Journal of Technology Management & Innovation

Received May 14, 2007 / Accepted June 4, 2007

IMPACT ASSESSMENT SYSTEM FOR TECHNOLOGICAL INNOVATION: INOVA-TEC SYSTEM

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Abstract

Technology impact assessment may be a helpful tool in the decision-making process. The present work suggests a method to evaluate the impact of technological innovation, providing information organized according to criteria and indicators in several areas where the innovation can be perceived, focusing the complexity of the innovation under investigation. The method consists of a system that allows the analysis of: i) the innovation range starting from the generation of the significance index, and ii) the assessment of the innovation performance through the analysis of the performance indicators which will compose the magnitude index. This system has a support tool, the software "*INOVA-tec System v 1.0*", with information shown as a guide to allow a well-informed and a well-based evaluation. The INOVA-tec System enables the reduction of the subjectivity of evaluation as a guide to indicators that should be analyzed and the components that may have some importance in the assessment.

Key-words: Technological innovation, technology rapid appraisal, impact assessment, techonological forecasting.

Introduction

The Technological Innovation is the insertion of a new technology into the production process, generating new products that tend to alter the profitability or the market share of the innovatory company (Rosenthal, 1995). In this way, your success depends not only on technical viability, but also on acceptance by the market. In other words, the generation of a technological innovation is an activity of economical risk, for it involves uncertainty related to the acceptance among the consumers. In this context, the innovation management confers a greater viability on the market, reducing the time lag between the release of a new product and its investment payback. The good performance of innovations depends on the phase that management tools and technological forecasting are used, generally on *ex ante* assessment as an essential component for the creation of forecasting scenarios and as a guiding factor to help funding agencies or investors decide about the distribution of financial resources among several projects. The technology impact assessment, in a general manner, may be a helpful tool on the decision-making process. Search engines and systemized data compression tools, which allow the generation of traceable conclusions, compound the key-elements to assure that the decision-making process culminate in the appropriate innovation management, with the best resources and results. This work proposes a methodological system to evaluate the impacts of technological innovations providing information organized according to criteria and indicators in several areas where the impact can be perceived in a direct or indirect manner: social, economical, environmental, institutional and capacity development, introduction of (new) technology and unexpected events. The proposed system is based on previous methods of risk analysis, such as GMP-RAM METHOD - Risk Assessment Method for Genetically Modified Plants (Jesus-Hitzschky et al. 2006)

and Environmental Impact Assessment methods utilized during ISO 14000 implementation. Many validated issues or parameters of analysis described in previous reports (EFSA, 2006; NAS, 2002) were also considered. The *INOVA-tec System* allows the evaluator to point out the specific parameters to his/her innovation enabling the analysis of each particular case, so that the innovation can be applied in a responsible and sensible way. This information is organized as three tools: ***i) worksheet for the significance of innovation analysis***; ***ii) worksheet for indicators assessment; and iii) matrix of Impact that is built by the General Impact Value.*** The use of *INOVA-tec System* reduces the subjectivity of evaluation working as a guide to the indicators that should be analised and the components that may have some importance in this evaluation. In this way it allows, as a whole, the reduction of negative impacts, and the best use of resources for innovation introduction so that the prevention and mitigation of environmental damages can be achieved. The method can be used by program and project evaluators, managers and also regulatory and supervisory agencies. To better understand this system, it is presented in a digital format[1] (*INOVA – tec System v.1.0. Software*) where the three tools are linked so that the user can fill in the worksheets and automatically observe the results in the tables, graphis, matrix and in the conclusive report.

Technological Innovation Environment and *INOVA-tec* Method

Martins (2006) says that a new focus to the ST&I (Science, Technology and Innovation) policies consists on the use of science and technology in order to achieve environmental goals. In addition, in agreement with this school of thought, Dormann and Holliday (2002) declare that the way through which the innovation is developed and carried out is a key point on the generation of a sustainable society. In this way, it is a general belief that it's necessary to generate wide knowledge about technological innovation, so that the generated impacts can positively contribute to the improvement of the several areas previously cited.

The Oslo Manual of OCDE (2005) declares that the nature and the innovation panorama change through time, and this evolution occurred not only in the need of changes but also on the indicators that show those adjustments. The indicators show, therefore, the kind of impact that the innovations generate. However, still according to the OCDE (2005), the evaluation methods must evolve on the same field as innovations evolve, involving indicators that show, more efficiently, the several impacts on the most diverse scenarios and fields (Figure 1). In this way, an efficient way to measure the probable impacts that an innovation may cause in the environment where it is or will be inserted is to evaluate *ex-ante* and *ex-post* the development of it on the market, contributing to the concept of sustainability (Figure 2). The *INOVA-tec System* allows a wide evaluation, showing the indicators at several levels, being able to act directly within the scope of research institutions and technological companies, and indirectly promoting the discussion of proposition of new innovation policies. An spinoff of *INOVA-tec System* is the adequacy or generation of public and Research & Development policies (Figure 1) more suitable to the innovative process, in the way that the comprehensive assessment of innovation allows the rational environmental manegement allied with the accountability of clarity in the results.

