background for policymaking within a multi-layered system of governance. The paper also offers insights to public decision-makers of other potential GMO adopting countries regarding the adoption of GM crops and the allocation of public funds among alternative agricultural practices.

The paper is structured as follows. After this introduction, Section 2 briefly discusses the global trend in relation to GM adoption and introduces some related controversies related with the GM issue. In Section 3, SMCE is proposed as a useful framework for analyzing the GM adoption problem. Section 4 looks at the case of Cotton Farming in Turkey as an illustrative example of analyzing the GM issue within the SMCE framework. In this context, Section 5 presents the methodology in general and introduces the evaluation criteria. Section 6 presents the results in general, which are elaborated in Section 7. Section 8 concludes.

2- GM Adoption as a Global Trend and Some Related Controversies

Since the first commercialization of the Genetically Modified (GM) crops in 1995 in USA, many countries have adopted the GM crops (ISAAA, Global Status of Commercialized Biotech/GM Crops: 2009 The first fourteen years, 1996 to 2009, 2009). GM Crops are now farmed in 25 countries in an area of more than 130 million hectares (see Appendix 1). In this context, as (Qaim, 2005) notes "this is the fastest diffusion of any new crop technology in the history of humankind", mainly as a result of higher income prospect of GM adopting farmers given the reduced pest control (and in some cases, higher yields – especially in developing countries) (Brookes & Barfoot, 2009).

Despite high adoption rates in the world in general, public debates and controversies about GM crops still continue, especially within European Union. The two major concerns about the new advances in biotechnology are the Intellectual Property Right related problems (affecting mostly the small scale farmers) and the new environmental and health risks associated with this new technology (Qaim, 2005) (Falkner, 2000). Hence, new institutions are required to deal with the IPRs and risk assessment issues. In the EU, for instance, recent efforts gave pace to the formation of the Cartagena Protocol on Biosafety, a protocol which establishes international rules for trade in GMOs, reinforces the right of importing countries to reject GMO imports on environmental or health concern grounds and promotes the *precautionary principle* (Falkner, 2000).

Given the multifaceted nature of the issue and plurality of values, the decision about the approval and adoption of GM farming is not an easy one. The traditional decision frameworks (one dimensional cost-benefit analysis, valuation studies, and profit maximization) become non-functional considering the complexities, uncertainties and incommensurability of the issue. Hence new decision making frameworks and methods, combining both participatory and scientific approaches, are needed in order to better assess the GM adoption decision. At this juncture, this study proposes, the Social Multi-Criteria Evaluation framework, for analyzing such a complex and conflicting issue.

3- SMCE as a Useful Framework for Evaluation of Adoption of GM Crops

The need to develop a pluralistic methodology with which to approach complex decision problems, wherein different evaluation perspectives should be considered, is one of the main reasons why multi-criteria analysis has been put forward as a promising, and appropriate, framework for dealing with real world problems. To reiterate what was said in the introduction, the real world is complex, and multiple-identities are present, and as Roy (2005) suggests, a choice of a mono-criterion decision analysis may (i) lead to wrongly neglecting certain aspects of realism; (ii) facilitate the setting up of equivalencies, the fictitious nature of which remains invisible; (iii) tend to present features of one particular value system as objective.

Given that the search for a collective process of decision-making involves moral, scientific and cultural, as well as political and economic, inputs, there a need to give a ‘voice’ to a range of non-reducible indicators (technical incommensurability) and to legitimate understandings and values (social incommensurability). In this context, MCDA methods rather than focusing on finding an optimal solution subject to a constraint search for a compromising solution. (Guitouni & Martel, 1998). In this sense, they avoid the problems of mono-criterion decision making by (i) delimiting a broad spectrum of points of view likely to structure the decision process regarding the actors involved; (ii) constructing a family of criteria which preserves, for each of them, without any fictitious conversion, the original concrete meaning of the corresponding evaluations; (iii) facilitating debate on the respective role (weight, veto, aspiration level, rejection level, etc) that each criterion might be called upon to play during the evaluation process. (Roy, 2005).

In fact, the GM farming issue is a typical problem of our millennium where uncertainties and decision stakes are high, values are in dispute and urgent decisions are needed (Funtowicz & Ravetz, 1994). In this context, Social Multi-criteria Evaluation (SMCE), among a set of MCDA methods (such as MCDM[1], PMCE[2], SMCDA[3]), proposed by Munda (2004) seems to be an adequate framework in dealing with a complex decision problem and assuring the quality of decision making process since it is *inter/multi-disciplinary* (with respect to the research team), *participatory* (with respect to the stakeholders) and *transparent* (since all criteria are presented in their original form without any transformations in money, energy or whatever common measure) at the same time. (Munda, 2004). The main goal of this paper is to show the potentialities of a SMCE framework for dealing the GM adoption problem. To achieve this, a real world case is used: The Cotton Farming Case in Turkey.

4- Cotton Farming in Turkey as an Illustrative Example

For years, agricultural policies in Turkey were economic growth oriented and environmental concerns were not seen as important, and in fact, this was the case in other developing countries just after the green revolution. Yet, growing environmental problems inevitably called for a change in the agricultural policy priorities of Turkey (Karapinar, 2010). Today, the one-dimensional, income generation oriented farming system is more and more questioned and there is a quest for multi-objective policy making system.

Looking at the current situation in the agricultural sector in Turkey, it is seen that around 30% of the population still lives in rural areas and the arable land, which is limited in size, is used intensively

[1] Multi-Criteria Decision Making
[2] Participative Multi-criteria Evaluation
[3] Stakeholder Multi-criteria Decision Aid

used. The majority of the rural population usually lives on land which is inadequate in area and insufficient in quality, sometimes as sharecroppers, or in small family enterprises with backward techniques, weak market relations and low-level productivity. Moreover, both the pressures brought about by rapid population growth and problems in inheritance lead to smaller divisions of agricultural enterprises, particularly in the traditional regions.

Therefore, Turkey, as country who did not benefit fully from the conventional applications of the Green Revolution—unlike for instance the South Asian countries—faces a big challenge of closing the agricultural technology gap with other countries. In this context, it is generally argued that the new advances in the agro-biotechnology may help Turkey to fill this gap with other countries (Karapinar & Temmerman, 2010). Yet, considering the controversies about the biotech crops, the agricultural policy making for Turkey becomes even more difficult.

Here, a particular discussion involves that of cotton farming given the fact that Turkey's economy is dominated by the textile industry and the basic raw material of the textile industry is cotton. (Ozertan & Aerni, 2007).

Today, concentration of cotton production in Turkey is located mainly in four regions, namely, Ege (Aydın, Izmir), Antalya, Çukurova-Adana and Güneydoğu Anadolu (South-eastern Anatolia)—especially in Şanlıurfa. (Ozertan & Aerni, 2007) and only Upland or American cotton (G.hirsutum L.) is grown, amounting to an estimate level of 1.820 million tons of unginned and 673.4 thousands tons of ginned cotton4 (TUIK). Although Turkey is one of the major cotton producers in the world (7th largest producer in 2007 (FAOSTAT)), it is also a very major cotton importer (946.2 thousands tonnes in 2007 ((FAOSTAT)) since the domestic production levels cannot match the needs of the textile industry.

The biotech discussions were first introduced to Turkey's agenda in the late 1990s. The first legal document on the issue was that of the Ministry of Agriculture and Rural Affairs' (MARA) instruction on "Field Trials of Transgenic Culture Crops" published in 1998, followed then by several field trials

[4]The 2008 figures can be misleading because of the bad precipitation conditions, driving down the productivity to the levels of 368 kg/Da from levels of 425 kg/Da . In 2007, the figures were 2.275 million tons of unginned and 867 thousands tons of ginned cotton.

for different crops (e.g. cotton, corn, potato)[5]. Turkey signed the Cartagena Protocol on Bio-safety in 2000 and became liable for making the necessary legislation. Between 2001 and 2005, MARA carried out the legislative work and the draft National Biosafety Law was finally formed in 2005. Yet, the draft law come to the national assembly just recently and was fully legalized in March 2010. The current legislation is largely based on Cartagena Biosafety Protocol, putting the precautionary principle in the center of the regulations (Kivilcim, 2010). While there are currently no authorized GM crops in Turkey (neither for farming, nor for importing only), local NGOs and related institutions claim that large amounts of GMOs (and derived products) are imported (Demirkol, 2010).

Looking at the social actors involved in the biotech debate in Turkey, one can mention, MARA (Government), Seed Producers, Farmers, NGOs (No-to-GMO Platform) and Consumer Associations. The No-to-GMO platform is formed by many domestic and international non-governmental organizations such as Greenpeace, Chamber of Agricultural Engineers (ZMO), Farmers' Union, many academicians and other 70 NGOs, as of November 1, 2009 (GDO'ya Hayır Platformu).

