Using Marginal Abatement Cost Curves to Realize the Economic Appraisal of Climate Smart Agriculture Policy Options

by

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

About EX-ACT: The Ex Ante Appraisal Carbon-balance Tool aims at providing ex-ante estimations of the impact of agriculture and forestry development projects on GHG emissions and carbon sequestration, indicating its effects on the carbon balance. See EX-ACT website: ***www.fao.org/tc/exact***

Related resources

- EX-ANTE Carbon-Balance Tool (EX-ACT): (i) Technical Guidelines; (ii) Tool; (iii) Brochure
- See all EX-ACT resources in EASYPol under the Resource package, Investment Planning for Rural Development, EX-Ante Carbon-Balance

EASYPol: is a multilingual repository of freely downloadable resources for policy making in agriculture, rural development and food security. The site is maintained by FAO's Policy Assistance Support Service, www.fao.org/tc/policy-support

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E-ISSN 2219-9497

E-ISBN 978-92-5-107168-7 (PDF)

Abbreviations

AFOLU	Agriculture, Forestry, land Use
C	Carbon
CCC	The Committee on Climate Change
CO2e	CO2 equivalent
EX-ACT	EX-Ante Carbon balance Tool
GHG	Green House Gases
IRR	Internal Rate on Return
MACC	Marginal Abatement Cost Curve
MEC	Marginal External Cost
MPC	Marginal Private Cost
MSB	Marginal Social Benefit
MSC	Marginal Social Cost
NPV	Net Present Value
PES	Payement for Environnemental Services

1 SUMMARY

The AFOLU sector (Agriculture, Forestry, Land Use) is directly linked with climate change issues, on an environmental aspect as well as on an economical and social aspect (food security).

On the one hand, the sector directly contributes to climate change. Indeed, agriculture represents 14% of the total worldwide GHG emissions, and deforestation accounts for 17% [1]. The AFOLU sector is thus responsible for one third of the GHG emissions in the world. Moreover, this sector is increasingly vulnerable to climate changes and hence requires adaptation measures. On the other hand, it is estimated that the mitigation potential of the AFOLU sector could reach up to 4.5-6 Gt CO2e/year in 2030[2]. Many of the technical mitigation options are readily available[3] and could be deployed immediately. Furthermore, estimates indicate that many of these options are of relatively low cost, or generate significant co-benefits in the form of improved agricultural production systems, resilience and other ecosystem services[4].

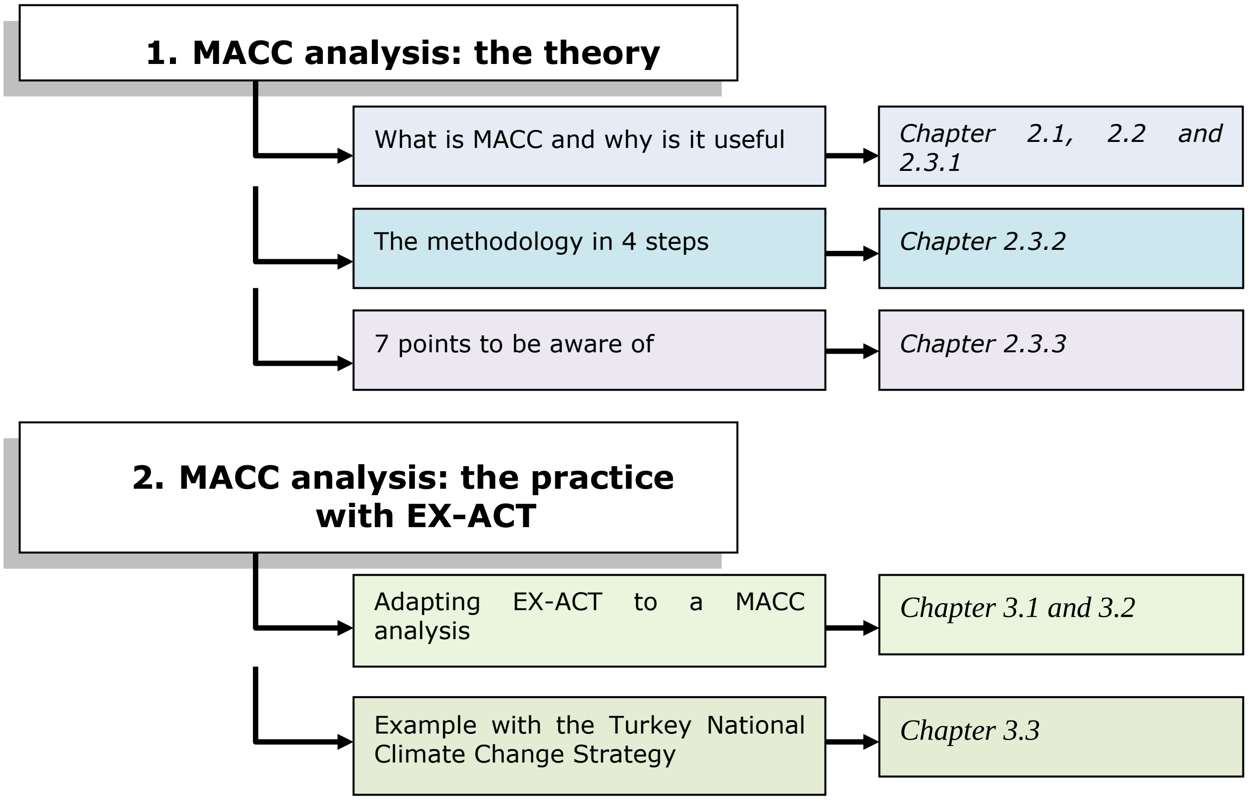
Yet, while there is a wide range of technical solutions, it is not immediately apparent which options deliver the most economically efficient reductions in GHG within agriculture. This is why methodologies such as a Marginal Abatement Cost Curves (MACC) have been developed over these past twenty years. MACC also enables the comparison of the cost-effectiveness of mitigation options between different sectors (e.g. agriculture, power, transport, industry and domestic energy consumption). MACC has become a useful tool for policy makers to prioritize mitigation options.

This paper aims at putting forward a methodology to use MAC-curves within the AFOLU sector. It especially targets policy planners and policy makers. The agricultural sector, also called agriculture or AFOLU, encompasses farm-based activities (crop production, livestock) as well as forestry and land use. It does not include the downstream agro-industry sector.

The first part of these guidelines explains the methodology in order to assess the cost-effectiveness and the mitigation potential of technical practices in agriculture. It also underlines the limits of the MACC approach. The second part looks at a practical MACC analysis example, using the EX-ACT tool. The outline of the paper is presented below.

[1] UNFCCC, 2008.
[2] IPCC, 2007; Smith and al, 2007.
[3] Bellassen et al., 2010; Bernoux et al., 2006; Cerri et al., 2004, 2007; Henry et al., 2009.
[4] Smith et al., 2008.

Figure 1: Outline of the paper



2 Introduction

Objective: The objective of this paper is to provide good practice guidance for the construction of Marginal Abatement Cost Curves (MACC) in the AFOLU sector, in general and by using the EX-ACT tool.

The purpose is not to set a fixed method that will not allow considering the specificities of different contexts or countries. On the contrary, it is a general guideline provided to narrow down subjectivities and provide a common understanding of important aspects to be taken into account while establishing a MACC analysis in the agricultural sector.

Target audience: This paper targets the national agriculture sector, forestry and food security policy makers, institution-based, agency and donor decision-makers.

Required background: In order to fully understand the content of this module the user must be familiar with:

- Concepts of climate change mitigation and adaptation
- Concepts of land use planning and management
- Elements of project economic analysis

Readers can follow links included in the text to other EASYPol modules or references[5]. See also the list of EASYPol links included at the end of this module.

3 THE USE OF MACC WITHIN THE AGRICULTURAL SECTOR: METHODOLOGY AND LIMITS

3.1 Background of Marginal Abatement Cost Curves

Marginal Abatement Cost Curves (MACC) were first developed after the two oil price shocks, in the 1970's. They aimed at reducing crude oil consumption, and later electricity consumption[6]. The MACC was then used for different purposes: assessment of abatement potential and costs of air pollutants[7] or water availability[8]. MACC began to be used in the agricultural sector in the years 2000, using qualitative judgment[9] and more empirical methods.[10] [11]

In recent years, MACC has become very popular with policy makers, especially with the McKinsey and Company report (2008, 2009, 2010), analysing the global GHG abatement cost curves for different sectors, including agriculture.

Policy-makers use MAC-curves in order to demonstrate how much abatement an economy can afford and the area of focus, with respect to policies, to achieve the emission reductions.

The study of Climate Change in Agriculture – Impacts, adaptation and mitigation[12] has identified the development of marginal abatement cost modelling as one of the five areas of research and policy advocacy relevant for the OECD in relation to furthering the economics of climate change in agriculture.[13]

[5] EASYPol hyperlinks are shown in blue, as follows:

a) Resource packages are shown in **underlined bold font**
b) other EASYPol modules or complementary EASYPol materials are in ***bold underlined italics***;
c) links to the glossary are in **bold**; and
d) external links are in *italics*.

[6] Farugui et al. 1990, Jackson 1991.
[7] Silverman 1985, Rentz et al. 1994.
[8] Addams et al. 2009.
[9] ECCP, 2001; Weiske, 2005-2006.
[10] McCarl and Schneider, 2001, 2003; US-EPA, 2005, 2006; Weiske and Michel, 2007; Schneider et al., 2007, Smith et al., 2007a,b, 2008; Pérez and Holm-Müller, 2005; De Cara et al., 2005; Deybe and Fallot, 2003.
[11] Developing greenhouse gas marginal abatement cost curves for agricultural emissions from crops and soils in the UK, M.MacLeod and al., Agricultural Systems, Volume 103, Issue 4, May 2010, Pages 198-209 http://onlinelibrary.wiley.com/doi/10.1111/j.1477-9552.2010.00268.x/pdf
[12] OECD publishing.
[13] Climate Change in Agriculture – Impacts, adaptation and mitigation, Anita Wreford, Dominic Moran and Neil Adger, OECDpublishing, 2010 http://www.fao.org/fileadmin/user_upload/rome2007/docs/Climate%20Change%20and%20Agr.pdf

3.2 Understanding a Marginal Abatement Cost Curve

3.2.1 The socially optimal quantity of pollution

To answer the question “how much pollution a society should allow?” the marginal benefit from an additional unit of pollution has to be compared with the marginal cost of that additional unit.