Figure 1 presents the innovation environment and the *INOVA-tec System*, showing its evaluation areas: economical, environmental, social, institutional and capacity development, unexpected events and technology introduction. In Figure 1 the interaction between companies and 'IEPs' (Institutos de Ensino e Pesquisa - Teaching and Research Institutes) is part of 'Innovation Systems', according to the innovation policies and demands. In this Figure the demands are ruled not only by society needs but also by law, which will both influence economical and Research & Development scenarios. This model differs from the one presented on Oslo Manual because it's not based only on the company but on the innovative environmental as a whole. However, it agrees with that model when it faces the innovation as a system ruled by demand. On the model suggested here the innovation demands take into account both economical and Ressearch & Development scenarios, as well as society, its needs and the repercussion of public perception on laws concerning the innovative product and its market and trade. The spinoffs of *INOVA-tec System* use for assessment of technological innovations impacts, taking into account the scenarios depicted above and its several fields proposed, will make public administrators able to public policies more suitable to economical and social conditions of the country that will receive the innovation. Figure 2 is a schema of *INOVA-tec System*, showing the potentiality of use by several actors, interests and assessment timing. In case the assessment has a prospective interest the analysis must be done *ex-ante* the technology use, focusing on the 'Innovation Assessment Range' and ilustrating its focus on potential impacts assessment. Will have more interest in this kind of analysis: funding agencies, investors and decision-makers, in order to decide among a project portfolio or what is the range of a funded innovation. The assessment *ex post* of the innovation development foresee

[1] Available for download in the site of Embrapa Meio Ambiente:
http://www.cnpma.embrapa.br/forms/inova_tec.php3

the assessment of all indicators, gathered in accordance with the assessment criteria on its fields and which analyis allows the clarification of 'Indicators Performance'. It is part of general impact assessment the analysis of the range or prospective assessment and the Indicators Performance in order to prepare the structure of the impact matrix and therefore to elaborate the 'Innovation Scenario'. The general analysis of impacts and innovation scenario must be the focus of the analysis made by regulatory and supervisory agencies, technology buyer companies and society on the whole.

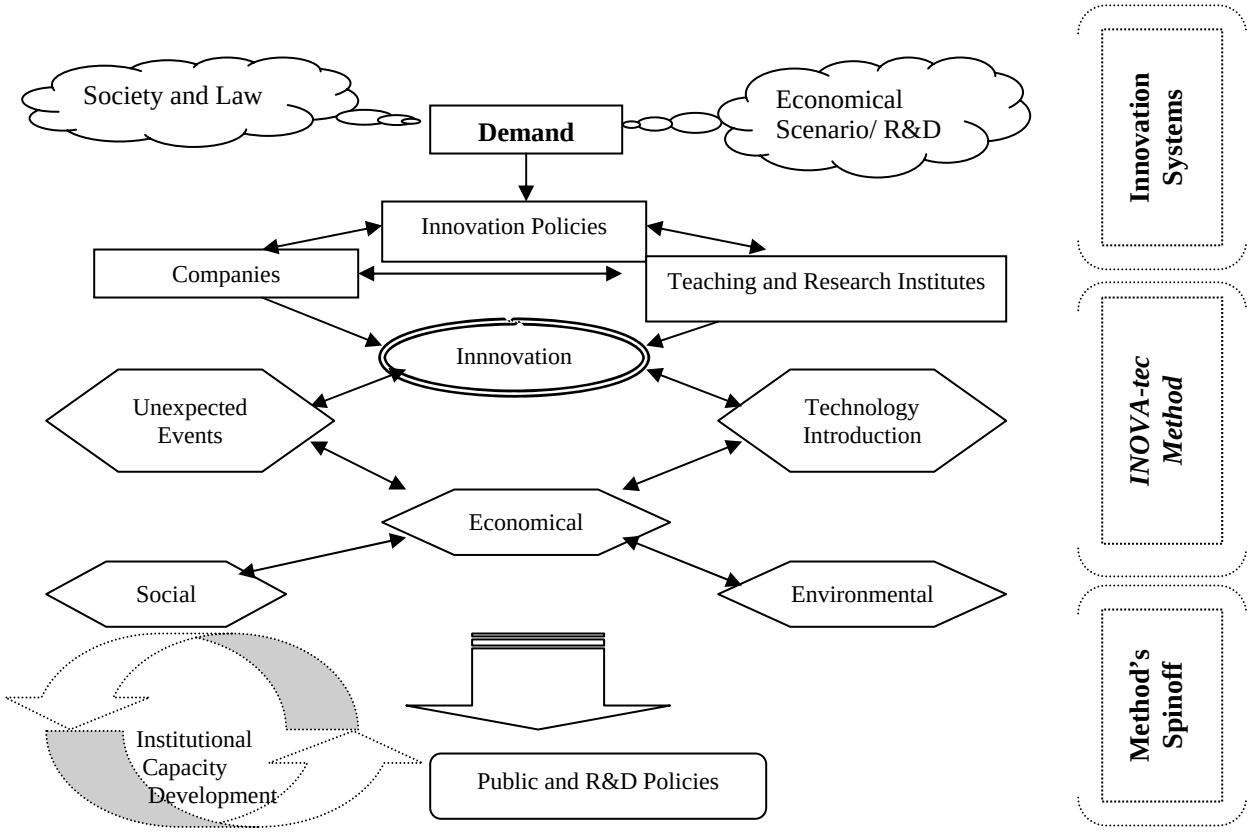

Figure 1: Technological Innovation Environment and *INOVA-tec* System (Adapted from Oslo Manual, 1997).