5- Methodology: Fieldwork

The cotton farming alternatives to be considered for Turkey and the relevant evaluation criteria are determined based on a review of the Agro-Biotech literature and X in-depth interviews conducted with experts, representatives of governmental and non-governmental institutions and cotton farmers in (for a list of interviews, see Table 1 in Appendix 1)

As is well known, there are two main farming techniques in the cultivation of crops. These are:

- *Extensive methods* – where products are generated by altering the ecosystem. Utilization of external inputs is very limited and an increase in production is only possible by increasing the farm size (Gregory, et al., 2002)
- *Intensive methods* – where several land management options, such as degree of land preparation, choice of germplasm, use of external nutrients, use of irrigation and pest and

[5] However, the results of these field studies were not officially disclosed until May 2009, when a partial disclosure is made about the places and methods of the field trials, following a legal petition by the No-to-GMO platform.

weed control methods, are used to produce more product per area of land already used for agriculture (Gregory, et al., 2002).

These main farming techniques are relevant for cotton farming as well and all cotton farming alternatives are in a way the sub-forms of these two general methods given their degree of intensification. In this context, six alternatives can be considered for cotton farming in Turkey (either currently practiced or may be practiced) and these are presented in Figure-1 by using the categorization of Gregory *et al* (2002) and Stirling & Mayer (2000).

<<Insert Figure-1 Here>>

1- Ecological (Organic) Farming (ECO) – All farming activities are in line with the organic farming standards of the European Union. As such, no synthetic chemicals are used in crop production and this is certified by the monitoring institution.

2- ECO with GM Seeds – Ecological farming with the genetically modified germplasm choice.

3-Business as Usual (BAU) – Status quo in cotton production given the current practice with all its deficiencies and problems.

4- BAU with GM seeds – Business as Usual with the genetically modified germplasm choice

5-Good Agricultural Practice (GAP) –The reformed version of BAU towards a more efficient use of resources and inputs within an integrated pest management (IPM) framework. IPM is defined as "a procedure to manage pest populations by harmonizing control methods such as natural enemies, pesticides and cultural practices" (Uhm, 1999). This procedure limits the use of chemicals but does not ban. The purpose of IPM is not to remove all of the pest population but manage and control them in such a way that environmental side-effects are minimized (Uhm, 1999).

6- GAP with GM Seeds – A different version of GAP where genetically engineered seeds are used within an integrated pest management framework. In this context, there are additional rules for pre-release and post-release monitoring of the cotton and product labeling. Also, there are refuge zone requirements for preventing the development of pest resistance.

While this is the whole set of alternatives, it is important to note that not all these alternative practices are feasible in the Turkish case. For instance, under the current organic farming laws, ECO-GM option is not a viable option. As such, the following selection procedure is followed to determine the final set of feasible alternatives for this study.

First of all, all of the methods which are currently practiced are taken into account. Second, methods that are not currently practiced in Turkey, but still feasible under the current circumstances, are taken into account as well. It is also assumed that all theoretically possible methods are practiced in their best possible manner. The best practice assumption is necessary to control for the effect of human actions and provide an equal comparison basis for the alternatives.

Following the above procedure, as already mentioned, ECO-GM option is eliminated since it is not theoretically possible to practice such an alternative given the organic farming regulations of the European Union (EC Regulation, No 834/2007, Article (9), 2007)**.** BAU-GM is eliminated as well since though theoretically feasible, it is not a best practice.

BAU-Non GM is taken into as the business as usual alternative. GAP-Non GM and GAP-GM options are theoretically feasible alternatives and as such are considered as relevant for the Turkish case.

The final set of alternatives is as follows:

1- Ecological Farming (ECO)
2- Business as Usual (BAU)
3- Good agricultural practice (GAP)
4- GAP with GM (GM)

Table-1 gives a detailed description of each alternative considered based on Gregory *et al* (2002) categorization[6].

<<Insert Table-1 Here>>

Evaluation Criteria

In identifying the suitable evaluation criteria by which to judge these alternative policies, care was taken to cover all the important aspects of the problem at hand given the diversity of interests. First, based on the literature review for GM and Cotton Farming, a first set of preliminary criteria was determined taking into account the ecological, social, and economic dimensions. Then, experts and stakeholders were consulted through in-depth interviews, in order to:

- to reveal the most important criteria of the interviewee and to determine the relative relevance of the other criteria and,
- to check whether any important criteria was eluded from the preliminary criteria set selected by the authors.

While deciding on the final set of criteria, it was important to ensure non-redundancy of all criteria as well. The final set of evaluation criteria is given in Table-2.

<<Insert Table-2 Here>>

[6] This table differs from the categorization of Gregory *et al* (2002) in the sense that our alternatives do not vary according to their utilization of water resources and irrigation techniques but rather according to their harvesting technique. We are not using water usage since;

- using different irrigation techniques for different alternatives would not permit us to isolate the marginal impacts of germplasm choice, and
- best practices are assumed in all four alternatives and that means best irrigation technology available is used in all four of them.

5.1 – Construction of Multicriteria Impact Matrix

5.1.1 – Ecological Dimension

Agro-Biodiversity

Taking into account the four dimensions of agrobiodiversity already mentioned, namely (i) the number of species in a given environment, (ii) the genetic variation within species, (iii) the preservation of the habitat and (iv) the cultural diversity, it is possible to specify a measurable criteria under each dimension.

(i) **Number of species in a given environment:** Considering the agricultural practices, the number of the species is negatively affected by two things; pesticide usage and the extent of the land used for agriculture. The negative impact from the use of pesticides can be measured by *the Environmental Impact Quotient (EIQ) of the chemicals* and the negative impact from the land use can be measured by *the area of land used for unit production.*

(ii) **Range of genetic variation within species**: This aspect is related to the use of germplasm and is measured by *the loss of genetic variation within species*.

(iii) **The preservation of the habitat:** The habitat preservation has two different facets: The preservation of the wild habitats and the wise management of the habitats modified for human use. For the first facet, *the area of land used for unit production* will be used as the measurement criterion. For the management of the altered habitats, the *EIQ of the chemicals used* is appropriate since the farm habitat management is directly related to the synthetic chemical usage.

(iv) **The cultural diversity:** The cultural diversity dimension is crucially important for the agrobiodiversity (Srivastava, Smith, & Forno, 1996; Brookfield & Stocking, 1999; FAO, 2004) and the *loss of indigenous knowledge* is used here as the measurement criterion.

Taking into account all these sub-criteria with the objective of maximizing the agro-biodiversity, we have the following ranking of our alternatives: $\mathbf{AgBIO_{ECO} > AgBIO_{GAP} \approx AgBIO_{GM} > AgBIO_{BAU}}$ (For details, see the Appendix **A2-1.1**)

Unintended Gene Flow Potential

The complex structure of the ecosystem makes it impossible to measure the exact probability of gene flow and therefore in the literature it is more common to look at whether the probability of the unintended gene flow is greater than zero or not. In such a binary outcome context, the probability of gene flow appears only in the GM alternative.

<<Insert Table-3 Here>>

Greenhouse Gas Emission

Considering that alternatives perform same for the tertiary sources, only the primary and secondary sources of emissions mentioned by Lal (2005) are taken into account as the most important agricultural GHG emission sources. After the evaluation, the final ranking is formed as $\mathbf{GHG_{ECO}>GHG_{GM}>GHG_{GAP}>GHG_{BAU}}$.

ECO performs better than GM since it has neither machinery use (for spraying and harvesting) nor chemical use. GM performs better than GAP since there is less machinery use for spraying purposes and also GM has a greater potential[7] for applying no-tillage or conservation tillage activities. Moreover, GM uses fewer pesticides and hence contributes less in terms of the secondary sources as well. Lastly, with the greater use of chemicals (and hence greater need for spraying), BAU performs the worst since it contributes more from both primary and secondary sources.

5.1.2 Social Dimension

Impact on Public Health

We consider two sub-criteria to calculate the impact of the alternatives on public health. These are the *Health impact of the chemical input* and *the degree of uncertainty in relation to health impacts.* Considering these two sub-criteria, we have the ranking as $\mathbf{HI_{ECO}<HI_{GAP}<HI_{BAU}=HI_{GM}}$ (See Appendix **A3-2.1** for details.)

[7] In our field study, we observed that farmers are not very aware of the conservation or no-tillage technologies. Interviewed experts (Eser, 2009) claimed that No-Tillage technology is not suitable for Turkey (nedenini belirtebilirsin) under the current circumstances, yet we believe that there is a possibility of adopting this technology in the future.