The marginal social cost (benefit) is the total cost (benefit) to society as whole for producing one further unit. It is not only the direct cost (benefit) borne by the producer; it also includes the cost (benefits) to the external environment and other stakeholders. As a result, the marginal social cost (benefit) is expressed as follow:

$$MSC = MPC + MEC$$

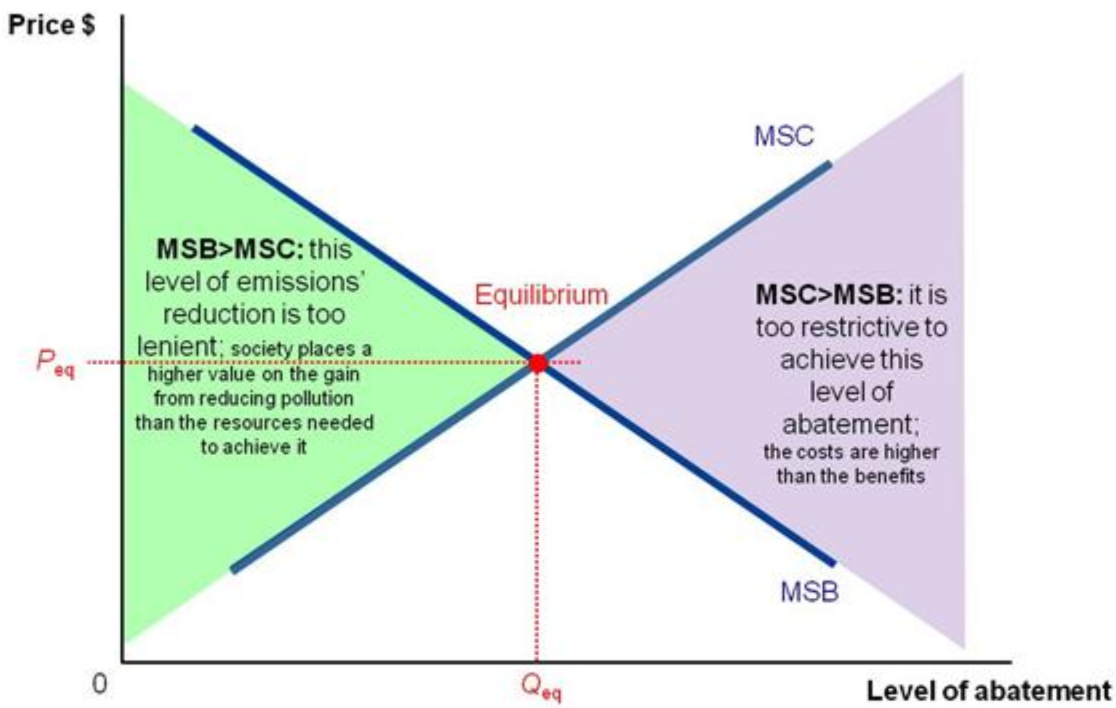
With MSC = marginal social cost
MPC = marginal private cost
MEC = marginal external cost

Social costs or benefits take into account externalities, while private costs/benefits do not. An externality is a consequence of an economic activity, not transmitted through prices, experienced by a third party who did not agree to the activity. An externality can either be positive (it is a benefit for the third party) or negative (it is a cost for the third party). For example, industrial farm animal production presents a negative externality due to the overuse of antibiotics: it contributes to the increase of the pool of antibiotic-resistant bacteria. Keeping bees for their honey is a positive externality since bees actively contribute to the pollination of crops. In the case of pollution, the social cost is generally higher than the individual cost due to these externalities.

The graph below illustrates the evolution of the cost and benefits to society regarding the level of abatement. The MSC of abatement is the cost to society as polluters reduce their emissions: reducing one more unit of pollution is more expensive, thus the MSC is an upward curve. The MSB of abatement is the social gain of having a cleaner environment; it is the society demand for pollution abatement. The society is willing to pay for a cleaner environment, but this willingness decreases with the increasing level of abatement[14]. The equilibrium is reached when MSC is equal to MSB. Q_{eq} is the social optimal quantity of abatement. It is desirable to reduce the emissions as long as the marginal benefits are higher than the marginal costs.

[14] Callan and Thomas, 2007.

Figure 2: the socially optimal level of abatement

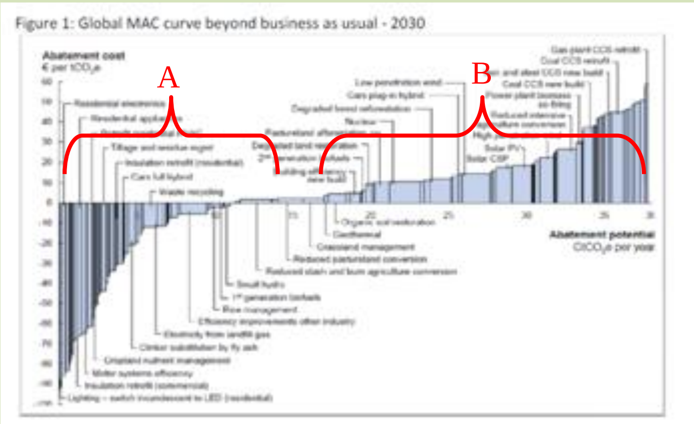
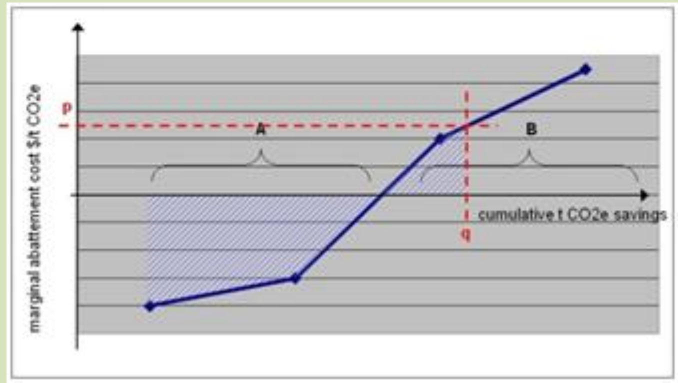


3.2.2 The MACC curve

A marginal abatement cost curve represents the relationship between the cost-effectiveness of different abatement options and the total amount of GHG abated *(cf. table 1)*. It reflects the additional costs of reducing the last unit of carbon and is upward-sloping: i.e. marginal costs rise with the increase of the abatement effort.

MACCs can be derived in different ways, either as a histogram or as a curve, as presented in table 1.

Table 1: the two designs of MACC

The histogram	**The curve**
 *Source: http://www.ecn.nl/docs/library/report/2011/o11017.pdf*	 *Source: FAO 2011*
The histogram assesses the cost and reduction potential of each single abatement measure Each bar represents a single mitigation option. ➢ The width of the bar represents the amount of abatement potential available from the action (in $MtCO_2e$). ➢ The height of the bar represents the average unit cost of the action (cost per ton of CO_2e saved). ➢ The area (height * width) of the bar represents the total cost of the action, i.e. how much it would cost altogether in order to deliver all the CO_2 savings from the action The total width of the MACC shows the total CO_2 savings available from all actions, and the sum of the areas of the total amount of bars represents the total cost of abatement for all actions. This type of MACC representation is easy to understand; the marginal cost and the mitigation potential can be unambiguously assigned to one option. We will especially focus on this type of graph in the rest of the paper.	The curve indicates the cost, usually in $/t CO2-eq, associated with the last unit (the marginal cost) of emission abatement (in general in million tons of CO2). The curve enables us to analyze the cost of the last abated unit of CO2 for a defined abatement level while the integral of the abatement cost curve (the area under the curve) gives us the total abatement costs. For example here, the point (q,p) represents the marginal cost, p, of abating an additional unit of carbon emissions at quantity q. The integral of the area under the curve (hatched area) represents the total abatement costs of carbon emission reduction q.
In both cases, moving along the curve from left to right worsen the cost-effectiveness of low carbon options since each ton of CO_{2e} mitigated becomes more expensive. Different mitigation options will occupy different positions on the curve. Some options may be able to reduce emissions and save money (A), other options may reduce more emissions, but incur a positive cost (B).	

Usually, two different approaches are used to build such curves: either an economy-orientated top-down model or an engineering-orientated bottom-up model. The top down analysis is based on a macro-economic general equilibrium model, providing overall cost to the economy. Top-down curves are preferred for studying macroeconomic and fiscal policies for mitigation purposes. The bottom-up approach models abatement potential and cost for individual technologies or measures. There are more useful for studying options that have sectoral and technological implications[15]. To be rigorous and consistent the MACC appraisal has to follow a common recognized methodology, accounting for AFOLU specificities. The results have to be transparent and comparable to other sectors of activity (energy, transportation, manufacturing...).

3.3 Using MACC as a planning tool in agriculture

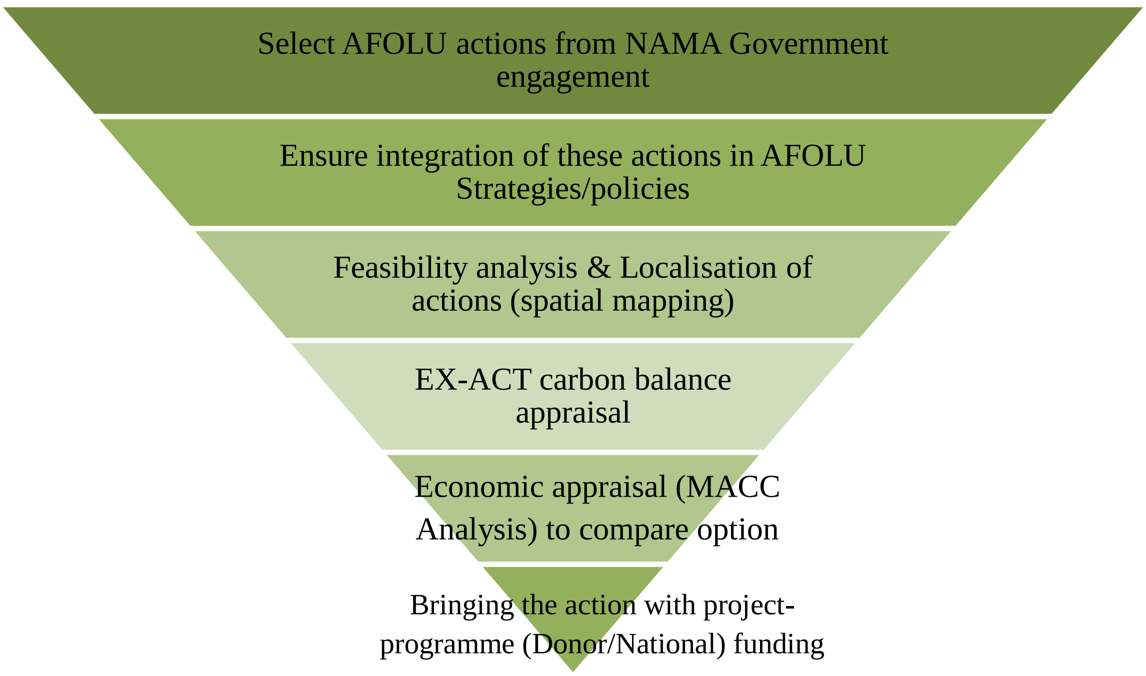
3.3.1 Relevance of the MACC approach to appraise low carbon options within a policy

Low carbon growth is an economic growth with a reduced carbon footprint. Nationally Appropriate Mitigation Actions (NAMAs) may become an interesting path to foster low carbon growth. NAMAs are voluntary country engagement proposals to the United Nations Framework Convention on Climate Change (UNFCCC). They consist in a set of government prioritized actions aimed at reducing or limiting Green House Gas emissions. They are expected to be the main vehicle for mitigation action in developing countries under a future climate agreement. NAMAs combine a set of actions that are necessary to facilitate the transition to low-carbon growth for different sectors of the economy, including agriculture and forestry.