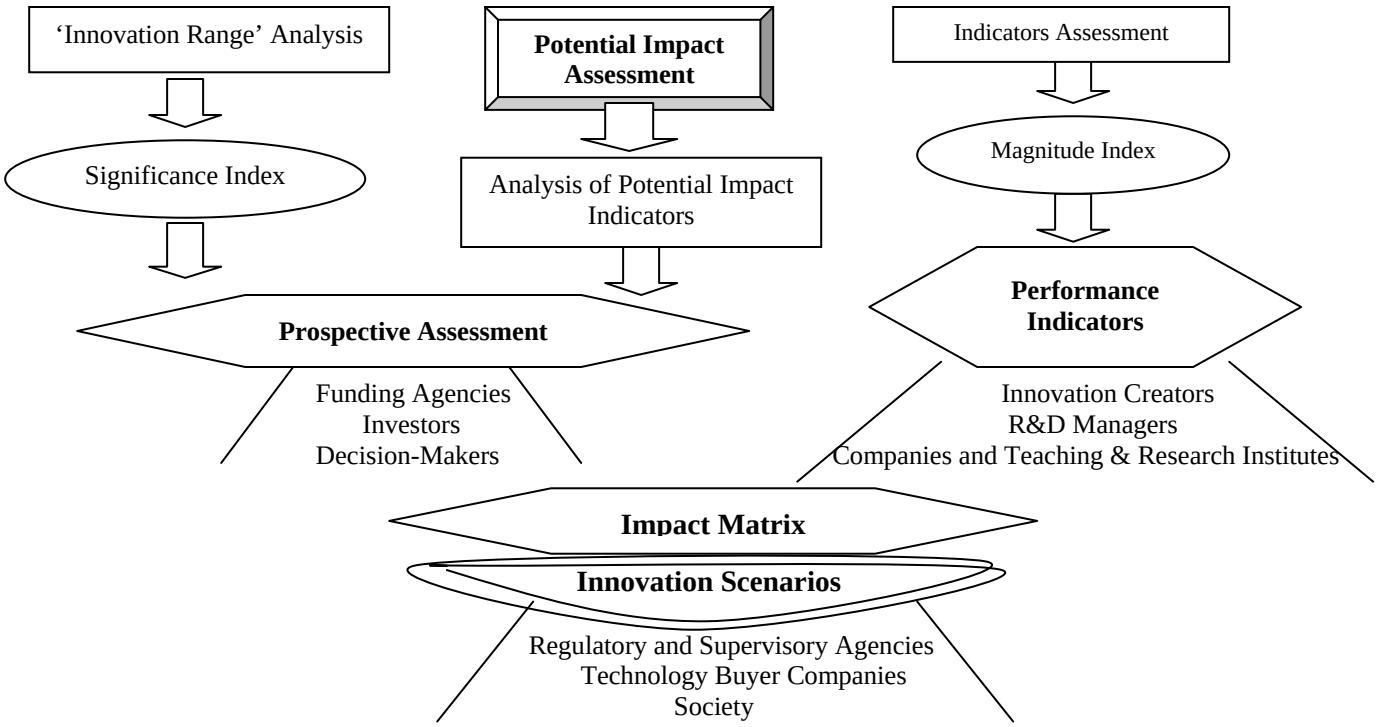

Figure 2: Structure of INOVA-tec System.

Method

Innovation Characterization

In order to perform the technological innovation assessment it's recommended to perform first of all the innovation characterization for the purpose of assuring the proper assessment report and hereby the attendance and monitoring of its application performance.

Below are presented the necessary information to collect more relevant data in order to assure acuity of assessment. This information is presented on the first page of *INOVA-tec Software.*

Technological Innovation Assessment

The assessment is performed by the analysis of indicators that are arranged according to their area criteria such as: environmental, economical, social, capability and institutional approach, technology introduction and unexpected occurrences. The novelty is the possibility to add specific parameters to the technology innovation under assessment. In this case by case analysis the factors of moderation and the indexes are parameterized to perform helpful assessment. Three tools support the **Impact Assessment Sytem for Technological Innovation 'INOVA-tec System'**: (1) worksheets to compile the *Prospective Range*, through the Significance Index; (2) indicators worksheets to compile an *Impact Level Performance* defined by the Magnitude Index. Finally the combination of both Indexes (Significance X Magnitude) design the (3) *Matrix of Impact* that is created by the General Impact Value.