ECO has the minimum impact on health since there is no chemical use and no uncertainty of impacts. Comparing GAP and BAU (having the same uncertainty levels), we see that GAP performs better since the chemical input is lower than BAU. Lastly, GM and BAU are considered to have the same health impact. Although the health impact of GM related to chemical use is much lower, the uncertainty related to GM products worsens the ranking of GM. The uncertainty level is chosen such that the final impact is the same as the current practice (BAU) following the ENTRANSFOOD project results (Kuiper, König, Kletera, Hammes, & Knudsen, 2004).

Level of Competition in Agricultural Input Market

There are two dimensions of the competition in input providing market: The number of total input providers in the market and the distribution of the market shares of these providers. The first dimension refers to the monopolization level of the market and the second dimension refers to the dependency of the farmer to a specific provider.

Taking into account these two dimensions, we have the following ranking:

$\mathbf{CL_{ECO}>CL_{GAP}>CL_{BAU}>CL_{GM}}$.

In BAU, since farmers can retain their seeds, they can be the seed provider of themselves and of other farmers. Moreover, in conventional agriculture, seed production market entry costs are lower given that conventional seed provision is easier than GM seed provision, and therefore the number of input providers in the market is higher. In contrast, GM requires the purchase of the seeds and chemicals as a bundle from the same company. So, in GM farmers are more dependent to a specific provider and the number of providers is limited due high entry costs. Hence, BAU performs better than GM in overall ($CL_{BAU}>CL_{GM}$).

In relation to GAP-BAU comparison, in BAU, farmers are more dependent to chemicals and hence to the input provider firms than they are in GAP, so BAU performs worse than GAP ($CL_{GAP}>CL_{BAU}$).

Lastly in ECO, farmers do not use any chemicals and are not obliged to buy any organic seed from the input providers and as such they have no dependency in real terms on input provider. ($CL_{ECO}>CL_{GAP}$)

Rural Employment

For the evaluation of the alternatives in terms of rural employment, the labor intensity of the alternatives is used as a measure. Following this measure, we have the ranking as

$\mathbf{RU_{ECO} > RU_{BAU} \geq RU_{GAP} \geq RU_{GM}}$

Labor may be used in farming as an input for plant protection (spraying and pecking), harvesting, irrigation and other minor activities. ECO uses labor in plant protection in the form of pecking since use of pesticides is not allowed. Moreover, harvesting is also obligatory to be practiced manually since use of chemicals required for mechanical harvesting is not allowed in ECO. Therefore, ECO has the highest rural employment opportunities as it has the most labor requirement. Comparing BAU and GAP, we see that GAP need less labor thanks to less chemical use, i.e. less spraying labor and they do not differ with respect to other labor sources. And lastly, GM has the least labor usage since it uses even lesser labor in spraying than GAP.

5.1.3 – Economic Dimension

Farmers' Profit

Looking at the profit function of the farmer in section 3.13, we note that there are three main determinants affecting the profit of an ordinary farmer: Price (TL/Kg), Cost (TL/Ha) and Productivity (kg/Ha). These three parameters have different values for the four alternatives in our setup. Therefore, by choosing the proper alternative, the farmer can maximize her profit.

After collecting and examining relevant data and gathering information from different sources (e.g. chambers of agriculture, farmer and expert interviews, FAO statistics and global studies on agricultural trends), we have obtained the following ranking of alternatives: $\mathbf{\Pi F_{GM} \geq \Pi F_{GAP} \geq \Pi F_{ECO} \geq \Pi F_{BAU}}$. (See Appendix **A3-3.1** for details.)

BAU performs worse than GAP in terms of farmer's profit, since the cost/Ha is higher due to higher use of chemicals and fertilizers and the productivity (kg/Ha) is lower due to crop loss caused by wrong chemical use. Given that the market price of cotton is the same for both, GAP yields at least as much profit as BAU for farmers [$\Pi F_{GAP} \geq \Pi F_{BAU}$], even without considering a possible price premium related to the better quality of GAP produce.

Making a similar comparison between GAP and GM, the cost/Ha is lower in GM since the chemical cost is now lower[8] and the productivity in GM is at least as much as in GAP[9]. Although the price of the GM cotton is lower than the conventional cotton, several world studies show that in both developed and developing countries, there exists a profit gain despite the fall in the price[10]. Moreover, farmers will not adopt the GM technology if the technology premium is too high (Qaim, 2005) so firms will have the incentive to set the prices in such a way that farmers will have net benefits from adopting the technology (Esin, 2009). As such, we conclude that the profit level in GM is at least as much as[11] the profit in GAP [$\Pi F_{GM} \geq \Pi F_{GAP}$].

Lastly, the ECO alternative is compared with the rest. The field studies revealed that the cost per area is the highest within all alternatives due to high amount of labor usage, even without considering the fixed cost related with the certification. Also, the average yield per area is the lowest. Yet, the market price for cotton is very high due to the special marketing properties (about 25% higher than regular cotton) (Lakhal, Sidibé, & H'Mida, 2008). Yet our expectation reveals that the profit level in ECO is lower than GM and higher than GAP considering current/most realistic conditions. Taking this ranking as the main object of analysis, other possible rankings will also be considered in sensitivity analyses.

Input Providers' Profit

Looking at the profit function of input providers and after examining the properties of the alternatives and evidences from other countries, we reach the ranking as $\mathbf{\Pi I_{GM} \geq \Pi I_{BAU} \geq \Pi I_{GAP} \geq \Pi I_{ECO}}$.

[8] Although the price of seeds increases the cost level, the decrease in cost due to less use of chemical overcome this increase and the cost level becomes lower. Studies show that new additional technology costs account only for 28% of the total technology gains in developed countries and only 14% in developing countries. (Brookes & Barfoot, 2009)

[9] According to our field studies, we found out that there isn't a significant crop loss due to insufficient and/or wrong chemical use. But still, rumors in the seed industry about the (undisclosed) results of the GM field trials suggest that there exist a productivity increase. Also international studies show that there exist a substantial yield increase with the adoption of GM alternative (Qaim, 2005) (Brookes & Barfoot, 2009). So, we conclude that GM productivity is at least as much as the productivity in GAP alternative.

[10] Yet, studies show that in some cases GM prices can be higher than conventional prices thanks to a price premium related to tha better quality of GM crops (Brookes & Barfoot, 2009)

[11] The profit levels in both alternatives may be the same but still there exists non pecuniary benefits related to the GM technology and these intangible benefits are the reason for adopting this technology. (Brookes & Barfoot, 2009)

Given that BAU and GAP do not differ in terms of the amount of seed used and seed prices[12], they should basically yield the same income from seed sales for input providers. Yet, the input providers will earn more income from chemical sales in BAU—which uses more chemicals during agricultural production. Therefore, the profit level in BAU is greater than (or equal to) the GAP profit level [$\Pi I_{BAU} \geq \Pi I_{GAP}$].

Comparing the profits in GM and BAU, the seed price is higher in GM. Although in GM the firms sell less chemicals (especially in Bt varieties), evidences from other countries (Brookes & Barfoot, 2009) show that GM alternative yields more profit than BAU, for input providers. Additionally, GM technology enables the input providers to sell seeds and necessary chemicals as bundles, which leads to a profit increase.

Lastly, by comparing ECO with others, the provider gains no profit from the chemical sale and the profit is earned only through the seed sales. The field study revealed that organic seeds are also sold by the input provider firms and their prices are not high enough to compensate the profit lost due to non-selling of chemicals. Still, it is expected that farmers will be more inclined to use their retained seeds from previous years. So, the providers' profit is lower in ECO than in GAP.

Cotton Specific Trade Deficit

There are two main strategies for improving Net Exports (*NX)*; either increasing $P_E \times Q_E$, (the value of cotton exports) or decreasing$P_I \times Q_I$ (the value of cotton imports).

As such, we have three possible trade scenarios for Turkey:

Scenario 1: Allow GM imports even if GM production is not allowed. [13]

Scenario 2: Do not allow GM imports if GM production is not allowed.

Scenario 3: Allow only imports of goods produced with the same domestic production alternative.

Therefore, we have three possible strategies for each alternative and a total of twelve strategies, summarized in Table-4.

[12] We assume that farmers do not use their saved seed from the previous seasons, by looking at the evidences that appeared from the field studies. This is especially true for a cash crop like cotton.

[13] The policy maker may believe that there exist no health risk however may want to avoid the environmental risks resulting from the farming of GM crops.