The following approach could allow countries to switch directly from NAMAs to a set of AFOLU actions assessed and prioritized on the environmental impact, for example via the support from tools such as EX-ACT, measuring the carbon balance, but also the economical impact, e.g. via MACC. *(cf. figure 3)*. These actions need to be incorporated in the sector policy and planning framework, with donor support through project implementation. It would mobilize sector ministries and implementing agencies from agriculture and forestry and possibly from the ministry of planning.

[15] UNFCCC, 2006.

Figure 3: From NAMAs to low-carbon options in sector planning and projects



Source: FAO TCSP (2011).

3.3.2 Methodology for a MACC assessment in the AFOLU sector

The proposed methodology aims at establishing priorities between AFOLU low carbon options. First, the options mitigating climate change are identified and chosen. Then, the maximum technical potential of GHG mitigation is quantified, depending on land use constraints. Finally, the cost of the action is estimated.

The following provides the required steps for a MACC assessment in the AFOLU sector.

3.3.2.1 Criteria of selection to be considered before selecting low carbon options to appraise

The MACC approach is not a sufficient instrument to guide policy decisions as it considers only two dimensions; i) mitigation potential and, ii) costs. Yet, some options' externalities need to be identified *(cf. table 2)*. Thus some options could be strictly excluded because they do not allow adaptation, or have harmful impacts on e.g. poverty reduction, employment, trade-balance.

Finding a quantifiable cross-cutting indicator is difficult and sometimes not compulsory. In such cases, it is better to justify the reasons why an option was chosen and according to which criteria.

Table 2: Example of an externality assessment matrix

Option	Environmental externality				Economic externality				Social externality		
	biodiversity	landscape	Water management	erosion	employment	Trade Balance	Poverty reduction	Adaptation to climate change	security	Conflict farmer-pastoralist	farmer health
Option 1	X	X	X	X	X		X		X		X
Option 2	X		X	X		X	X			X	X
Option 3	X	X	X		X		X			X	X
Option 4	X	X	X		X	X	X			X	X
Option 5	X			X	X	X	X		X		X
Option 6	X				X	X	X	X	X		X
Option 7	X		X	X	X		X	X		X	X
Option 8	X		X		X	X		X		X	X

Too many negative externalities

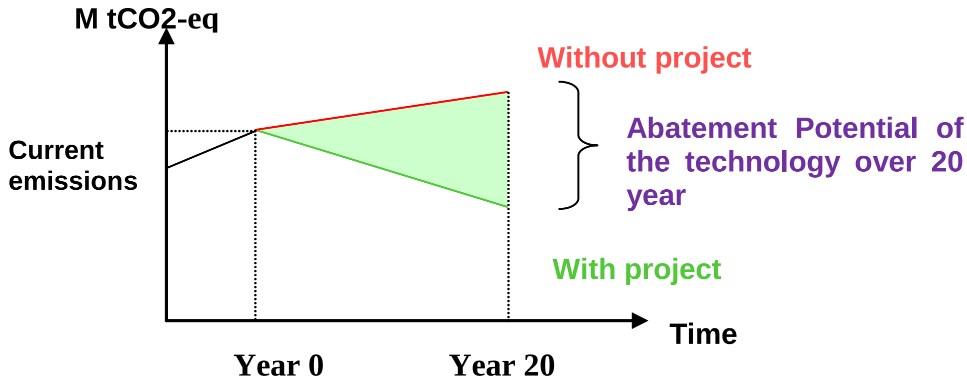
Eliminatory externality

If an option presents an exceeding number of negative externalities that are not in line with the national priorities, it will be excluded from the MACC analysis, e.g. the option in red in the table above.

3.3.2.2 Assessing the carbon balance of AFOLU options

A carbon balance is considered as the difference between the carbon emitted and stored by a proposed AFOLU option in comparison with a reference scenario (baseline scenario), during a time reference *(cf. figure 4)*.

Figure 4: Carbon balance frame of appraisal



According to the UNFCCC, the reference also called “baseline” scenario should be the most plausible baseline scenario including the most credible options of land use, possible land use changes and main management practices that could have occurred on the land within the project boundary without the implementation of the project.

The “with project” and “without project” scenarios have to be developed by local interactive expert groups. These scenarios aim at predicting the area concerned by Land Use Changes (LUC), changes in agriculture/breeding practices and the consumption of energy.

It could be relevant to assess the carbon balance of different scenarios and take into account the adoption rate of the mitigation actions. A calculation for the maximum technical potential can then be compared with the results of a high, central and medium feasibility scenario.[16] Part 3.3.3.3 explains more precisely the notion of technical maximum potential and feasibility.

3.3.2.3 Evaluation of the cost-effectiveness of the option

The step will quantify the cost-effectiveness in terms of USD/t CO2e for each mitigation action. First, the costs and benefits need to be quantified, as well as the timing of costs and benefits, which enables to calculate the Net Present Value (NPV).

The NPV is used in capital budgeting to analyze the profitability of an investment or a project. It represents the difference between the present value of the future cash flows from an investment and the amount of investment. The present value of the expected cash flows is computed by discounting them at the required rate of return.

A positive NPV means that the project is profitable, whereas a negative NPV means that the costs are higher than the benefits.

[16] Methodology proposed in the study UK Marginal Abatement Cost Curves for the Agriculture and Land Use, Land-Use Change and Forestry Sectors out to 2022, with Qualitative Analysis of Options to 2050, SAC Commercial Ltd, November 2008
http://www.theccc.org.uk/pdfs/SAC-CCC;%20UK%20MACC%20for%20ALULUCF;%20Final%20Report%202008-11.pdf

Figure 5: Formula to calculate the NPV

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_0$$

Ct = the cash flow the investor receives each year
C0 = the initial investment
R = the discount rate
T = the time (duration of the project)

The costs traditionally used focus on direct technical abatement costs; implementation, capital and production costs. However, when possible, it is recommended to take into account the other indirect impacts and hidden costs.[17]

The costs and benefits taken into account are the additional costs and revenues due to the project, compared to a reference situation where nothing is done. Some methodologies (Word Bank, IEA 2009) use a delta NPV, which is the difference between the NPV of the project and the NPV of the reference situation. In this case, it is assumed that the reference situation is not a static one, and changes occur, having impacts on the cost and benefits over time. The formula to calculate the MAC is therefore (NPV of the project – NPV of the reference situation) / (GHG emissions in the reference situation – GHG emissions in the situation with the project). This approach is mostly required at the policy level analysis.

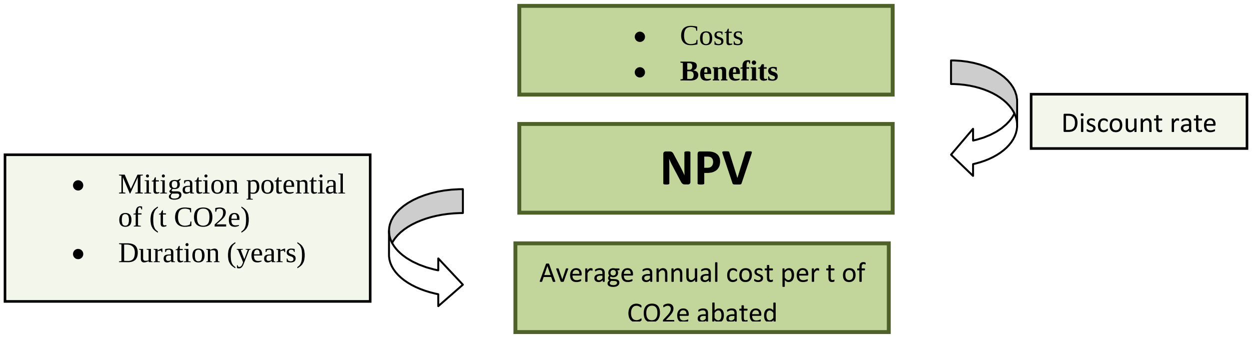
The main issue in this step is the choice of an appropriate discount rate. The matter is tackled in part 3.3.3.4.

Furthermore, the NPV is then divided by the amount of GHG avoided and the duration of the project, thus giving the average annual cost or gain of abatement for each measure, in USD/t CO2e/year.

With the information on the mitigation potential (t of CO2e abated) and the average cost of each mitigation measure (USD/t CO2e/year), the MAC curve can be drawn. The next step is the analysis of the MACC results, and the choice of the most interesting mitigation options for policy makers.

[17] The Committee on Climate Change's methodology and approach to using Marginal Abatement Cost Curves to derive Domestic Carbon Budgets

Figure 6: From the economical data of a mitigation action to the marginal cost of the action



3.3.2.4 Option ranking

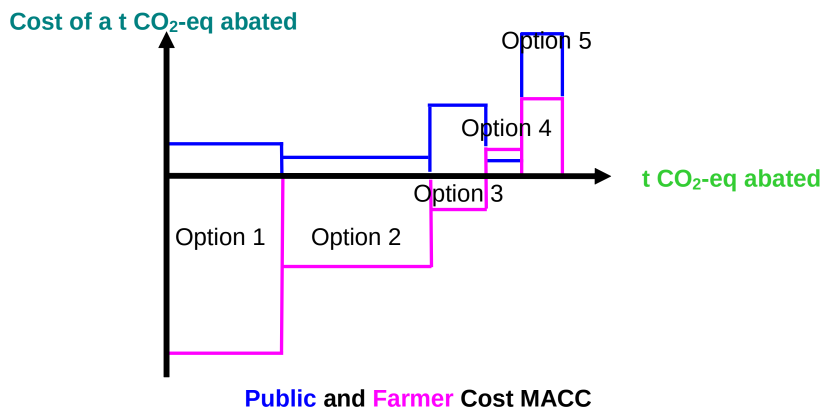
The low carbon options can be sorted in the MACC into different options:

- *The public cost* of the option. It is the factor that is generally used, showing the most cost efficient option. However this ranking hides the farmers' willingness to adopt an option, and therefore the adoption rate could be lower than expected. The public costs illustrate the support of the government towards the mitigation measure. It includes direct investment for example in seeds' development or in tree plantation, fund transfers to help farmers such as subsidies-voucher for fertilizers, seeds and feed, financing of technical support in the form of extension service (agricultural adviser), payment of environment services and finally administrative cost, to manage all the previous investments and financings.

- *The farmer interest*. The private cost represents the costs and benefits for the farmer: the expenses for purchasing fertilizers, and supplements feed, increasing labor and the revenues from a higher yield. Within some low carbon options, the farmer or the micro-agent may lose a specific income–source by not doing / avoiding a specific option (for instance loosing income of crops on new deforested area, due to non deforestation). This is accounted as an opportunity cost for the private operator. Such opportunity costs need to be covered by appropriate incentives (payment of Environment services, honorarium of forest control-protection, input voucher) to ensure the low carbon option is implantable and sustainable after project. Such incentives are accounted as additional incomes for private sector. The farmer interest could be used to identify the easiest option to be implemented on the field. However, the abatement cost is always expressed in currency per T of CO2-eq, whereas the farmers would rather be interested in a benefit in terms of currency per working days or per hectare (depending on the level of intensification). Therefore it could be worth expressing the benefits from a farmers' point of view to ensure better option penetration.