1 - Worksheets to compile *Prospective Range:* the Significance Index

The first tool identifies prospective analysis of the *object* related to the use of a specific technological innovation. In this phase of assessment are considered the following moderation factors: spatial range, reach and influence. This first part of assessment may be used as *ex* post assessment as well as *ex ante* assessment, either by an evaluator who is going to decide about an innovative application or by a funding agency/investors that are going

to decide about the destination of financial resources among technological innovations projects.

These moderation factors are showed in a worksheet that gives values to the importance and significance of the factor in terms of the *Extent* of its use – local, regional, national and international - and the Scope direct or indirect of their application (environment, human health, product or process quality, social, economical, political and legal). The analysis of these moderation factors allows the generation of the Significance Index (table 1). It is given a range of values to each moderation factor of innovation. Each weight given to the moderation factors will be considered for the generation of the Sigficance Index, according to the formula below:

Σ (Scope $_{a,g}$ X Influence $_{a,g}$) = Innovation Range

Innovation Range X Extent = Significance Index

Table 1: Moderation factors for Significance Index estimate

EXTENT	**WEIGHT VALUES**
Punctual	1
Local	2
Regional	3
National	4
International	5
SCOPE	**POSSIBLE VALUES**
Environment	1,2 e 3
Human Health	1,2 e 3
Ressearch/product Quality	1,2 e 3
Social	1,2 e 3
Economical	1,2 e 3
Political	1,2 e 3
Legal	1,2 e 3
INFLUENCE	**POSSIBLE VALUES**
Indirect	1
Direct	2
Null	0

2 - Indicators Worksheets to compile an *Impact Level Performance*: the Magnitude Index

The second tool consists on preformatted worksheets (tables 2, 3, 4, 5, 6, 7, 8, 9) that organize the parameters or indicators according to the focus of the field and enable the users to fill in with values related to the level of importance or magnitude of the parameters.

The goal of this method creation is to consider the indicators assessment within every possible field, without privileging any parameter. In this way, INOVA-tec System foresees the regulation of weights, but not the priorization of fields.

In case of an *ex post* assessment, the indicators worksheet must be fully evaluated, while in case of an assessment *ex ante* the innovation appliance, only some potential indicators (marked with a star) must be analysed.

Each weight given to indicators or moderation factors will be taken into account to the generation of the Magnitude Index, according to the formula below:

Indicator Weight$_{a,h}$ X Weight range value $_{a,h}$ + Σ (Correction Factors $_{a,h}$) = Total Weight of Indicators from Field A = Total weight of Field A
Σ (Total Weight of Field A, B, C, D, E, F, G, H) / Fields Number Analyzed = Magnitude Index (General Impact Index)

Fields for Indicator Description, Indicator Weight, Factors of Moderation and Criteria of Assessment

On the worksheet the parameter or indicator under assessment is grouped within its field according to its criterion or characteristic. These items are predetermined on the worksheet in order to allow an accurate evaluation of related impacts.

These summarized data on the indicators worksheet were identified and compiled from the contribution of experts on several areas of the assessment approach. This counsel was done through personal interviews, with the purposes of: firstly to identify and consolidate the necessary indicators and thereafter to make adjustments of indicators' weights and weight ranges of each moderation and correction factors, when necessary. Some tests were accomplished for adjustments not only on used parameters but also on the functionality of support Software for the system application.

To each indicator presented on Table 2 - 9 the system gives a weight, that varies within 1 and 3. This variation on weights is done as follows: indicators that show greater weight are the ones with potentialized impact. In the case of Environmental Field the indicators of

environment recovery have weight 3, since according to this item a certain environment may be recovered potentializing its future use, for conservation or preservation. On the same way, it is given the maximum value (3) to the field 'unexpected events' since it brings with it the possibility of adverse or undesirable effects. On the other hand, indicators added by users have weight 1, so that the final result don't suffer great distortions.

In spite of creating an hierarchy within each field, this will not be used for the decision-making but for a scenario generation and so the general panorama of the innovation environment. In this way, the fields' weights as the same, since they are consider egually important. In other words, the innovation assessent should contemplate the use of INOVA-tec System in each of its fields. In case an indicator is not significant for the innovation under analysis it is enough to ignore it, on the same way more specific new indicators for the evaluation can be added the field "Specific indicators".

Data/Information for the Evaluation Field

This central column is the field where the user describes all information related to the criterion of assessment. Literature searches or prospective data must be the source of the scientific data, described to perform the *ex ante* analisys or the scenario elucidation of the technological innovation. Experimental results or from innovation application must be used as the assessment basis, that is, for weight allocation. These collected data must be inserted in the worksheet's central column in order to ensure the acuity and support of the achieved results.

These data will be shown on methodology results in the format of assessment 'descriptive report'.

Table 2: Worksheet of indicators to compile an *Impact Level Performance*: the Magnitude Index - Environmental field.
*Potential Impact (*ex ante*): Indicators used for *ex* ante technology assessment.