<<Insert Table-4 Here>>

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The most realistic scenario representing Turkey's current situation is the second one and given the some realistic yield and price estimates, the alternatives are ranked as $\mathbf{CA_{GM} \leq CA_{ECO} \leq CA_{GAP} \leq CA_{BAU}}$. Since this ranking is subject to change according to price and yield estimates, a sensitivity analysis will be conducted for the other scenarios, yield and price estimates. (See Appendix **A2-3.2** for details.)

5.1.4 Impact Matrix

The analysis above gives us the following ordinal impact matrix in Table-5:

<<Insert Table-5 Here>>

6 - Multi-criteria Analysis

Application of a Mathematical Aggregation Convention

In order to obtain a final ranking of the available alternatives, the criterion scores must be aggregated by means of a mathematical algorithm. As Munda (2005b) and Gamboa (2007) note, such ranking should be as *simple* as possible to guarantee consistency and transparency, *non-compensatory* to avoid that bad environmental or social consequences are systematically outperformed by good economic consequences or vice-versa, *intensity of preference* is not taken into account thus avoiding compensability and allowing for weights being importance coefficients and not trade-off. A simple ranking algorithm, respecting all these properties, is the following Condorcet consistent rule (see Young & Levenglick (1978) for its social choice characterization and Munda (2005) and Gamboa & Munda (2007) for its implementation in a multi-criteria framework).

Given a set of criteria $G = \{g_m\}, m = 1,2, \dots, M$ and a finite set $A = \{a_n\}, n = 1,2, \dots, N$ of alternatives, let us assume that the evaluation of each alternative an with respect to an evaluation criterion g_m is based on an ordinal, interval or ratio scale of measurement. For simplicity of exposition, let us assume that a higher value of a criterion score is preferred to a lower one (the higher, the better), that is:

$$\begin{cases} a_j P a_k \Leftrightarrow g_m(a_j) > g_m(a_k) \\ a_j I a_k \Leftrightarrow g_m(a_j) = g_m(a_k) \end{cases}$$

where P and I indicate a preference and an indifference relation, respectively, both fulfilling the transitive property (if $a_i P a_k$ and $a_k P a_j$ then $a_i P a_j$). Let us also assume the existence of a set of criterion weights $W = \{w_m\}, m = 1,2, \dots, M$ with $\sum_{m=1}^{M} w_m = 1$ derived as importance coefficients. The mathematical problem to be dealt with is then how to use this availableinformation to rank in a complete pre-order (i.e. without any incomparability relation[14]) all the alternatives from the best to the worst one. The mathematical aggregation convention can be divided into two main steps:

1. Pair-wise comparison of alternatives according to the whole set of criteria used.

2. Ranking of alternatives in a complete pre-order.

Pairwise comparison

An $N \times N$ matrix, E, called *outranking matrix* (Arrow and Raynaud, 1986; Roy, 1996) can be built as follows:

Any generic element of E: e_{jk}, jk is the result of the pair-wise comparison, according to all the M criteria, between alternatives j and k. Such a global pair-wise comparison is obtained by means of the following equation:

$$e_{jk} = \sum_{m=1}^{M} \left(w_m(P_{jk}) + \frac{1}{2} w_m(I_{jk}) \right)$$

where $w_m(P_{jk})$ and $w_m(I_{jk})$ are the weights of criteria presenting a preference and an indifference relation, respectively. It clearly holds $e_{jk} + e_{kj} = 1$.

By calculating e_{jk} for each alternative, the outranking matrix in Table-6 is obtained:

<<Insert Table-6 here>>

[14] The relation between each pair of alternatives must be either of preference or indifference.

Ranking of alternatives

The maximum likelihood ranking of alternatives is the ranking supported by the maximum number of criteria for each pair-wise comparison, summed over all pairs of alternatives considered. More formally, all the $N(N-1)$ pair-wise comparisons compose the outranking matrix E. Call R the set of all $N!$ possible complete rankings of alternatives, $R = \{r_s\}, s = 1,2, \ldots, N!$.

For each r_s, compute the corresponding score φ_s as the summation of e_{jk} over all the $\binom{N}{2}$ pairs j, k of alternatives, i.e.

$$\varphi_s = \sum e_{jk}$$

where $j \neq k,\ \ s = 1,2, \ldots, N!$and $\ e_{jk} \in r_s$.

The final ranking (r^*) is the one which maximizes φ_s

which is:

$$r * \Leftrightarrow \varphi_* = \max \sum e_{jk}$$

where $e_{jk} \in R$

By applying the above ranking procedure, the following four in Table-7 present the maximum score among the 24 possible rankings.

<<Insert Table-7 Here>>

The table suggest that, the ranking of ECO>GM>GAP>BAU receives the highest score after the aggregation process. The other top rankings are also represented in the table and the first two rankings are seen to be robust after the sensitivity analysis implying that BAU performs worse than all other alternatives and ECO performs better than all other alternatives yet a comparison between GM and GAP is still questionable.

7- Discussion

In line with earlier findings, insights from the SMCE shows that the BAU is not a sustainable alternative for cotton farming in Turkey and this means that there is urgent need for a new agricultural policy. The analysis especially made it clear that changing cotton farming towards the GM alternative is a better strategy than staying in the BAU. Of course, considering the fact that uncertainties in "gene flow" and "health issues" are still huge and some social actors do care about these uncertainties, it should be no surprise to see people opposing to the adoption of GM. Therefore, there is still need for R&D in GM crops and any funds allocated to research aiming at eliminating uncertainties surely benefit the whole society.

Currently, the R&D research in the world is mainly conducted by the private sector and the market is dominated by a few major biotech companies, whose primary interest is not to uncover the uncertain areas of GM farming but to develop newer and more profitable varieties. Since the genetic engineering technology requires a more sophisticated (and hence costly) research than other conventional techniques, it is somehow natural that private sector allocates its scarce funds for R&D investment in the most profitable areas. Therefore, it is the government's responsibility to investigate the non-profitable areas and give R&D funding for enabling a more public-oriented GM research. But, as Karapinar and Temmerman (2010) mention, higher levels of investment in GM research also requires a strong political commitment and newer institutional approaches (such as public-private partnership) helping to make this new technology available to small farmers and to solve the market competition problems related to the intellectual property rights.

Of course, it is also important to note the limitations of this analysis and make some general remarks. First, this analysis was a static analysis considering only criteria relevant for the current state of the country, hence, providing insights about the current situation. In dynamic setting results may change, especially in relation to the economic dimension[15]. Yet, it is not possible to conduct a dynamic analysis in a SMCE context since criteria may also be subject to change: A criterion important for

[15] For instance, considering that in the long run organic cotton will lose its niche market property with the large amount of productions (worldwide or domestic), the currently higher organic cotton price will eventually fall to the levels of its conventional and GM counterparts, implying a possible deterioration in the position of ECO in economic dimension.

today may lose its relevance in the future. Therefore, one should not see such an analysis as a one shot activity but rather repeat it periodically with new criteria reflecting the priorities of the period in question.

Another concern for this analysis could be the hypothetical nature of the alternatives, except for the BAU. The analysis considers theoretically best practices in GM and GAP alternatives—two alternatives completely hypothetical for Turkey—which creates eventually a monitoring problem and results in additional costs, especially in the case of GM. A similar problem arises in the ECO alternative as well. The ECO alternative in this analysis assumes that the certification cost is covered by a third party institution other than farmers[16], considering that certification process creates a large fixed cost and small scale organic farming becomes non-profitable[17]. The problem is to determine on whom (society, biotech firms or farmers) this cost burden would fall.

All in all, even if the above limitations to GM and ECO alternatives are perceived of importance, one can argue that Turkey should at least reform its agricultural policies from BAU to GAP. Otherwise, it has been shown that GM or ECO alternatives are the dominant strategies. Of course, such transformations require a strong political commitment for a reform, especially in agricultural institutionalization.

8- Conclusion

It appears that the world is moving towards a new era of agricultural practice driven by the advances in agro-biotechnology and countries have to decide whether to adopt or oppose to these new technologies. Yet, advances in agro-biotechnology are complex, and uncertainties and diverse stakes are surrounding them. Knowing that a decision about a complex and conflicting problem such as GMO adoption requires a transparent and pluralistic evaluation methodology, this study introduced the SMCE framework for the GM crop adoption problematique in the specific case of Turkey.

The primary objective of this evaluation exercise, however, was not to suggest a specific policy decision to the government but rather to provide policy makers, researchers and other constituencies

[16] The certification cost can be covered by public institutions or alternative certification processes such as *participatory certification*, (or Participatory Guarantee Systems for Organic Agriculture) can be offered, as well.
[17] The field study revealed that current organic farming producers are large scale farmers (over 3000 Da) owning also cotton processing and ginning factories.

with a useful framework to understand the mechanism and the primary (possibly hidden) motives behind a policy decision and also to discuss the policy outcomes in the GMO context. Considering the fact that governments are not always benevolent in nature, it is very important to disclose the party benefiting most from a specific policy decision. The SMCE framework makes it possible to understand this distribution issue by looking at the final outcome as well.