- *The ratio between public and farmer (also called "Leverage effect").* The factor helps to better understand the farmer benefit for each dollar spent by public policy. That could be a way to sort the options regarding their poverty-reduction potential.

Figure 7: Final MACC chart integrating both public and private cost



The MACC presentation of the previous feasible options allows prioritizing them regarding the cost-effectiveness of carbon abated and the leverage effect. Once drawn, the MACC is ready for interpretation *(cf. Table 3).*

Table 3: Example of MACC interpretation

	Comment	**Priority**
Option 1	Farmer benefit **>** Public Cost Option with good leverage effect and great potential	**2**
Option 2		**1**
Option 3	Farmer benefit < Public Cost Interesting option for farmer but cost-inefficient regarding the leverage effect	**3**
Option 4	it costs the Farmer to implement this option (avoided deforestation for example but could be implemented with PES (Farmer Cost > Public cost)	**4**
Option 5	**Farmer cost and Public cost are high** **Those options could not be financed at this stage of technology**	**Long term?**

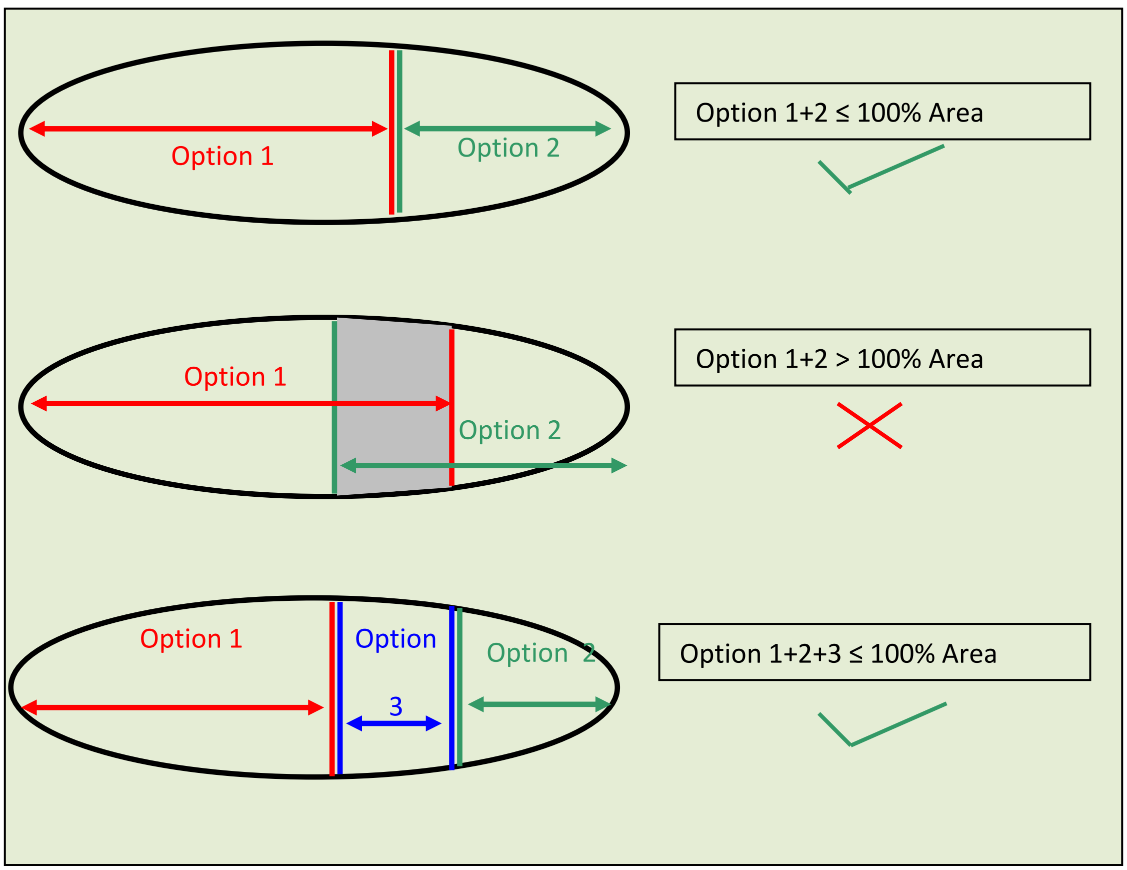
Regarding public costs, the cost for the government of implementing a specific mitigation action could be compared with the price of the ton of carbon on the market. It could help identify and choose actions that can be financed by the carbon market. If the public cost is lower than the current price of one ton of CO2e on the market, selling carbon credits from the mitigation option would allow financing it entirely.

3.3.3 Development of the MACC analysis: points to be aware of

3.3.3.1 Precautions to be taken with the superimposition of two mitigation options

Sometimes it is not possible to account for several options on the same area since the project boundaries would not be respected. If two options are implemented on the same area, the user needs to build a third option for this surface area. However, these carbon potential is not the sum of the two previous options (option 3 ≠ option 1 + option 2). Figure 8 below explains this situation. This issue is linked with the one about interactions between measures. If option 1 and 2 are implemented on the same area, they can interact together. It is necessary to take into account this interference in the MACC analysis, as explained in part 3.3.3.5.

Figure 8: The need of creating an additional option when several options are applied on the same area (avoiding double accounting)



The land use (LU) change follows the same logic. An area allocated to a new LU could not be used for an option corresponding to the initial LU.

To follow the EX-ACT methodology, the most representative mitigation potential is the maximum potential of all selected management practices. The approach is conservative and is supposed to be the best choice because there is evidence in the literature that certain options are not additive when applied simultaneously. Thus, the final carbon balance is not the addition of the two previous potentials. With a conservative approach, only the practice with the best mitigation potential is taken into account.

In some cases different options cannot be split. For example:

- At field scale, the "no tillage-residue management" practice could be implemented only if there is no residue burning and no grazing.
- At the agro-system scale, there is a need of manure production. Therefore, straw has to be harvested (excluding no-tillage practice, and implying no fire use), forage have to be produced (land-use change, or pasture improvement), and livestock better managed.

3.3.3.2 Construction of the baseline scenario

The assumptions for building the baseline scenario are very important. Indeed, depending on the hypothesis taken into account, the results of carbon balance can be very different.

The baseline scenario should be the most plausible baseline scenario [18] including the most credible options of land use, possible land use changes and main management practices that could have occurred on the land within the project boundary, without the implementation of the project.

Currently, there is no consensual precise methodology to build the baseline. The future GHG emissions are indeed driven by numerous factors such as future economic development, population growth, international prices, technological development, and so on, thus leading any projection to have more or less uncertainty. In any case, some criteria's have to be respected to elaborate the BAU scenario.

Different kind of baseline scenario can be build:

- No change scenario
- Use of past trends to get the future trends
- Use of models and forecasts for the future

The no change scenario is often applied on small scale appraisal for which the project aims at changing a current "static" situation. It is the simplest way of building the baseline scenario as the current situation is the well known entry point.

The two other approaches will be used according to the availability of data linked to future trends. The use of predictive models should be preferred when available. By default, if no projections have been conducted, the easiest would be to forecast the future by using the past trends.

As a result, the best way to overcome this issue is to compare the results with different baseline scenarios, and see how the results are impacted by the choice of the baseline scenario.[19]

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[18] UNFCCC *http://cdm.unfccc.int/UserManagement/FileStorage/W9RY2SX45CMGK3QT16ZFPUED7IBN0V*

3.3.3.3 Choice of the feasible mitigation potential against maximum technical potential

The mitigation potential and consequently the total cost of abatement depend on the adoption rate of the mitigation action. It is also useful to analyze different scenarios according to the level of penetration. Finally, the maximum technical potential and another degree of feasibility have to be distinguished.

The Committee on Climate Change, which is an independent body advising the UK Government on setting and meeting carbon budgets and on preparing for the impacts of climate change, advises to draw four different MACC:

- *Maximum technical potential*: the official IPCC definition is «*the amount by which it is possible to reduce GHG emissions by implementing a technology or practice that has already been demonstrated. There is no specific reference to costs here, only to 'practical constraints', although implicit economic considerations are taken into account in some cases*». The maximum technical potential should reflect a 100% technology implementation.[20]
- *High feasible potential*: it is a percentage of uptake if the government made the measure mandatory through regulation[21]
- *Central feasible potential*: it represents the likely percentage arising if there were a policy to subsidise the cost of implementing mitigation measures or penalise emissions[22]
- *Low feasible potential*: it is the level of uptake if the government encourages adoption through education and information.[23]

3.3.3.4 Choice of the discount rate

In order to calculate the abatement cost of one ton of CO2e, the Net Present Value (NPV) of the action, which is a mean to measure the profitability or the cost of a project, has to be known.

The choice of the discount rate, in order to calculate the NPV, can have significant implications on the cost effective potential for abatement. The discount rate is the minimum level of return on investment a company or a government deems acceptable.

The higher the discount rate, the higher the 'repayment' needs to be[24]. For example a low-tillage equipment lasting 10 years will have to generate benefits, e.g. yield increase and fertilizer savings, worth almost 20% more when using a 7% discount rate compared to a 3.5% discount rate. The treatment of discount rates has significant differences to the cost effectiveness of abatement options.

Two types of discount rates are usually used referring to different related concepts:

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[19] FAO 2011, Readers can find more guidance on the construction of a baseline scenario in the EX-ACT paper *Main Recommendations for the Elaboration of the Baseline Scenario.* **http://www.fao.org/fileadmin/templates/ex_act/pdf/Policy_briefs/Building_the_baseline_draft.pdf**
[20] CCC, 2008.
[21] MacLeod et al, 2010.
[22] MacLeod et al, 2010.
[23] MacLeod et al, 2010.
[24] CCC, 2008.

- The *private rate* reflects the cost of capital, using a private weighted average cost of capital (WACC). It represents the cost of a loan, foregone income from an alternative investment or transaction costs. That kind of discount rate could be used to describe farmers' preference for the present time. Usually, a 10% discount rate is used, measuring the cost faced by private individuals when making investment decisions.

- The *social discount* rate provides an estimate of the rate for which society trades off the future and the present. It reflects society's preference over time, i.e. present benefits and subsequent costs. The lower discount rate can be 3.5% for example. The BERD (2010) states that "*Most MAC-curves calculate the cost of carbon-reducing investment projects from the perspective of a social planner, where costs are engineering resource costs, discount rates reflect the government cost of borrowing and investment risks are ignored* (rather minimized). *These models produce a very optimistic picture of a vast abatement potential that could be realised at no cost or even at a profit to society. However, because many of the abatement opportunities deemed to be money-saving are unlikely to be financially viable in the marketplace, societal-abatement cost curves have been viewed with scepticism by project developers and financial institutions*." [25]

In reality, abatement is not achieved by governments, but by a myriad of private and public investors who have different perspectives from social planners and who pay taxes and receive subsidies (BERD, 2010). It is why a type of hybrid discount rate can be used, as suggested by the CCC (2008), where the social discount rate also includes costs of capital.[26]

Yet, another solution has been recommended: to use declining discount rates applied to environmental benefits that will persist far into the future. For example, Weitzman[27] (2001) recommends declining discount rate scale as follows. Use a discount rate of 4% for the first five years, 3% for the sixth year until year 25; 2% for years 26 through 75 years.