Weigh	Indicator / Moderation Factor	Data / Information for Evaluation	Factor's Weight range	Correction Factor
Environment Field				
Water Resources, Soil and Air				
2	Water quality (Turbidity, OBD, etc ...due to innovation introduction)		Gets worse (-1) / Maintain (0) / Gets better (1)	
2	Heavy metal amount ... due to innovation introduction		Increases (-1) / Maintain (0) / Decreases (1)	
2	Chemical or Organical Residues (Industrial sewer, waste, etc)		Increases (-1) / Maintain (0) / Decreases (1)	
2	Air Pollutants Emission in the air due to innovation introduction		Increases (-1) / Maintain (0) / Decreases (1)	
2	Change on natural resources demand (Comparative analysis of use and consumption of water, soil, mineral)		Increases (-1) / Maintain (0) / Decreases (1)	
Biological Resources: microrganism, flora and fauna				
2	Change of ecosystem balance (Change on ecological level: microrganisms, flora and fauna)		Affect individual (-1) Comunity (-2) Not affect any ecological level (0)	
2	Occurrence of negative effects on plants, human health and animal (Occurrence of deseases, contamination and / or death)		Yes (-1) No (0)	
2	Change on natural resources demand (Comparative analysis of animal and/or vegetal use and consumption)		Increases (-1) / Maintain (0) / Decreases (1)	
Environmental Conservation				
2	Environmental Management or Monitoring Practice. *Ex ante: Yes. Comparative analysis with conventional methods. The management used prior to the innovation was effective for environmental conservation matters.		Creation (2) Improvement (1) Not interfere (0) Extinction (-2)	
Environmental Recovery				
3	Reduction of level of solid, chemical and biological pollutants *Ex-ante:Yes		Yes (1) / No (0)	
3	Biodegradation Mechanisms *Ex-ante: Yes The innovation is a biodegradation mechanism that recovers a degraded area.		Creation (2) Improvement (1) Not applies (0)	
3	Gives stability to a threatened ecosystem *Ex-ante:Yes Comparison with the ecosystem prior to innovation introduction		Yes (1) / No (0)	

Table 3. Worksheet of indicators to compile an *Impact Level Performance*: the Magnitude Index - Institutional development field. *Potential Impact (*ex ante*): Indicators used for *ex* ante technology assessment

Weigh	Indicator / Moderation Factor	Data / Information for Evaluation	Factor's Weight range	Correction Factor
Development Field Institutional				
Normalization of Partnerships				
2	Agreement made (through a formal contract) *Ex-ante: Yes. A formal contract for the realization of the research or development project with at least one partner.		Formal contract (2) / Protocol without legal valeu or a letter of intent (1) / Does not have (0)	
Financial assistance				
2	Financial assistance ways *Ex-ante: Yes. (high-risk fund, angel investor...).		Has financial assistance (1) / does not have (0)	
Partnetships				
2	Number of partners *Ex-ante: Yes Total number of partnets (publica, private, political instances, NGOs, civil organizations.		Note of the number of partnerships (+1)	Correction factor:Partner Focus: Social projects (+1) Environmental projects(+1)
Quality system implemented				
2	ISO or another quality certificate. * Ex-ante: Yes. If a partner has one or more quality certificates (ISO 9001; 14000; 17025 or another one).		Give (+1) one point for each implemented quality system (in each partner institution)	
2	Normative service. *Ex-ante: Yes.		Yes (1) / No (0)	

Table 4. Worksheet of indicators to compile an *Impact Level Performance*: the Magnitude Index - Capacitation field.
*Potential impact (ex-ante): Indicators used for ex-ante technology assesment.

Weight	Indicator / Moderation factor	Data / Information for Evaluation	Weight range of the factor	Correction factor	
Capacitation Field					
Formation of human resources					
2	Number of trainees (Scholarship holders involved in research or development of the innovation; formal) *Ex-ante: Yes		Give (+1) one point for each trainee (in each partner institution).		
2	Number of graduate students Masters, PhD, Post-Doc, MBA, involved in the research or development of the innovation *Ex-ante: Yes.		Give (+1) one point to each graduate student involved (in each partner institution).		
Trainings					
2	Technical trainings (Trainings directly related to R&D activities to capacitate the involved team) *Ex-ante: Yes.		Give (+1) one point to each training carried out for the development of the innovation.	Correction factor Number of participants Up to 10% of the employees of the organization (+1) / over 10% (+2)	
2	Lectures or trainings related to quality systems (project team members and collaborators) *Ex-ante: Yes.		Give (+1) one point for each training carried out for the development of the innovation.	Fator de correção Number of participants Up to 10% of the employees of the organization (+1) / over 10% (+2)	
Scientific Production					
2	Defended MSc dissertations associated to the innovation.		Give one point for each finished dissertation related to the innovation (+1)		
2	Defended PhD thesis associated to the innovation.		Give one point for each finished thesis related to the innovation (+1).		
2	Scientific papers published in national or international journals of the innovation sector.		Give one point for each published paper related to the innovation (+1)	Factor 1 Another sector (+1) / same sector (+2)	Factor 2 National (+1) / Intern. (+2)

2	Number of abstracts in proceedings and presentations in conferences.		Give (+1) one point for each presented work related to the innovation.	Factor1 Another sector (+1) / Same (+2)	Factor 2 Number of partic. up to 250 (+1) over (+2)	Factor 2 National (+1) Intern. (+2)