To conclude, it is seen that the SMCE framework has many advantages to the classical decision frameworks with its better adaptability to the complex real-world situations.

Appendices

A1-List of Countries Adopting GM crops

<<Insert Table-A1 Here>>

A2- List of In-depth Interviews

<<Insert Table-A2 Here>>

A3 - Technical Measurements

A3-1 Ecological Evaluation

A3-1.1 Agro-biodiversity

Recollecting all the sub-criteria, we have the table A3.1 with the alternatives' performance scores, respectively:

<<Insert Table-A3.1 Here>>

a) *EIQ of Chemicals Used*: Since ECO has no synthetic chemical usage, it performs better than all alternatives. Comparing GM and GAP, it is well established in the literature that the chemicals used in GM alternatives have lower EIQ values (Carpenter, Felsot, Goode, Hammig, Onstad, & Sankula, 2002) (Qaim, 2005) (Brookes & Barfoot, 2009). Therefore, in this aspect GM performs better than GAP. Lastly, with the more efficient use of chemical, GAP performs better than BAU and therefore the last ranking is $EIQ_{ECO}<EIQ_{GM}<EIQ_{GAP}<EIQ_{BAU}$

b) *Area of land used for unit production*: This aspect is directly related to the productivity of the farming alternatives. There are several studies comparing the alternatives according to their productive capacities [see Brookes & Barfoot, (2009)], considering these, we have the following ranking: GM>GAP>BAU>ECO.

c) *Loss of Genetic Variation within species*: This aspect is mainly related to the specialization of the farmers to a specific variety due to market expansion issues. This specialization increases the "dependence of the agricultural production on narrow ranges of agricultural varieties" (Tisdell, 2003). In this context, ECO performs best with the highest range of agricultural varieties. GM performs better than GAP since in GM alternative, instead of replacing the local varieties with a few numbers of HYVs, GM versions of the local varieties are produced. (Qaim, 2005) Lastly, there is no reason to assume that GAP and BAU performances differ since they mainly use the same germplasm (REF).

d) *Loss of Indigenous Knowledge*: Local knowledge, environmental adaptations and human interactions are the important aspects of this criterion. Alternatives threatening any one of these aspects will perform worse. In this context, ECO performs the best by being practiced within the customs of the indigenous people. It is also seen that GM performs the worst by being the most dependent alternative to the market structure. It is shaped by the market needs and does not consider the local practice. In between, GAP performs better than BAU by being more respectful to the environmental adaptations. At the end, the final ranking is as follows: ECO<GAP<BAU<GM.

A3-2 Social Evaluation

A3-2.1 Impact on Public Health

Recollecting all the sub-criteria, we have the following Table-A3.2 with the alternatives' performance scores, respectively:

<<Insert Table-A3.2 Here>>

a) *Chemical Use*: Since ECO has no chemical usage, it is best performer among all alternatives in this context. Comparing GM and GAP, it is well-established in the literature that GM farming's impact on health is lower either because of less hazardous material usage (as in the herbicide case) or because of a decrease in total chemical usage (as in the insecticide case) (Carpenter, Felsot, Goode, Hammig, Onstad, & Sankula, 2002). Additionally, GM practice provides improved safety for farmers thanks to reduced handling of hazardous chemicals given less spraying (Brookfield & Stocking, 1999). Therefore, GM ranks better than GAP. Finally, BAU ranks worse than GAP because of its higher and inappropriate usage of hazardous chemicals. The final ranking is therefore $CU_{ECO}<CU_{GM}<CU_{GAP}<CU_{BAU}$

b) *Degree of uncertainty*: Considering that there is no transferred gene in ECO, BAU and GAP alternatives, they all perform equally with respect to the gene transfer related uncertainty in health issues. Yet, GM alternative possess a certain degree of uncertainty.

Although the simple aggregation of the sub-criteria implies a ranking as $HI_{ECO}<HI_{GAP}<HI_{GM}<HI_{BAU}$, (**Scenario-1A**)given the importance of health issue, it is more appropriate to follow a precautionary principle about the degree of uncertainty sub-criteria. So a veto model will be used. According to this model, if an alternative has uncertainty, it cannot be preferred to any other alternatives. So, GM ranks last. (i.e $HI_{ECO}<HI_{GAP}<HI_{BAU}<HI_{GM}$) (**Scenario-2A**). But still, following the results of ENTRANSFOOD project (Kuiper, König, Kletera, Hammes, & Knudsen, 2004), it is assumed that HIBAU and HIGM do not differ significantly in terms of health impact. Therefore, the final ranking is $\mathbf{HI_{ECO}<HI_{GAP}<HI_{BAU}=HI_{GM}}$ (**Scenario-3A**-Main Scenario). A sensitivity analysis will be conducted for the overall MC exercise also by using other rankings.

A3-3 Economic Evaluation

A3-3.1 Farmers' Profit

The profit comparison is made with respect to the BAU alternative. Since cotton price is lower than the total cost without subsidies, BAU farmers have zero profit and the market price is assumed to be equal to cost/kg of BAU. The BAU figures are the averages of Adana, Urfa and Soke Regions (Adana CAE (Chamber of Agricultural Engineers) 2008, Urfa CAE 2007, 2008 and Söke Chamber of Agriculture. 2008)

We assume that any of the three GM types can be used while practicing GM alternative. (i.e. the best profit yielding types will be used in the ranking) These are:

GM-HT: Herbicide Tolerant (Roundup-ready) GM cotton farming

GM-Bt: Pesticide saving Bt-Cotton seeds

GM-HT/Bt: Cotton farming with stacked seeds showing both HT and Bt properties.

Moreover, on the productivity front, four scenarios are put forward according to the productivity increases in GAP with respect to BAU. (No productivity difference is assumed between GM types and GAP). $\Pi F_{ECO} > \Pi F_{GAP}$ if productivity increase is less than 2.5% (threshold value). Since a productivity increase higher than 2.5% is highly expected, Scenario-1 is used as the main scenario. The rankings in Scenario 2 and Scenario 3 are used in sensitivity analysis, as well.

Rankings:

Scenario-1B *(main scenario)* 5% prod. increase: $\mathbf{\Pi F_{GM} \geq \Pi F_{GAP} \geq \Pi F_{ECO} \geq \Pi F_{BAU}}$

Scenario-2B no prod. increase: $\Pi F_{ECO} \geq \Pi F_{GM} \geq \Pi F_{GAP} \geq \Pi F_{BAU}$

Scenario-3B 2.5% prod. increase**:** $\Pi F_{GM} \geq \Pi F_{ECO} \geq \Pi F_{GAP} \geq \Pi F_{BAU}$

<<Insert Table-A3.3 Here>>

Notes and Explanations:

(1) *Fertilizer and Fertilizing Labor Cost*: A better fertilizer usage is assumed in GAP and GM(*) yielding an anticipated decrease from 20 Kg/Da to 17 Kg/Da resulting a cost decrease of 6.5 YTL/Da. Due to higher prices of organic fertilizers and animal manure, same amount of fertilizer costs 65 YTL/Da in ECO.

(2) *Seed Costs*: Field studies revealed that farmers are buying organic seeds from seed companies instead of retaining their own seeds, so no significant seed cost difference is assumed between ECO and GAP/BAU. For GM alternatives, a 100% (150% in stacked type) seed cost increase is assumed as a worst case scenario, although international evidence shows that GM seed price premiums are not that high (Brookes & Barfoot, 2009) (Qaim, 2005).

(3) *Pecking:* On average GAP and BAU has two rounds of pecking per season yet ECO is assumed to have three rounds since pecking is the main technique against herb invasion. This implies a 50% increase in pecking cost for ECO. (Each round costs 17 YTL/Da approx.) GM-Bt type shows the same pecking properties as GAP and BAU. GM-HT and GM-HT/Bt types do not need any pecking counter herb invasion yet a less frequent form of pecking is assumed for soil ventilation and irrigation channel opening purposes (10 YTL/Da approx.)

(4) *Pesticide and Spraying Labor Cost:* ECO has no usage of pesticide and hence no cost. GM-HT type has less spraying than BAU and GAP due to less herbicide usage. The field studies revealed that herb invasion is a major issue for cotton farmers and a decrease by approx. 45% in the total herbicide and application cost is expected. For GM-Bt type, only approx. 18% decrease is expected since worm invasion is not a major issue in general. For stacked GM-HT/Bt type, a decrease of approx. 64% is expected.