3.3.3.5 Interaction between two options

An abatement measure can be applied on its own, i.e. stand alone, or in combination with other measures[28]. In the second case, measures are likely to interact and their abatement potential and cost effectiveness may change For example, if farmers in developing countries increase the productivity of their crops, but use more fertilizers, it will increase the extent to which the N fertilizer can be reduced but at the same time it can decrease the cost of forest preservation, since there will be less deforestation due to higher yields (*figure 9*).

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[25] BERD, Special Report on climate change, Effective policies to induce mitigation, 2010
[26] The Committee on Climate Change's methodology and approach to using Marginal Abatement Cost Curves to derive Domestic Carbon Budgets
[27] Weitzman, M.L. (2001) "Gamma Discounting, *"American Economic Review 91*(1), 260-271.
[28] MacLeod and al, 2010.

These interactions have to be accounted on the final MACC chart, but the message of priority could be distorted.

Figure 9: The impact of interaction on the final decision.

Option 1: increasing crops' productivity by using more fertilizers and improved seeds presents an abatement cost of 10 USD/tCO_2-eq.

Option 2: reducing deforestation presents an abatement cost of 15 USD/ tCO_2-eq.

Therefore option 1 should be chosen in priority.

Option 1 may have an impact on option 2. With higher yields, the population won't need more arable land to produce their necessary quantity of corn, maize, sorghum ...The slash and burn practices are supposed to decrease, resulting in less forest areas cleared to cultivate crops. As a result, the action of protecting the forest would become cheaper, reaching 5 USD/t CO2e instead of 15 USD, since a percentage of the forest is not threaten anymore due to the crops 'intensification.

If options are sorted again by cost-effectiveness, the option 2 could be chosen in priority. In this case, the message conveyed is false and hazardous, i.e. option 2 is under evaluated if option 1 is not applied.

To jeopardize the risk of interactions, the ranking of options have to be conducted before the cost interaction appraisal, and the interactions need to be clearly notified on the MACC chart.

Each time a practice is implemented, the abatement rate and cost of the remaining measures have to be recalculated. Failing to take into account interactions between measures is likely to lead to significant double-counting and over-estimation of the overall abatement potential. [29]

3.3.3.6 Time dimension in long-term policy planning

To account for dynamic processes, a dynamic MACC can be built. Such work is useful for systems that change in time. For example, thanks to technology evolution, it is expected that option costs would decrease in the long-term, via commodity prices, R&D, investment, learning effects, economies of scale and indirect effects of non GHG policies. At the same time, as systems become more efficient overtime, the total mitigation potential will decline, resulting in higher costs per t CO2e. Therefore, while MACCs are useful tools for assessing the current cost-effectiveness of different mitigation practices, policy formulation should include analysis of the measures cost dynamics, i.e. how the cost effectiveness might change through time[30].

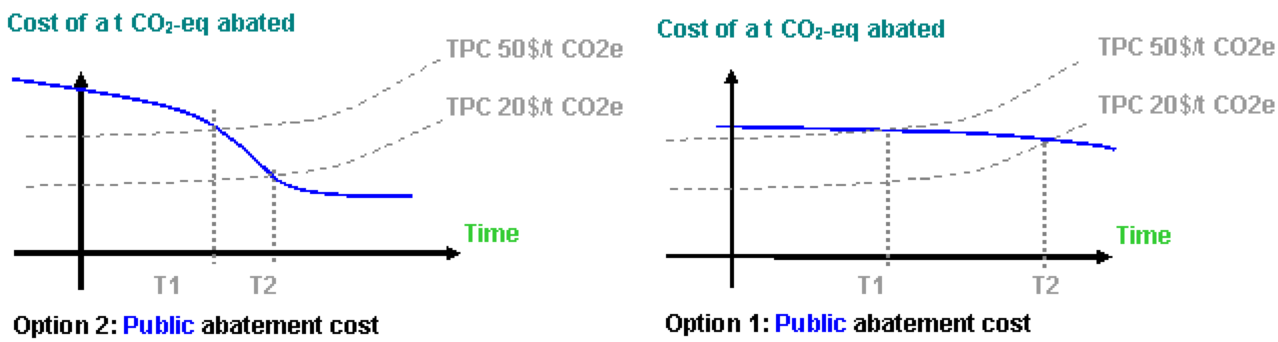
The current cost-ineffectiveness option, i.e. options on the right side of a MACC, could become interesting in long term policy as the cost of implementation and the benefit might change due to technology improvement.

[29] MacLeod et al, 2010. Developing green house gas marginal abatement cost curves for agricultural emissions from crops and soils in the UK, M. MacLeod and al., Agricultural Systems, Volume 103, Issue4, May 2010, p.198-209 http://www.sciencedirect.com/science/article/pii/S0308521X1000003X

[30] MacLeod et al, 2010.

For each option a time-based curve could be drawn to estimate the time when the cost effectiveness will be reached *(cf. figure 10).*

Figure 10: Option cost evolution



As an example, option 1, for example increasing crops' productivity, seems to be increasingly effective compared to option 2, e.g. reforestation, since the cost at the beginning is lower. However, if option 2 belongs to a dynamic sector, the cost could decrease rapidly and become cheaper than option 1.

The assumption taken to foresee the cost's evolution is very important before concluding which option needs public expenditure.

Some options may have irreversible impacts and present opportunity window to be implemented on short delay (avoided deforestation, exploitation of wetlands).

3.3.3.7 Non recognition of ancillary benefits

MAC curves usually only concentrate on carbon emission abatement, thus attributing all of the costs associated with the abatement to carbon emission reductions. Ancillary costs or benefits are not included, even if the reduction in CO2 emissions generates co-benefits on animal welfare, energy consumption, diffuse water pollution or air pollution. These co-benefits are difficult to quantify as they involve different spatial and temporal scales[31].

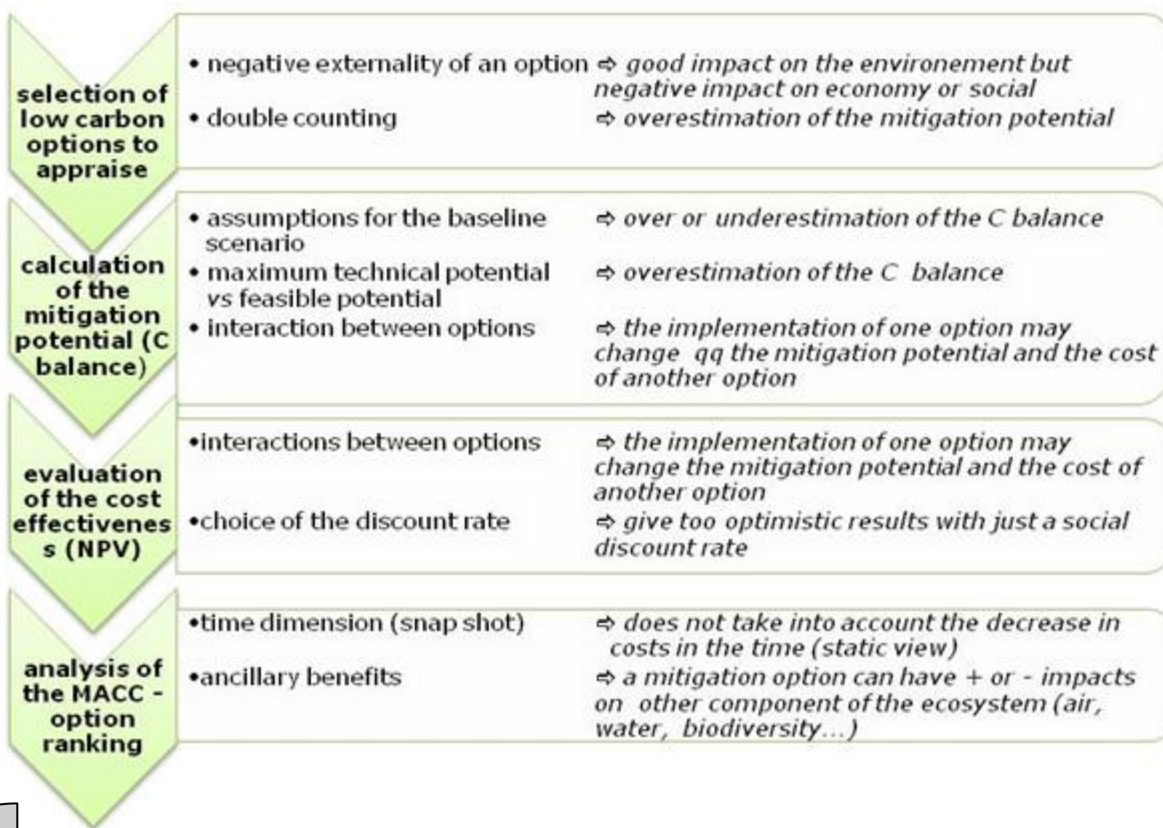
Such a limit needs to be taken into consideration when choosing low carbon options to build an agricultural policy.

Figure 16 below sums up the four steps to build a marginal abatement cost curve in the agricultural sector, and points out the limits to take into account before making a decision with the MACC results.

[31] Kesicki, 2010.