Table 5. Worksheet of indicators to compile an *Impact Level Performance*: the Magnitude Index - Economic Field.
*Potential impact (ex-ante): Indicators used for ex-ante technology assessment

Weight	**Indicator / Moderation factor**	**Data / Information for Evaluation**	**Weight range of the factor**	**Correction factor**
		Economical Field		
3	Financial return (Cost reduction – work force reduction, economy of raw material, energy etc.)		Occurs (1) Does not occur (0)	Factor Up to three years (+2) / 3 to 5 years (+1)/More than 5 years(0)
2	Qualitative return *Ex-ante: Yes (Process improvement, normative service, knowledge multplication etc.)		Occurs (1) Does not occur (0)	
3	Foreign currency increase *Ex-ante: Yes (Perspective of international trade relationships)		Occurs (1) Does not occur (0)	
2	Payment/reception of Royalties *Ex-ante: Yes		Payment in the acquisition of technology. National (-1). International (-2). Reception (2)	
2	Control of productive chain (If innovation components come from other links of the productive chain) *Ex-ante: Yes		High control (2) Medium (1) Low (0) None (-1)	
2	Market where the innovation will be inserted. *Ex-ante: Yes		Monopoly (-2) Oligopoly (-1) Competitive (0)	
2	Market perspective (demand size) *Ex-ante: Yes		High (2) / Medium (1) Low (0)	
2	Product life cycle (time during which the product will stay on the market) * Ex-ante: Yes		Long (1) Short(0)	
2	Entry barriers (difficulties to enter the market) *Ex-ante: Yes		High (-1) Low (1)	

3	Valeu added.* Ex-ante: Yes. High technology, high knowledge level and R&D investment results		High (1) Low (0)	
3	The innovation may be commercialized *Ex-ante: Yes. If the final object of the innovation has potential to be commercialized.		Yes (+1) No (0)	

Table 6 Worksheet of indicators to compile an *Impact Level Performance*: the Magnitude Index - Social Field.
*Potential impact (ex-ante): Indicators used for ex-ante technology assessment.

Weight	**Indicator / Moderation factor**	**Data / Information for Evaluation**	**Weight range of the factor**	**Correction factor**		
Social Field						
Work Relations						
3	Influence on work conditions (Worker health and safety)		Improves (1) Keeps (0) Worsens (-2)			
3	Reduction in jobs		Demission (-1) Fair realocation (0)			
3	Creation of jobs. (Direct / indirect)		Occurs (2) Does not occur (0)	Factor 1 temporary (+1) Permanent (+2)	Factor 2 Direct (+2) Indirect (+1)	
Social Reach						
2	Social class that benefits from the innovation * Ex-ante: Yes		Occurs (1) Does not occur (-1)	Class A (+1) / Class B (+2) / Class C (+3) Class D (+4) / Class E (+5)		
Science Popularization						
2	Number of lectures and courses given, number of participants and kind of audience.		Give one point (+1) to each presented lecture related to the innovation.	Factor 1 National (+1) Intern. (+2)	Factor 2 Number of participants. – Up to 50 (+1) / Over 50 (+2)	
2	Articles in newspapers / media		Give one point to each article related to the innovaion.	Factor National (+1) / Intern. (+2)		

Tablel 7. Worksheet of indicators to compile an *Impact Level Performance*: the Magnitude Index - Innovation introduction field.
*Potential impact (ex-ante): Indicators used for ex-ante technology assessment.

Weight	Indicator / Moderation factor	Data / Information for Evaluation	Weight range of the factor	Correction factor
Field Introduction of the Innovation				
Technological Advancement				
2	Kind of innovation * Ex-ante: Yes		Disruptive (2) / Incremental improvement (1)	
2	Business incubation		Occurs (1) Does not occur (0)	
Commercial Development				
2	Service rendering		Service rendering / consulting. Occurs (1) / Does not occur (0)	
2	Patent registration *Ex-ante: Yes		Occurs (1) Does not occur (0)	
2	Registration of variety or cultivar *Ex-ante: Yes		Occurs (1) Does not occur (0)	
2	Software registration *Ex-ante: Yes		Occurs (1) Does not occur (0)	
2	Technology transfer *Ex-ante: Yes		Occurs (1) Does not occur (0)	
Technology Effectiveness				
2	Change in innovation efficiency		No change (0) Increase (1) Decrease (-1)	
2	Time interval until releasing the product		Short term (2) Medium term (1) Long term (0)	
Innovation Environment				
2	Service / demand creation		Demand created (1) Demand answered (2)	
Enviroment for organization innovation				
2	Impact on the production line (Development of the innovation or the innovative product requires adequation of infrastructure)		Occurs (1) Does not occur (0)	
2	Development of the innovation or the innovative product requires capacitation of the developmet of production team.		Punctual training (0) Continuous training (-1)	

Table 8. Worksheet of indicators to compile an *Impact Level Performance*: the Magnitude Index - Unexpected occurrences field.
*Potential impact (ex-ante): Indicators used for ex-ante technology assessment.