(5) *Harvesting:* In BAU, GAP and GM alternatives mechanized harvesting is used thanks to defoliant chemicals however in ECO alternative manual harvesting is done resulting approx. 50% increase in harvesting cost

(6) *Non-Varying Costs:* These are costs that do not vary between alternatives such as farm rent, seed plantation cost, water usage cost, transportation cost and so on. Although tillage properties of alternative may differ (conservation tillage or no tillage), same tillage practice is assumed for each alternative following the claims of farmers and experts.

(7) *Productivity:* Field studies revealed that organic cotton producers have approx. 370 to 390 kg/Da productivity. But here a lower productivity of 350 Kg/Da is assumed considering that the current production is done in the most productive lands and the average is to fall when less productive lands will be used in organic production. No productivity difference is assumed between GM and GAP although most of international evidences show a productivity increase. (James, 2002) (Qaim, 2005) (Brookes & Barfoot, 2009)

(8) *Price:* As already mentioned, BAU farmers have zero profit. This is because the market price is assumed to be equal to cost per kg. GAP and BAU have same price. International evidences show that ECO has approx. 20% to 25% price premium (Lakhal, Sidibé, & H'Mida, 2008).

22.5% price premium is used in the analysis. (25% gives the same ranking in Scenario-1 with a prod. increase threshold of 4.8%) Also Frisvold et al. (2006) shows that GM causes approx. 1.5% decrease in world cotton price. Yet, from a more conservative view, a 5% price decrease is assumed for GM cotton.

A3-3.2 Cotton Specific Trade Balance

First of all, in order to be able to analyze the situation, some basic assumptions should be made as follows:

Production=exports: QeECO<QeBAU<QeGAP=QeGM For simplicity, it is assumed that the country is exporting its entire cotton production and is importing cotton again for the industry usage. QeGAP and QeGM are assumed to be 5% higher than QeBAU and QeECO is 12.5% lower than QeBAU. [See section A2-3.1 note (7) – *Productivity*].

Imports: Same for all alternatives. It is assumed that imports are 50% higher than the exports similar to the case of Turkey.

Prices: pGM<pBAU=pGAP<pECO . pECO is assumed to be 22.5% higher than pBAU and pGM is 5% lower than pBAU. [See section A2-3.1 note (8)—*price*].

Considering the three possible trade strategy scenarios and the assumptions above, the following Table-A3.4 can be constructed.

<<Insert Table-A3.4 Here>>

Following the results in the table, the rankings for each scenario is represented below.

Scenario-1C: $\mathbf{CA_{ECO} \leq CA_{GAP} \leq CA_{BAU} \leq CA_{GM}}$

Scenario-2C: $\mathbf{CA_{GM} \leq CA_{ECO} \leq CA_{GAP} \leq CA_{BAU}}$ *(Main scenario)*

Scenario-3C: $\mathbf{CA_{GM} \leq CA_{GAP} \leq CA_{BAU} \leq CA_{ECO}}$

References

1- Basu, K., & Van, P. H. (1998). The Economics of Child Labor. *The American Economic Review , Vol: 88* (No. 3), pp. 412-427.

2- Brookes, G., & Barfoot, P. (2009). Global Impact of Biotech Crops: Income and Production Effects. *Agbioforum* (12(2)), 184-208.

3- Brookfield, H., & Stocking, M. (1999). Agrodiversity: definition, description and design. *Global Environmental Change* (issue 9), pp 77-80.

4- Carpenter, J., Felsot, A., Goode, T., Hammig, M., Onstad, D., & Sankula, S. (2002). Comparative Environmental Impacts of Biotechnology-derived and Traditional Soybean, Corn, and Cotton Crops. *Council for Agricultural Science and Technology,Ames* .

5- COGEM. (2008). *Import and processing of genetically modified cotton GHB614.* COGEM.

6- Darnhofer, I. (2005). Organic Farming and Rural Development: Some Evidence From Austria. *Sociologia Ruralis, , Vol 45,* (Number 4,), pp 308 - 323.

7- Demirkol, K. (2010). *GDO: Çağdaş Esaret (GMO: Modern Slavery).* Istanbul: Kaynak Yayinlari.

8- Edwards, S. (2001). Does the Current Account Matters? *NBER Working Paper* (No. 8275).

9- Eser, V. (2009, February 24). (C. İ. Aydın, Interviewer)

10- Esin, İ. H. (2009, February 23). Monsanto Turkey Represenative. (C. İ. Aydın, Interviewer)

11- European Union, . (2007, June 28). Council Regulation (EC) No 834/2007 on organic production and labelling of organic products and repealing Regulation. *Official Journal of the European Union ((EEC) No 2092/91)* .

12- Falkner, R. (2000). Regulating Biotech Trade: The Cartagena Protocol on Biosafety. *International Affairs (Royal Institute of International Affairs 1944-) , Vol. 76* (No. 2 Special Biodiversity Issue), pp 299 - 313.

13- FAO - Food and Agricultural Organization. (n.d.). *FAOSTAT*. Retrieved May 2010, from http://faostat.fao.org/

14- FAO. (2004). *"Building on Gender, Agrobiodiversity and Local Knowledge".*

15- Frisvold, G., Reeves, J. M., & Tronstad, R. (2006). Bt Cotton Adoption in the United States and China: International Trade and Welfare Effects. *AgBioForum , Vol. 9* (No. 2), pp 69-78.

16- Funtowicz, S. O., & Ravetz, J. R. (1994). The worth of a songbird: Ecological economics as a post-normal science. *Ecological Economics , Vol. 10* (Issue: 3), pp.197-207.

17- Gamboa, G., & Munda, G. (2007). The problem of windfarm location: A social multi-criteria evaluation framework. *Energy Policy* (Issue: 35), pp. 1564-1583.

18- GDO'ya Hayır Platformu. (tarih yok). *GDO'ya Hayır*. May 2010 tarihinde http://www.gdoyahayir.org/bilesenler adresinden alındı

19- Gosh, A., & Ramakrishnan, U. (2006). Do Current Account Deficits Matter? *Finance and Development (Quarterly Magazine of IMF) , Volume 43* (No. 4).

20- Gregory, P. J., Ingram, J. S., Andersson, R., Betss, R., Brovkin, V., Chase, T., et al. (2002). Short Communication: Environmental Consequences of Alternative Practices for Intensifying Crop Production. *Agriculture, Ecosystem and Environment* , pp 279-290.

21- Guitouni, A., & Martel, J.-M. (1998). Tentative guidelines to help choosing an appropriate MCDA method. *European Journal of Operational Research , Vol. 109* (Issue 2), pp 501 - 521.

22- Günver, A. (2009, July 16). SÖKPAM Pamuk Representative. (C. İ. Aydın, Interviewer)

23- ISAAA. (2009). *Global Status of Commercialized Biotech/GM Crops: 2009 The first fourteen years, 1996 to 2009.* ISAAA.

24- James, C. (2002). *Global Review of Commercialized Transgenic Crops: 2001 Feature: Bt Cotton.* Ithaca, NY: ISAAA.

25- Karapinar, B. (2010). 'Sustainability' in Agriculture: Stakeholders' Perceptions in Turkey. In B. Karapinar, F. Adaman, & G. Ozertan (Eds.), *Rethinking Structural Reform in Turkish Agriculture: Beyond the World Bank's Strategy* (pp. 191 - 211). New York: Nova Science Pub Inc.

26- Karapinar, B., & Temmerman, M. (2010). Intellectual Property Rights and Innovation: Promoting New Technologies in Turkish Agriculture. B. Karapinar, F. Adaman, & G. Ozertan içinde, *Rethinking Structural Reform in Turkish Agriculture: Beyond the World Bank's Strategy.* Nova Science Pub Inc.

27- Kivilcim, Z. (2010). The Legal Framework For Agrobiotechnology in Turkey: The Challenges to the Implementation of the Precautionary Principle. In B. Karapinar, F. Adaman, & G. Ozertan (Eds.), *Rethinking Structural Reform in Turkish Agriculture: Beyond the World Bank's Strategy* (pp. 267 - 282). New York: Nova Science Pub Inc.

28- Kuiper, H. A., König, A., Kletera, G. A., Hammes, W. P., & Knudsen, I. (2004). Concluding remarks. *Food and Chemical Toxicology , Volume 42* (Issue 7), Pages 1195-1202.

29- Lakhal, S. Y., Sidibé, H., & H'Mida, S. (2008). Comparing conventional and certified organic cotton supply chains: the case of Mali. *Int. J. Agricultural Resources, Governance and Ecology , Vol. 7* (No. 3), pp.243-255.

30- Lal, R. (2004). Carbon emission from farm operations. *Environment International* (issue 30), pp. 981-990.