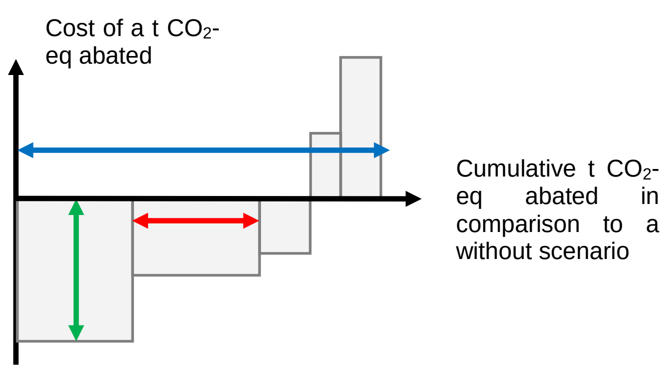
Figure 11: Methodology to build a MAC curve for AFOLU mitigation option

Step / Associated focus of attention (limits) / *Consequences*



The decision will depend on:

- The mitigation potential of each measure (t CO2e)
- The average cost of avoided emissions for each measure ($/T CO2e)
- Funds available for the financing (total cost per measure $)
- Government objectives (total mitigation to achieve)



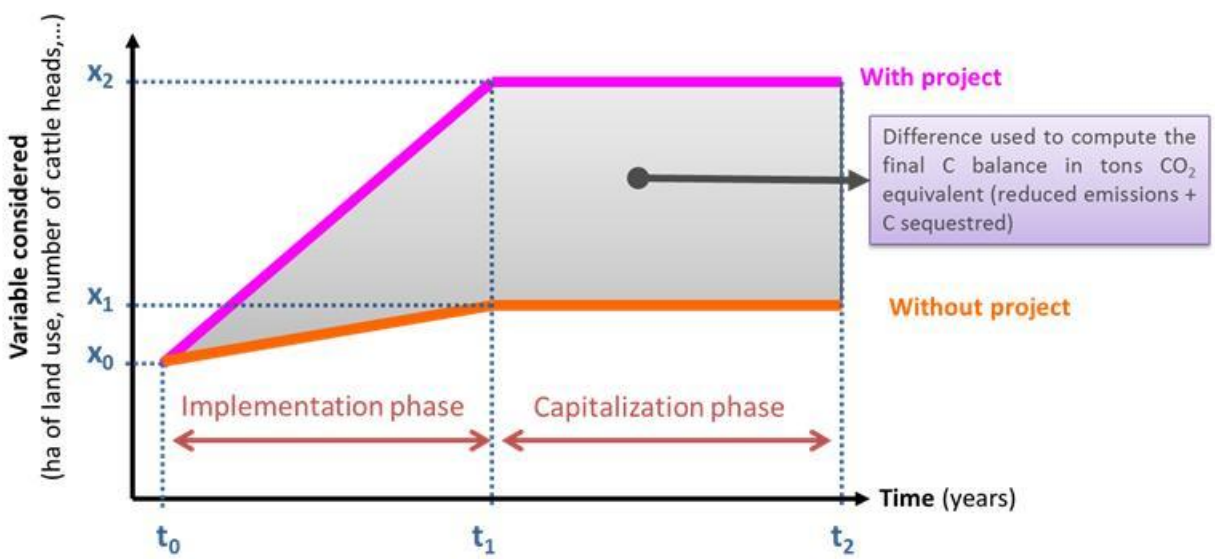
4 CONCRETE APPLICATION OF THE MACC WITHIN THE EX-ACT TOOL

4.1 Carbon balance appraisal with EX-ACT

EX-ACT is a tool developed by FAO and aimed at providing ex-ante estimates of the impact of agriculture and forestry development projects on GHG emissions and C sequestration, indicating its effects on the C-balance[32], which is selected as an indicator of the mitigation potential of the project[33]. It is capable of covering the range of projects relevant for the land use, land use change and forestry (LULUCF) sector. It can compute the C-balance by comparing two scenarios: "without project" (i.e. the "Business As Usual" or "Baseline") and "with project". The main output of the tool consists of the C-balance resulting from the difference between these two alternative scenarios (*figure 12*).

The model takes into account both the implementation phase of the project (i.e. the active phase of the project commonly corresponding to the investment phase), and the so called "capitalization phase" (i.e. a period where project benefits are still occurring as a consequence of the activities performed during the implementation phase). Usually, the sum of the implementation and capitalization phases is set at 20 years. EX-ACT was designed to work at a project level but it can easily be up-scaled at program/sector or national level[34].

Figure 12: Quantifying C-balance "with" and "without project" using EX-ACT



Source: Bernoux et al. 2010

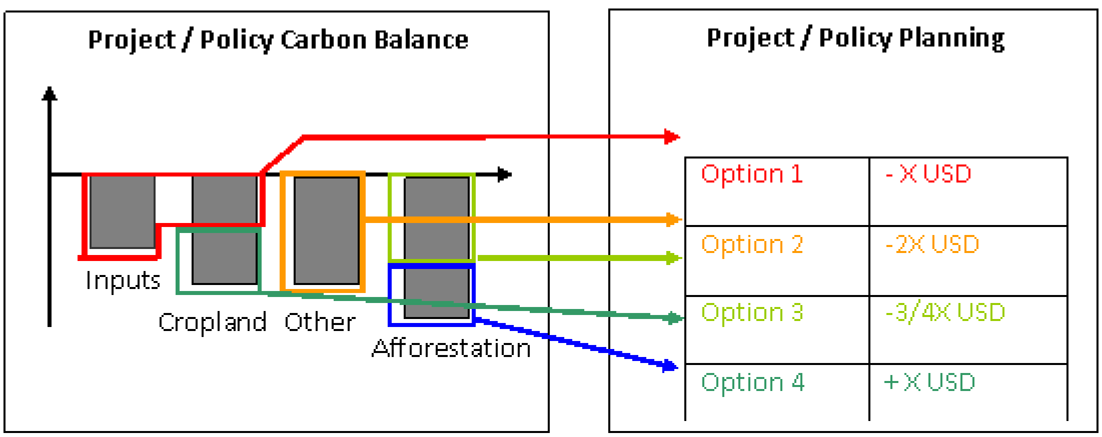
[32] C-balance = GHG emissions - C sequestered above and below ground.
[33] EX-ACT 2010.
[34] Bernoux et al. 2010.

EX-ACT measures C stocks and stock changes per unit of land, as well as Methane (CH_4) and Nitrous Oxide (N_2O) emissions expressing its results in ton of Carbon Dioxide equivalent per hectare (t $CO_2e.ha^{-1}$) and in ton of Carbon Dioxide equivalent per year (t $CO_2e.year^{-1}$).

4.2 Linking EX-ACT results with MACC design

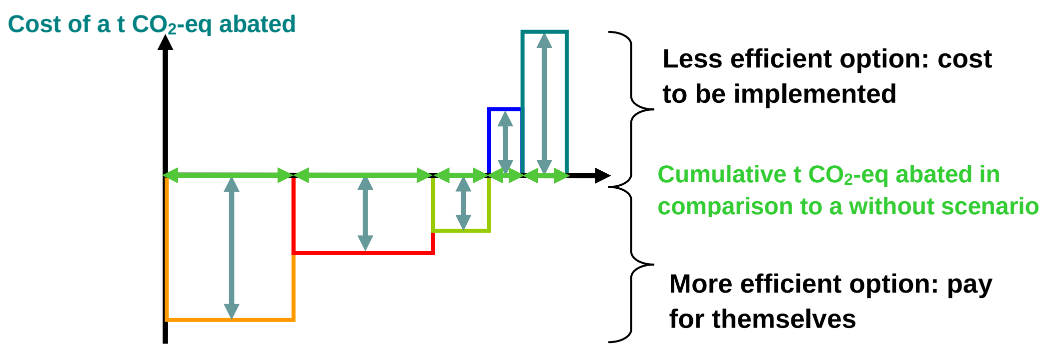
The low carbon options planned by project designers are occasionally crosscutting the EX-ACT modules. The modular approach prevents us from clearly seeing the carbon balance of each adopted option.

Figure 13: How to manage the complexity



A MACC enables to manage these two dimensions of complexity. The curves could be presented to businesses or public policy makers to compare the results of different investments in terms of carbon storage and benefits.

Figure 14: ... using MACC to synthesize the information

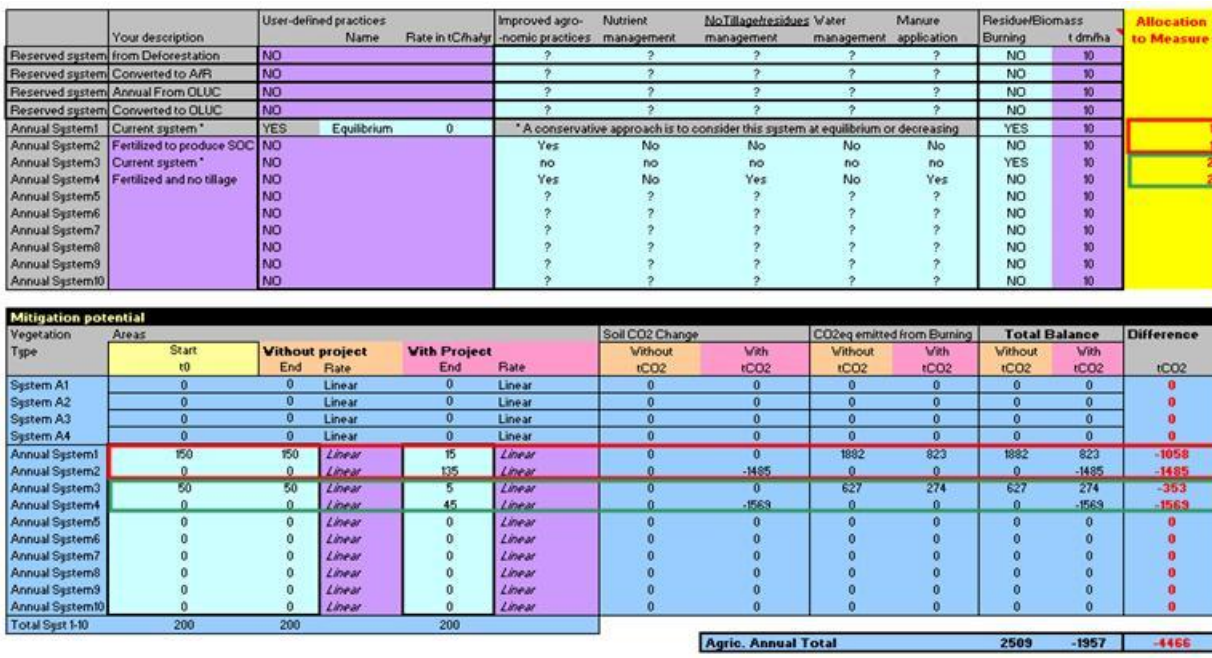


For visibility purposes it is recommended to limit the number of options to preserve the MACC chart visibility. One option can be split into several EX-ACT modules, e.g. annual crop and inputs. It is thus necessary to carry out a synthesis of the different parts of the general option, linked with their agronomic feasibility. Each carbon balance provided by the tool needs to be allocated to an option, in order to match the carbon balance with the MACC potential.