Weight	Indicator / Moderation factor	Data / Information for Evaluation	Weight range of the factor	Correction factor
Unexpected occurrences (accidents)				
3	Adverse environmental effect		Occurs (-1) / Not (0)	
3	Possibility of unproper use of the innovation		Occurs (-1) / Not (0)	
3	Damage to human, animal or plant health		Occurs (-1) / Not (0)	
3	Lawsuit against the innovation		Occurs (-1) / Not (0)	
3	Risk of adopting the technology related to the characterisc of the innovation.		High (-2) Medium (-1) Low (0)	

Table 9. Worksheet of indicators to compile an *Impact Level Performance*: the Magnitude Index - Specific indicators field.

Weight	Indicator / Moderation factor	Data / Information for Evaluation	Weight range of the factor	Correction factor
1	**Specific indicators**	**Insert justification or explanation for the indicators**	**Give weights (-2 to +2)**	
1	*Insert specific indicators for your evaluation*			

3 - *Matrix of Impact* that is built by the General Impact Value

The third tool provides a structure to observe the potential impact and the prospective scenario to introduce the technology innovation, in the ex-ante analysis. In the ex-post evaluation, that uses the Significance Index and all indicators to build the Magnitude Index, these both are crossed to show the final result form the analysis in a matrix format (Figure 3).

After the identification of the scope of technology, innovation characterization, impact assessment, and the significance analysis of related effects comes the final step in this impact assessment process — reviewing the potential impact and establishing at which level impact management, by preventive or corrective actions, must be taken in order to allow effective and safe use of the technology innovation. This is performed by the Matrix of Assessment step.

The Matrix (Figure 3) is constructed with two axes, where the "x" axis stands for the classes of the Index of Magnitude (indicators performance) and the "y" axis stands for the classes of the Index of Significance (prospective analysis). That is indicated in the matrix 'General Impact Value', which is the final result of all indicators of all fields. To complement the evaluation the results from the Index of Magnitude and the Index of Significance for each field are plotted in the Matrix according to their position (points are plotted using letters that represent each field). The general value for the field performance is the result of the sums of all the indicator values inside the field under evaluation. The illustration of this result of the field evaluation (plotting the letters like a code) allows formulating a list of recommendations with the goal of potentializing the positive impact of the innovation for each field. This measure favors the first proposition of the system: fields should be considered as equally important, and thus corrective measures should be taken in order to mitigate distortions of impacts among them.

Figure 3: Matrix of Assessment is the final step of this Impact Assessment tool. The Matrix of Assessment gives an overview of impact evaluation and establishes at which level impact management must be taken. The "x" axis represents the classes of the Index of Magnitude and the "y" axis represents the classes of the Index of Significance.

Significance Index	01-07 Very low indicator performance	08-14 Low indicator performance	15-21 Medium indicator performance	22-28 High indicator performance
141-210 Very favorable scenario	**9**	**10**	**11**	**12**
71-140 Favorable scenario	**5**	**6**	**7**	**8**
0–71 Unfavorable scenario	**1**	**2**	**3**	**4**

Magnitude Index

He level of performance of the technology under evaluation is classified as:

(1) Prospective assessment: **unfavorable** scenario to the innovation / innovation in early implementation stage (potential impact assessment) or with **low success perspective – innovation not recommended**.

(2) Prospective assessment: **unfavorable** scenario to the innovation / innovation with **low performance** – ***corrective actions are recommended***.

(3) Prospective assessment: **unfavorable** scenario to the innovation / innovation with **medium performance** – ***monitoring with restrictions is recommended.***

(4) Prospective assessment: **unfavorable** scenario to the innovation / innovation with **excellent performance – *innovation recommended***.

(5) Prospective assessment: **favorable** scenario to the innovation / innovation in early implementation stage (potential impact assessment) or with **low success perspective** – ***management whit restrictions are required***.

(6) Prospective assessment: **favorable** scenario to the innovation / innovation with **low performance - *corrective actions are recommended***.

(7) Prospective assessment: **favorable** scenario to the innovation / innovation with **medium performance - *Monitoring and management required.***

(8) Prospective assessment: **favorable** scenario to the innovation / innovation with **excellent performance – *innovation recommended***.

(9) Prospective assessment: **favorable** scenario to the innovation – ***investments in the innovation sector are recommended*** / innovation with **low performance** – ***management required*.**

(10) Prospective assessment: scenario **favorable** to the innovation – ***investments are recommended*** / innovation with **low performance - *management required.***

(11) Prospective assessment: **favorable** scenario to the innovation – ***investments are recommended*** / innovation with **medium performance - *monitoring required.***

(12) Prospective assessment: **favorable** scenario to the innovation – ***investments are recommended*** / innovation with **excellent performance – *innovation highly recommended.***

Digital Format – Introduction of the Software INOVA-tec System (v. 1.0)

The software INOVA-tec System v. 1.0 is an electronic format of the worksheets that was created in Microsoft Visual Basic v. 6.0 and can be accessed in Embrapa Environment link: http://www.cnpma.embrapa.br/forms/inova_tec.php3 (impact assessment file to download). To run the INOVA-tec, just download the file to your PC and execute it with a double click.