31- Milesi-Ferretti, G. M., & Razin, A. (1996). Sustainability of Persistent Current Account Deficits.". *NBER Working Paper* (No: 5467).

32- Munda, G. (2005). A solution for the discrete multi-criterion problem in a public policy framework. *Unpublished Manuscript* .

33- Munda, G. (2004). Social multi-criteria evaluation: Methodological foundations and operational consequences. *European Journal of Operational Research* (No. 158), pp. 662 - 677.

34- Murugkar, M., Ramaswami, B., & Shelar, M. (2007, September 15). Competition and Monopoly in Indian Cotton Seed Market. *Economic and Political Weekly* .

35- Ozertan, G., & Aerni, P. (2007). GM Cotton and Its Possible Contributions to Environmental Sustainability and Rural Development in Turkey. *Int. J. Agricultural Resources, Governance and Ecology , Vol. 6* (Nos. 4/5), pp 552-575.

36- Qaim, M. (2005). Agricultural Biotechnology Adoption in Developing Countries. *American Journal of Agricultural Economics* (87), pp 1317-1324.

37- Rogers, A. (1978, February). prbanization, Agricultural Change, and Spatial Concentration in Open Dualistic Economic Development. International Institute for Applied Systems Analysis Working Paper WP-78-S.

38- Roy, B. (2005). Paradigms and challenges, chapter 1. In J. Figueira, S. Greco, & M. Ehrgott (Eds.), *Multiple criteria decision analysis: state of the art surveys* (pp. pp 3-24). New York: Springer International Series in Operations Research and Management Science.

39- Snow, A. A., & Lu, B.-R. (2005). Gene Flow from Genetically Modified Rice and Its Environmental Consequences. *Bioscience* , pp 669-678.

40- Srivastava, J., Smith, N. J., & Forno, D. (1996). *Biodiversity and agriculture : implications for conservation and development.* Washington, D.C.: Worldbank.

41- Stirling, A., & Mayer, S. (2000). A Precautionary Approach to Technology Appraisal? – A multi-criteria mapping ofgenetic modification in UK agriculture. *TA-Datenbank-Nachrichten* (Nr. 3, 9), pp 39-51.

42- Tisdell, C. (2003). Socio-economic causes of loss of animal genetic diversity: analysis and assessment. *Ecological Economics* , pp 365-378.

43- TUIK. (n.d.). Retrieved from www.tuik.gov.tr

44- TUIK. (n.d.). *Bitkisel Üretim İstatistikleri (Agricultural Production Statistics)*. Retrieved May 2010, from www.tuik.gov.tr

45- Uhm, K.-B. (1999, May 1). *Integrated Pest Management.* Retrieved November 14, 2009, from Agnet.Org: http://www.agnet.org/library/eb/470/eb470.pdf

46- Wolfenbarger, L. L., & Phifer, P. R. (2000). The Ecological Risks and Benefits of Genetically Engineered Plants. *Science , 290* (2088).

47- World Bank. (n.d.). Retrieved from www.worldbank.org

48- Young, H. P., & Levenglick, A. (1978). A Consistent Extension of Condorcet's Election Principle. *SIAM Journal on Applied Mathematics , Vol. 35* (No. 2), pp. 285-300.

TABLES

1- Table-1: Alternatives according their degree of intensification

	Site Preparation	Germplasm (Seed)	Nutrients	Pest Control	Harvesting
ECO	Manual & Mechanized	Crop & Cultivar Selection (Organic Seed)	Fallowing, Legumes, Organic Manure	Using Natural Enemies, Traps, Manual Weed Removal	Manual
BAU	Fully mechanized	Cultivar Selection (Conventionally Bred Seed)	Extensive use of Mineral Fertilizers	Extensive use of pesticides, Manual Weed Removal	Manual/ Mechanized
GAP	Conservation Tillage/ Minimum Tillage	Cultivar Selection (Conventionally Bred Seed)	Efficient Use of Mineral + Organic Fertilizers	IPM with less risky chemicals	Mechanized
GM	Conservation Tillage/ Minimum Tillage / No Tillage	Cultivar Selection (Genetically Engineered Seed)	Efficient Use of Mineral + Organic Fertilizers	IPM with less risky chemicals and refuge zones / Pest and Chemical Resistant Crops	Mechanized

2- Table-2: Evaluation Criteria

	Criterion	Definition	Needs And Expectation	Direction
Ecological	Agro-Biodiversity	Having many forms of plants and animals living in the same ecosystem. Each locality has its special varieties (endemic) and its own cultural habitat.	-Maximize the number of (plant and animal) species. -Maximize the variations within species - Preserve the habitat of species -Preserve the cultural habitat of the indigenous farmers.	Maximize
	Unintended Gene Flow Potential	-Cross-fertilization of Non-GM products with GM products. Having GM traits at non-intended areas.	-To prevent the gene flow from GM products to Non-GM products by farming them at appropriate distances.	Minimize
	GHG Emissions	GHG Emissions created by the agricultural machinery and input use.	-To reduce GHG emissions	Minimize
Social	Agricultural input market competitiveness	-Seed companies having patent related monopoly powers in the seed market. -Farmers depending on the seeds supplied by these seed companies.	-Prevent the monopoly/oligopoly structure of the input market - Reduce the farmer dependency on input providers	Maximize
	Human health considerations	Allergy and cancer risks implied by the synthetic chemical uses and gene transfers.	-Prevent allergenic reactions caused by gene transfer and chemical use. -Reduce the carcinogenic effects of chemical use by using less toxic chemicals or decreasing the amount of chemicals.	Minimize
	Rural Employment Level	The suitability of the farming practice for employment creation	- Prevent the rural to urban migration due to rural unemployment. (Decrease push factors of migration)	Maximize
Economic	Farmers' Profit	The profit gained by the farming activities. This is related to the costs induced by inputs, the yield per area and the farm gate prices.	-Decrease the input costs of the farmers -Increase the productivity of the farms -Increase the farm gate price	Maximize
	Input Providers' Profit	The profit gained by the seed and chemical provider firms.	-Increase the profit obtained by the seed and chemical importing/producing firms	Maximize
	Cotton Related Current Account Deficit	The value of cotton imports less the value of cotton exports. (Net exports of cotton)	-Minimize the trade deficit related to the cotton trade.	Minimize

3- **Table-3: Gene Flow Criterion Scores of the Alternatives.**

Criterion	ECO	BAU	GAP	GM
Presence of probability of gene flow	0	0	0	1

4- **Table-4: Possible Trade Scenarios involving Cotton Trade**

		Scenario 1	Scenario 2	Scenario 3
Production	**Exported**	**Imported**	**Imported**	**Imported**
GM	GM	GM	GM	GM
Conventional (BAU)	Conventional	GM	Conventional	Conventional
Conventional (GAP)	Conventional	GM	Conventional	Conventional
Organic	Organic	GM	Conventional	Organic

5- **Table-5: Impact Matrix**

			Alternatives			
		Weights	**ECO**	**BAU**	**GAP**	**GM**
Criteria – **Ecological**	***Agro-biodiversity***	1/9	First	Fourth	Third	Second
	Gene Flow	1/9	First	First	First	Second
	GHG Emission	1/9	First	Fourth	Third	Second
Social	***Level of Competition in Input Market***	1/9	First	Third	Second	Fourth
	Public Health Considerations	1/9	First	Third	Second	Third
	Rural Employment Level	1/9	First	Second	Third	Fourth
Economic	***Farmers' Profit***	1/9	Third	Fourth	Second	First
	Input Providers' Profit	1/9	Fourth	Second	Third	First
	Current Account Deficit	1/9	Second	Fourth	Third	First

6- **Table-6: Outranking Matrix**

	ECO	**BAU**	**GAP**	**GM**
ECO	0	0.833	0.722	0.667
BAU	0.167	0	0.278	0.389
GAP	0.278	0.722	0	0.444
GM	0.333	0.611	0.556	0

7- **Table-7: Rankings with highest scores**

	First	Second	Third	Fourth
1	ECO	GM	GAP	BAU
2	ECO	GAP	GM	BAU
3	ECO	GAP	BAU	GM
3	GM	ECO	GAP	BAU

8- **Table-A1: TABLE A1 – Global Area of Biotech Crops 2009: By Country (Million hectares)**