EX-ACT can be enriched to facilitate the consideration of previous examples:

- With the addition of new columns after each description line of EX-ACT module to allocate the carbon balance to an option type (cf. *figure 15-16*).
- With an automatic consolidation of all split options to a new EX-ACT "MACC" module (cf. *figure 17*)

Figure 15: Examples of allocating various carbon balances to a single option



	Your description	User-defined practices	Name	Rate in tC/ha/yr	Improved agro-nomic practices	Nutrient management	NoTillage/residues management	Water management	Manure application	Residue/Biomass Burning	t dm/ha	Allocation to Measure
Reserved system	from Deforestation	NO			?	?	?	?	?	NO	10	
Reserved system	Converted to A/R	NO			?	?	?	?	?	NO	10	
Reserved system	Annual From OLUC	NO			?	?	?	?	?	NO	10	
Reserved system	Converted to OLUC	NO			?	?	?	?	?	NO	10	
Annual System1	Current system *	YES	Equilibrium	0	* A conservative approach is to consider this system at equilibrium or decreasing					YES	10	1
Annual System2	Fertilized to produce SOC	NO			Yes	No	No	No	No	NO	10	1
Annual System3	Current system *	NO			no	no	no	no	no	YES	10	2
Annual System4	Fertilized and no tillage	NO			Yes	No	Yes	No	Yes	NO	10	2
Annual System5		NO			?	?	?	?	?	NO	10	
Annual System6		NO			?	?	?	?	?	NO	10	
Annual System7		NO			?	?	?	?	?	NO	10	
Annual System8		NO			?	?	?	?	?	NO	10	
Annual System9		NO			?	?	?	?	?	NO	10	
Annual System10		NO			?	?	?	?	?	NO	10	

Mitigation potential

Vegetation Type	Areas Start t0	Without project End	Without project Rate	With Project End	With Project Rate	Soil CO2 Change Without tCO2	Soil CO2 Change With tCO2	CO2eq emitted from Burning Without tCO2	CO2eq emitted from Burning With tCO2	Total Balance Without tCO2	Total Balance With tCO2	Difference tCO2
System A1	0	0	Linear	0	Linear	0	0	0	0	0	0	0
System A2	0	0	Linear	0	Linear	0	0	0	0	0	0	0
System A3	0	0	Linear	0	Linear	0	0	0	0	0	0	0
System A4	0	0	Linear	0	Linear	0	0	0	0	0	0	0
Annual System1	150	150	*Linear*	15	*Linear*	0	0	1882	823	1882	823	-1058
Annual System2	0	0	*Linear*	135	*Linear*	0	-1485	0	0	0	-1485	-1485
Annual System3	50	50	*Linear*	5	*Linear*	0	0	627	274	627	274	-353
Annual System4	0	0	*Linear*	45	*Linear*	0	-1569	0	0	0	-1569	-1569
Annual System5	0	0	*Linear*	0	*Linear*	0	0	0	0	0	0	0
Annual System6	0	0	*Linear*	0	*Linear*	0	0	0	0	0	0	0
Annual System7	0	0	*Linear*	0	*Linear*	0	0	0	0	0	0	0
Annual System8	0	0	*Linear*	0	*Linear*	0	0	0	0	0	0	0
Annual System9	0	0	*Linear*	0	*Linear*	0	0	0	0	0	0	0
Annual System10	0	0	*Linear*	0	*Linear*	0	0	0	0	0	0	0
Total Syst 1-10	200	200		200								
Agric. Annual Total										**2509**	**-1957**	**-4466**

Figure 16: Use of an allocation matrix to allocate a fraction of inputs for each option when only one line is used to calculate a carbon balance:

Carbon dioxide emissions from Urea application

	Amount of Urea in tonnes per year					Emission (t CO2eq) per year			Total Emission (tCO2eq)		
	IPCC factor	Start	Without Project		With Project		Start	End				Difference
		t0	End	Rate	End	Rate		Without	With	Without	With	
Urea	0.2	0	3	Linear	40	Linear	0	0.6	8	8	100	93
						Sub-Total I-2	0	0.6	8	8	100	93

allocated to measure		
1	2	3
75%	25%	

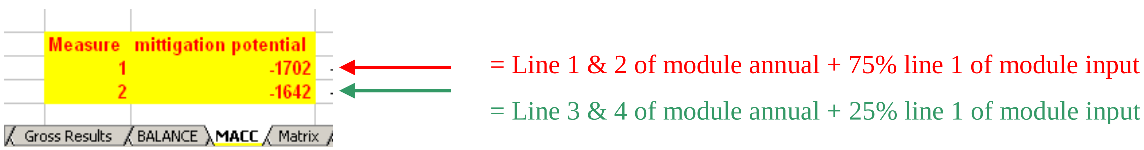
CO_2 equivalent emissions from production, transportation, storage and transfer of agricultural chemicals

Amount in tonnes of product (active ingrediente for Pesticides)

Type of input*	Default factor*	Start t0	Without Project End	Without Project Rate	With Project End	With Project Rate	Start	End Without	End With	Total Emission Without	Total Emission With	Difference
Urea	4.8	0	1	Linear	19	Linear	0.0	6.7	89.0	83	1,112	1029
N Fertiliser (ot	4.8	0	0	Linear	0	Linear	0.0	0.0	0.0	0	0	0
N Fertiliser in	4.8	0	0	Linear	0	Linear	0.0	0.0	0.0	0	0	0
Phosphorus s	0.7	0	0	Linear	0	Linear	0.0	0.0	0.0	0	0	0
Potassium sy	0.6	0	0	Linear	0	Linear	0.0	0.0	0.0	0	0	0
Limestone (Li	0.6	0	0	Linear	0	Linear	0.0	0.0	0.0	0	0	0
Dolomite (Lim	0.6	0	0	Linear	0	Linear	0.0	0.0	0.0	0	0	0
Generic Lime	0.6	0	0	Linear	0	Linear	0.0	0.0	0.0	0	0	0
Herbicides (Pe	23.1	0	0	Linear	0	Linear	0.0	0.0	0.0	0	0	0
Insecticides (P	18.7	0	0	Linear	0	Linear	0.0	0.0	0.0	0	0	0
Fungicides (Pe	14.3	0	0	Linear	0	Linear	0.0	0.0	0.0	0	0	0
						Sub-Total I-4	0.0	6.7	89.0	83	1112	1029
							Total "Inputs"			145	1936	1790

* from Lal (2004) Table 5 - central value -tCO2/t product
** tonnes of N, P2O5, K2O and CaCO3

Figure 17: "MACC Module" in EX-ACT to consolidate the previous Carbon balances



4.3 Example of the Turkey National Climate Change Strategy

4.3.1 Selection of the low carbon options to appraise and calculation of the mitigation potential

The Turkey National Climate Change Strategy identifies priority activities to be carried out in sectors for mitigating climate change, as well as urgent measures for adaptation. It runs from 2010 to 2020. Agriculture is one of the tackled sectors. Data from the official government publication[35] have been used to do the assessment. When no precise data were available, assumptions have been made, based on FAO Stat data for 2008. Figure 18 gives the land use in 2008[36] and table 4 the actions planned within the strategy.

[35] Republic of Turkey – National Climate Change Strategy (2010-2020) – TR Ministry of Environment and Forestry, May 2010, p.11 and 12 *http://www.iklim.cob.gov.tr/iklim/Files/Stratejiler/National%20Strategy.pdf*
[36] FAO Stat.

Figure 18: Turkey Land Use in 2008

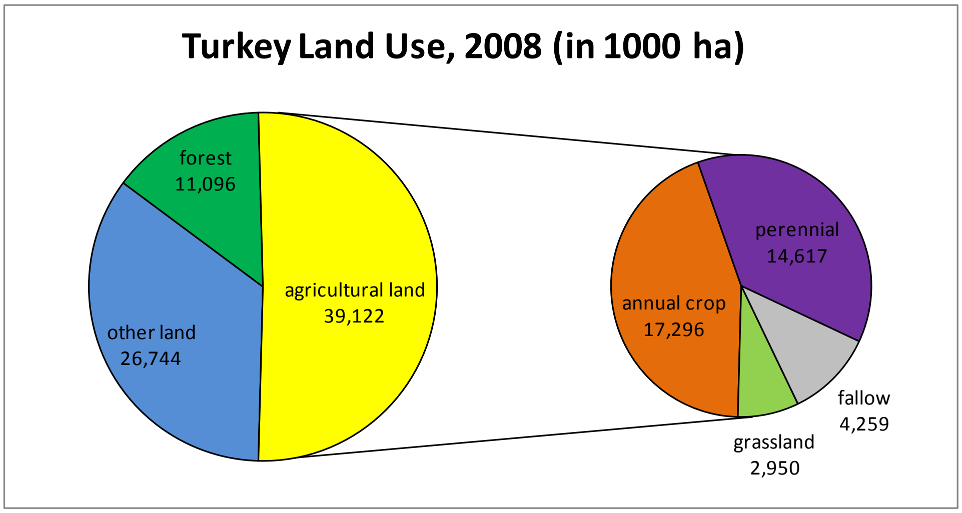


Table 4: Mitigation options planned in the Turkish strategy, with the surface area (or the number of head) concerned, and EX-ACT modules to refer to

Activities [12]	EX-ACT module	Surface area concerned (in ha or head or t of inputs)		% change (in blue when it is an assumption)	Grouping in one mitigation option
		"without" scenario[37]	"with" scenario		
traditional annual crops	Annual	*17,296,000*	*10,377,600*		
improved annual crops (nutrient management, better agronomic practices)		-	5,188,800	30%	crops improvement (seeds, rotation, nutrient)
organic & no tillage			1,729,600	10%	promotion of organic and no-tillage farming (tillage, manure)
traditional grassland	Grass	*2,950,000*	*2,212,500*		
improved grassland		-	737,500	25%	grassland improvement
traditional paddy rice	Irrigated rice	*99,493*	*74,620*		
improved paddy rice (irrigation)		-	24,873	25%	rice irrigation improvement

[37] FAO Stat *http://faostat.fao.org/default.aspx*

Activities [12]	EX-ACT module	Surface area concerned (in ha or head or t of inputs)		% change (in blue when it is an assumption)	Grouping in one mitigation option
		"without" scenario [37]	"with" scenario		
stabilization of livestock	Livestock	14,104,757	11,121,505	increase 2%/year	
better feeding practices for cattle		-	2,224,301	20%	livestock management
Afforestation (on fallow and degraded lands)	A-R	-	2,300,000		afforestation
fallow		*4,259,000*	*1,959,000*		
total less fertilizers (nutrient management)	Inputs	2,059,815	1,647,852	20%	Crops improvement (90%) and organic farming (10%)
Increased use of pesticides		33,914	40,697	20%	Afforestation (21%) and organic farming (79%)

After having reallocated the emissions of each activity to the appropriate option, the final carbon balance of the Turkish National Strategy is as follows (*table 3*). It is important to understand that the result depends on the baseline scenario and assumptions. Interactions between actions have not been studied in this example.

Table 5: Carbon balance for the Turkey National Climate Change Strategy

Options	Mitigation potential t CO2e
crops improvement	- 50,251,527
promotion of organic and no-tillage farming	- 39,157,006
livestock management	- 38,418,558
grassland improvement	- 13,666,858
afforestation	- 954,802,921
rice irrigation improvement	- 6,536,546
total	**- 1,102,833,415**

The afforestation option is the one that avoids the largest part of GHG. (87%)

4.3.2 Evaluation of the cost effectiveness and analysis of the MACC results

The next step is to calculate the costs of each option as well as its benefits. Data from the literature have been used, more or less adapted to the Turkish context. Two different analyses could be done here: either using public cost, i.e. the cost for the government to help and encourage the adoption of the option, e.g. vouchers to buy concentrates for the animals, bearing the cost of certification for farmers who want to turn to organic agriculture, free distribution of genetically improved seeds. In the present case, the available data allow us to study the costs for the farmers, except for the afforestation option, which is a public cost.

The costs reflect the implementation work, which occurs only once (tree plantation, certification of organic farms...) or a maintenance work, which is recurrent (nutrient management, no-tillage, use of pesticides, better feeding practices...).