Results

By using this electronic format, it is possible to attribute values for the factors of moderation in the worksheet and for the results of the indexes (Significance and Magnitude). These will be calculated and plotted in the Matrix of Assessment automatically. These results could be showed in tables or graphics format and in the description report.

Compiled Analysis

The following step involves compiling and analyzing the results from the matrix and worksheets. Each field coded with a letter is plotted in the matrix aiming to require some measures according to the level of impact. These impact measures must consider all data described in the worksheet, such as the specificity of the innovation technology, the activity under analysis, and the scenario situation. Essentially, this compilation is the core structure for performing impact management.

Aiming to potentialize the positive impact of the innovation on different fields, the code that represents each field is plotted in the matrix's row compatible with its performance. The visual and illustrative format for presenting those data facilitates the assessment by suggesting corrective measures for its optimization or mitigation of negative impacts. Therefore, for a proper evaluation the user needs to formulate his list of recommendations specific to the innovation under analysis.

Conclusions

Prospective analysis must be carried out to predict the occurrence of negative impacts of some technological innovation on the environment or on human health. Additionally this analysis must predict and optimize economic, capacitation, institutional or social success. These assessments allow us to define predictive measures to mitigate or avoid adverse effects or unexpected occurrences that could result from potential or identified

hazards. Thus, it is possible to develop the innovation with a high probability of success and safety.

These assessments allow us to define predictive measures to mitigate or avoid adverse effects or unexpected occurrences that could result from potential or identified hazards. Thus, it is possible to develop the innovation with a high probability of success and safety.

The impact assessment proposed here includes parameters that allow an estimation of the performance level based on the assignment of numeric values to several factors reported to correlate with impact. It results in lower subjectivity and higher transparency in the analysis processes. Technologies with the same objectives can also be compared using the proposed system.

Considering the range of different technology innovation to be evaluated and the performance behavior and safety concerns that must be addressed on a case-by-case basis, the proposed system may not cover all aspects related to a given innovation, although it presents a broad approach to impact assessment. Since there is always the possibility of developing a new and better method that could be used in many situations, the user is encouraged to expand the possibilities of this tool by adding or deleting parameters according to the kind of technology. On the other hand, investors and regulators must evaluate whether the chosen parameters are the best ones to define the potential impact of the technology under analysis.

This strategy is very important to allow a less superficial method, since it is able to identify which parameters are more correlated with the technology. In addition, characterizing impact by measuring it with quantifiable tools demonstrates a quantitative method where subjectivity is drastically decreased. Compared to current processes, the proposed method represents a less subjective and more transparent process for impact assessment.

Acknowledgements

The authors thank Dr. Carlos Alberto Moreira-Filho (Instituto de Ciências Biomédicas – Universidade de São Paulo – São Paulo – Brazil); Mr. Carlos Pian (Fundação de Amparo à Pesquisa do Estado de São Paulo – Brazil); Paulo Martins (Instituto de Pesquisas Tecnológicas – IPT – São Paulo – Brazil); Dr. Geraldo Stachetti Rodrigues (Embrapa Meio Ambiente – Jaguariúna – Brazil), Mr. Gilson Roberto Kohs (Instituto de Inovação – Campinas - Brazil); *Frineia Rezende da Silva (*MSc. in Ecology and Natural Resources – São Paulo – Brazil) and Mr. Hamilton Gustavo Palermo Hitzschky (a consultant for computation – Campinas - Brazil).

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References

Martins, P.R. ed., 2006. *Nanotecnologia, sociedade e meio ambiente. Inter-relações fundamentais para o desenvolvimento sustentável*. São Paulo: Xamã.

Dormann, J.; Holliday, C., 2002. *World Business Council for Sustainable Development. Innovation, technology, sustentainability and society.*

European Food Safety Authority, 2006. *Guidance document of the scientific panel on genetically modified organisms for the risk assessment of genetically modified plants and derived food and feed.* The EFSA Journal, 99, 1-100.

Jesus-Hitzschky, K. R. E.; Lanna, A. C.; Vieira, F. D.; Abreu, A. L.; Lima, D. U., 2006. A Proposed Risk Assessment Method for Genetically Modified Plants. *Applied Biosafety*, **11** (3), pp. 127-137.

National Academy of Sciences - NAS – Committee on Environmental Impacts Associated with Commercialization of Transgenic Plants, Board on Agriculture and Natural Resources, Division on Earth and Life Sciences, National Research Council. (2002). *Environmental effects of transgenic plants: The scope and adequacy of regulation*. Washington, DC: The National Academies Press.

Organização Para Cooperação E Desenvolvimento Econômico - OECD, 2005. *Manual de Oslo: Diretrizes para coleta e interpretação de dados sobre* inovação. 3rd ed. São Paulo: Finep.

Rosenthal, D.; Meira, S., 1995. **Os primeiros 15 anos da Política Nacional de Informática: o paradigma e sua implantação.** Recife: Protenicc.