Rank	**Countries**	**Area (Million Hectares)**	**Biotech Crops**
1	USA	64.0	Soybean, Maize, Cotton, Canola, Squash, Papaya, Alfalfa, Sugar beet
2	Brazil	21.4	Soybean, Maize, Cotton
3	Argentina	21.3	Soybean, Maize, Cotton
4	India	8.4	Cotton
5	Canada	8.2	Canola, Maize, Soybean, Sugar beet
6	China	3.7	Cotton, Tomato, Poplar, Papaya, Sweet Pepper
7	Paraguay	2.2	Soybean
8	South Africa	2.1	Maize, Soybean, Cotton
9	Uruguay	0.8	Soybean, Maize
10	Bolivia	0.8	Soybean
11	Philippines	0.5	Maize
12	Australia	0.2	Cotton, Canola
13	Burkina Faso	0.1	Cotton
14	Spain	0.1	Maize
15	Mexico	0.1	Cotton, Soybean
16	Chile	<0.1	Maize, Soybean, Canola
17	Colombia	<0.1	Cotton
18	Honduras	<0.1	Maize
19	Czech Republic	<0.1	Maize
20	Portugal	<0.1	Maize
21	Romania	<0.1	Maize
22	Poland	<0.1	Maize
23	Costa Rica	<0.1	Cotton, Soybean
24	Egypt	<0.1	Maize
25	Slovakia	<0.1	Maize

Source: ISAAA Brief 41-2009: Executive Summary (ISAAA, 2009)

9- Table-A2: List of in-depth interviews

#	Interviewee	Specialization area if any	
1	Academician	Plant Biotechnology	Istanbul
2	Academician	Genetic Engineering	Istanbul
3	Academician	Genetic Engineering	Istanbul
4	Academician	Political Economy	Istanbul
5	Seed Producer Representative	Agricultural Engineer.	Ankara
6	Government Representative	Agricultural Engineer, PhD.	Ankara
7	Academician	Biotechnology Law	Istanbul
8	NGO Representative	Agricultural Engineer	Istanbul
9	Farmer		Söke/Aydın
10	Organic Cotton Producer Representative		Söke/Aydın
11	Expert , Former Söke Chamber of Agriculture Representative	Agricultural Engineer	Söke/Aydın
12	Farmer, Söke Chamber of Agriculture Representative		Söke/Aydın
13	Expert, Farmer	Agricultural Engineer, M.Sc.	Söke/Aydın
14	Söke Irrigation Union Executive Secretary, Expert	Agricultural Engineer	Söke/Aydın
15	Expert, Input (Seed, Chemicals) Retailer	Agricultural Engineer	Söke/Aydın
16	Organic Cotton Producer Representative		Söke/Aydın

10- Table-A3.1: Agrobiodiversity Evaluation

Sub-criteria	Objective	ECO	BAU	GAP	GM
EIQ of Chemicals Used	Minimize	1	4	3	2
Area of land used for unit production	Minimize	4	3	2	1
Loss of Genetic Variation within species	Minimize	1	3	3	2
Loss of Indigenous Knowledge	Minimize	1	3	2	4
Loss of Agro-Biodiversity	**Minimize**	**7**	**13**	**10**	**9**

11- Table-A3-2: Public Healt Impact Evaluation

Sub Criterion	ECO	BAU	GAP	GM
Chemical Use	1	4	3	2
Degree of Uncertainty	0	0	0	1!
Impact on Public Health	**1**	**4**	**2**	**3!**

12- Table-A3.3: Profit Calculation of Alternatives with Different Productivity Scenarios

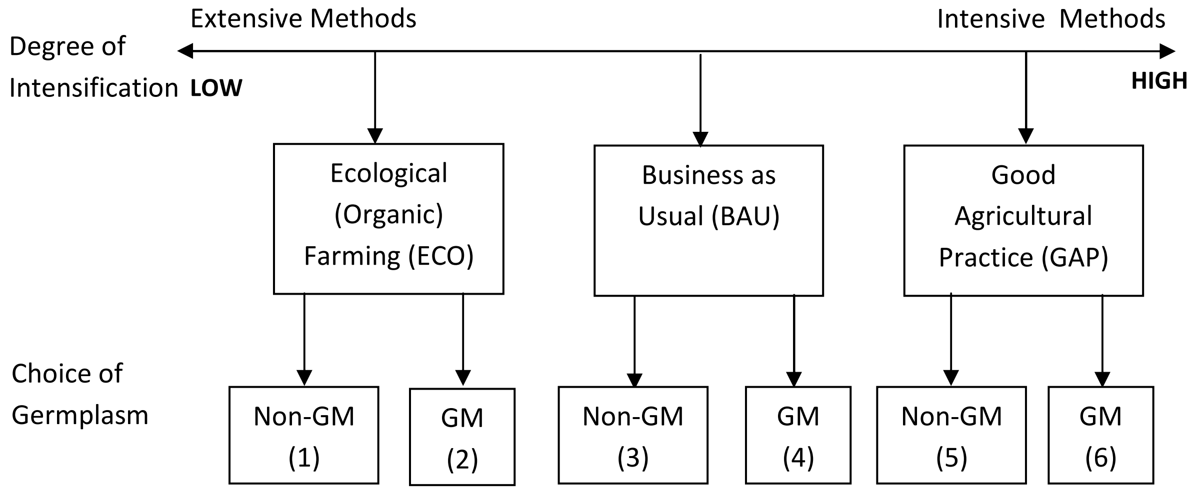
	COST ITEMS	UNIT	BAU	GAP	ECO	GM (HT)	GM(BT)	GM (HT/BT)
	FERTILIZER COST + LABOR COST **(1)**	YTL/DA	42.5	35	65	35	36	35
	SEED COST (3 KG/DA) **(2)**	YTL/DA	10	10	10	20	20	25
	PECKING **(3)**	YTL/DA	33.5	33.5	50	10	33.5	10
	PESTICIDE COST + LABOR COST **(4)**	YTL/DA	55	55	0	30	45	20
	HARVESTING **(5)**	YTL/DA	60	60	90	60	60	60
	NON-VARYING COSTS **(6)**	YTL/DA	249	249	249	249	249	249
	TOTAL COSTS (TC)	YTL/DA	450	442.5	464	404	448.5	399
	GENERAL MANAGEMENT COSTS (2%)	YTL/DA	9	8.85	9.28	8.08	8.45	7.98
	INTEREST (15% TC)	YTL/DA	67.5	66.375	69.6	60.6	63.375	59.85
	GENERAL TOTAL COST	YTL/DA	526.5	517.725	542.88	472.68	520.325	466.83
Scenario 1B	PRODUCTIVITY / DA **(7)**	KG/DA	400	420	350	420	420	420
5% prod.	COST PER KG	YTL/KG	1.32	1.23	1.55	1.13	1.24	1.11
increase	PRICE **(8)**	YTL/KG	1.32	1.32	1.61	1.25	1.25	1.25
Main Scenario	EXPECTED PROFIT	YTL/DA	0.00	35.10	21.46	52.50	4.86	58.35
Scenario 2B	PRODUCTIVITY / DA **(7)**	KG/DA	400	400	350	400	400	400
no prod.	COST PER KG	YTL/KG	1.32	1.29	1.55	1.18	1.30	1.17
increase	PRICE **(8)**	YTL/KG	1.32	1.32	1.61	1.25	1.25	1.25
	EXPECTED PROFIT	YTL/DA	0.00	8.77	21.46	27.50	-20.15	33.34
Scenario 3B	PRODUCTIVITY / DA **(7)**	KG/DA	400	410	350	410	410	410
2.5% prod.	COST PER KG	YTL/KG	1.32	1.26	1.55	1.15	1.27	1.14
İncrease	PRICE **(8)**	YTL/KG	1.32	1.32	1.61	1.25	1.25	1.25
	EXPECTED PROFIT	YTL/DA	0.00	21.94	21.46	40.00	-7.65	45.85

13- Trade Scenarios

		BAU	**GAP**	**ECO**	**GM**
	q export (Qe)	1	1.05	0.875	1.05
	q import	1.5	1.5	1.5	1.5
	p export	1	1	1.225	0.95
Scenario 1C	p import	0.95	0.95	0.95	0.95
	CA Deficit	-0.425	-0.375	-0.35313	-0.4275
Scenario 2C – Main Scenario	p import	1	1	1	0.95
	CA Deficit	-0.5	-0.45	-0.42813	-0.4275
Scenario 3C	p import	1	1	1.225	0.95
	CA Deficit	-0.5	-0.45	-0.76563	-0.4275

Figures:

Figure-1: Presentation of Agricultural Alternatives According to their degree of intensification and choice of germplasm.



(1) GM seeds with Organic farming [ECO – GM] **(2)** Ecological (Organic) Farming [ECO – Non GM] **(3)** GM seeds with business as usual [BAU – GM] **(4)** Business as usual [BAU – Non GM] **(5)** GM seeds with good agricultural practice [GAP-GM] **(6)** Good Agricultural Practice [GAP- Non GM]