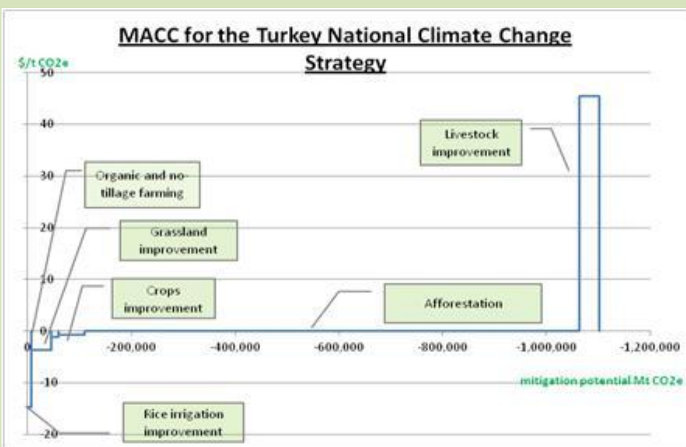
The benefits have to be known as well in order to calculate the free cash flow and the NPV. An Internal Rate on Return (IRR) and a payback period can equally be calculated, to enrich the economic analysis. Most of the benefits directly concern the farmer, e.g. increase in yield, savings on fertilizers' purchase, on water use, on fuel (no-till), whilst others are more general, good for both society and farmers like the fight against erosion.

Different situations have been analyzed to take into account the limits of a MACC assessment, with interaction between options and discount rate:

- A public discount rate of 3.5% versus a private discount rate of 10%, no-interaction
- Interaction between options versus no interaction, discount rate of 3.5%

4.3.2.1 Comparison of the MACC results depending on the discount rate

Public discount rate of 3.5%



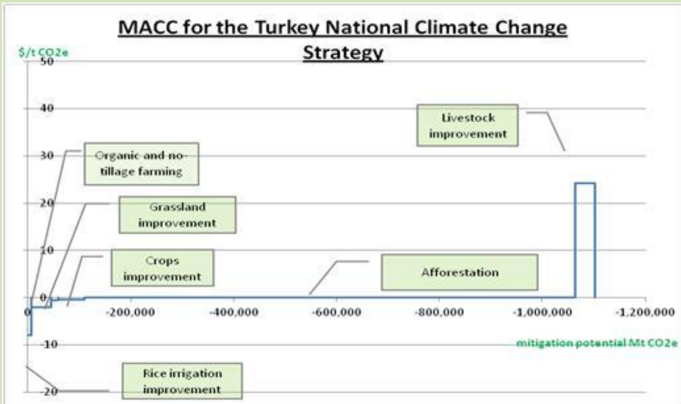
Comment: the rice irrigation improvement is the most cost-effective action with an average price of -15 $/t CO2e (so it is a profit). Each ton of GHG avoided due to crops improvement, afforestation and grassland improvement represents an almost zero cost option (prices between -1 and -0.1 $/t). The activities planned within the livestock management option are the most expensive, with an average price of 45 $/t CO2e.

The afforestation provides most of the mitigation potential.

Regarding the total cost of mitigation (mitigation potential * average cost per t CO2e), the promotion of organic and no-tillage farming is the cheapest action, followed by rice irrigation. Even if rice irrigation has a more profitable cost per t of CO2e, its limited mitigation potential explains why it is not the more profitable option in globally. Once again, the livestock management is the more expensive option.

The public discount rate gives an optimistic view on the abatement potential that can be achieved at profits for society through rice irrigation improvement and organic farming development.

Private discount rate of 10%



Comment: the option ranking remains the same as with a 3.5% discount rate: rice irrigation improvement is the cheapest option with an average price of -8$/t CO2e while livestock management is still the most expensive (24$/t).

The private discount rate gives less optimistic value for rice and organic option. However they are still profitable activities but with a less pessimistic value for livestock.

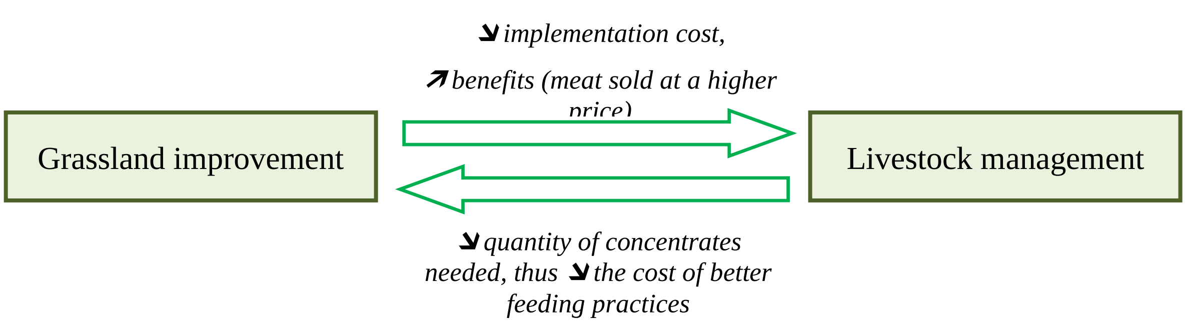
Private discount rate tends to minimize both the benefits (for negative marginal costs) and the costs (for positive marginal costs) of a mitigation option.

The choice of the discount rate will depend on which point of view the MACC analysis is done. If it is to evaluate the mitigation potential and cost of a farm or an agricultural cooperative, the private discount rate is the most appropriate. If the MACC is done from the point of view of a government, it would be more accurate to use a hybrid discount rate that includes both public and private criteria. Indeed, the interaction between both actors, the government and the private sector, is an important point in the definition of mitigation policies.

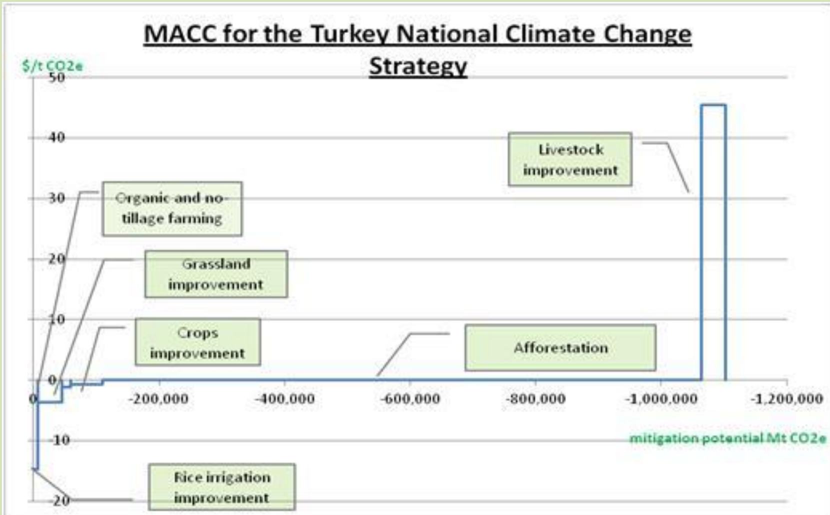
4.3.2.2 Comparison of the MACC results depending on the interactions between options

The implementation of the grassland improvements will decrease the cost of the livestock management (see *figure 19*). Indeed, better quality forage will be produced, richer in N, enabling to reduce the amount of concentrate given to the cattle within the better feeding practices. Limiting the increase in cattle number will also have impacts on the grassland improvement option. It will reduce the implementation cost of grassland (no additional animals can be bought since we want to stabilize the cattle size) and increase the benefits (the meat demand will exceed the supply, leading to an increase in the price of the meat).

Figure 19: Interactions between grass improvement and livestock management

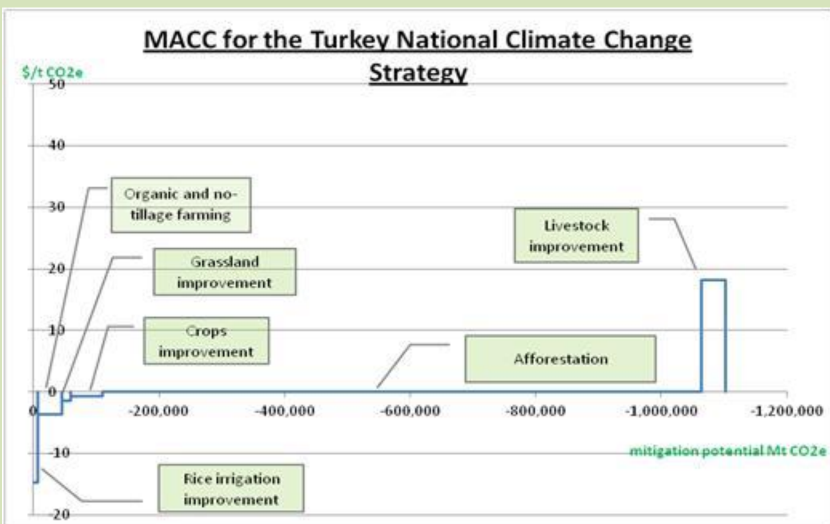


Without interactions



Comment: grassland improvement almost costs nothing (-1.1 $/t CO2e) while the livestock management costs 45$/t.

With interactions



Comment: the livestock measure now only costs 18$/t CO2e, and the grassland improvement option is a bit more profitable (-1.4$/t)

However, in our case, it does not change the option ranking. But it could convince the government to consider financing the livestock management activity in parallel with grassland improvement.

5 Conclusion

The AFOLU sector is a major actor to minimize the effects of climate change. Indeed, it has a pronounced mitigation potential, especially with regards to the carbon storage in agricultural soils and biomass. However, even if a wide range of mitigation options are known, there is still a reluctance to implement them at a large scale. One of the reasons is the lack of economic and financial background of such actions.

Marginal Abatement Cost Curves have been developed since the end of the 90s'. They are being increasingly used in different economic sectors, as a decision making tool for policy makers or large companies. The key challenge is to find ways of managing the complexity of the agricultural sector in ways that enables the development of MACC without sacrificing the validity of the results. The present guidelines particularly provide advice on the methodology to calculate the MACC of an agricultural project. It also highlights the limits and the points to be aware of before taking the results of the MACC for granted, such as the choice of the discount rate, the recognition of interactions between mitigation options and the narrow window of projection. The approach requires further development, for example the incorporation of ancillary costs and benefits of GHG mitigation into the calculation of the cost effectiveness or the time dimension.

MACC is one tool to help decision makers, but it must not be the only one. Complementary economical tools, risk management tools, marginal welfare costs, vulnerability assessments and others biological and production indicators must complete the tool kit in order to have a global study which takes into account all the parameters and possible effects of a policy.

6 READERS' NOTES

6.1 Links to other related EASYPol modules

- EX-ante Carbon-Balance Tool : Software
  http://www.fao.org/docs/up/easypol/873/ex-act_version_3-2_april_2011_101sp.xls
- EX-ante Carbon-Balance Tool : Technical Guidelines
  http://www.fao.org/docs/up/easypol/780/ex-act-tech-guidelines_101en.pdf
- EX-ante Carbon-Balance Tool : Brochure
  http://www.fao.org/docs/up/easypol/780/ex-act_flyer_101en.pdf

See all EX-ACT work in EASYPol under the Resource package, **Investment Planning for Rural Development - EX-Ante Carbon-Balance Appraisal of Investment Projects**

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