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Methodology for the Monitoring and Evaluation of Departmental Strategic Science, Technology, and Innovation Plans (PEDCTI): A proposal from the PHVA cycle

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ABSTRACT This article elaborates on a methodological proposal for the monitoring and evaluation of departmental strategic science, technology and innovation plans (PEDCTI). To accomplish this objective, the literature related to the monitoring and evaluation of policies, programs and plans was reviewed, a methodology was built, a set of monitoring and evaluation indicators was designed, and finally a validation process thereof was conducted. This article provides decision makers and PEDCTI implementers with a tool for monitoring plans and the results of their implementation.

KEYWORDS PHVA cycle, CTI planning, CTI regionalization, monitoring and evaluation.

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Metodología para el seguimiento y evaluación de los Planes estratégicos departamentales de ciencia, tecnología e innovación, pedcti: Una propuesta desde el ciclo PHVA

RESUMEN El presente artículo* desarrolla una propuesta metodológica para el seguimiento y evaluación de los Planes estratégicos departamentales de ciencia, tecnología e innovación, PEDCTI. Para alcanzar dicho objetivo se revisó la literatura relacionada con el seguimiento y la evaluación de políticas, programas y planes, se construyó una metodología y se diseñó una batería de indicadores de seguimiento y evaluación, y finalmente se realizó un proceso de validación de estos. Este artículo aporta a los tomadores de decisiones y encargados de implementar los PEDCTI una herramienta para el monitoreo de los planes y los resultados de su implementación.

PALABRAS CLAVE ciclo PHVA, planificación de la CTI, regionalización de la CTI, seguimiento y evaluación.

Metodologia para o seguimento e a avaliação dos Planos estratégicos estaduais de ciência, tecnologia e inovação, PEDCTI: uma proposta a partir do ciclo PHVA

RESUMO O presente artigo desenvolve uma proposta metodológica para o seguimento e a avaliação dos planos estratégicos estaduais de ciência, tecnologia e inovação, PEDCTI. Para atingir esse objetivo, revisou-se a literatura relacionada com o seguimento e a avaliação de políticas, programas e planos, construiu-se uma metodologia e desenhou-se uma bateria de indicadores de seguimento e avaliação; finalmente, realizou-se um processo de validação destes. Este artigo contribui para os tomadores de decisão e encarregados de implantar os PEDCTI, uma ferramenta para a monitoração dos planos e dos resultados de sua implantação.

PALAVRAS CHAVE ciclo PHVA, planejamento da CTI, regionalização da CTI, seguimento e avaliação.

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Introduction

This article elaborates a methodological proposal and builds a set of indicators to monitor and evaluate the strategic Plans of the science, technology, and innovation departments, pedcti, which are science, technology, and innovation -CTeI- activity-planning documents at territorial level.

Regarding the methodology, several phases were developed. First, literature was reviewed at national and international level in regard to programs, plans, and policies monitoring and evaluation methodologies of CTeI according the scope (González, 2003; Kellogg, 1988) and the stage they are evaluated (Quispe, 2004; Vásquez, Aramburú, Figueroa & Parodi, 2001; IDB, 1997). According to the scope, the evaluation can be conducted in terms of projects or sets of projects, programs, and policies; other type of evaluation, depending on the scope, include meta-evaluation, synthesis evaluation, strategic evaluation, and organizational evaluation (González, 2003). According to the stage in which a plan, program or project is evaluated, the evaluation may be ex-ante (IDB, 1997), base line evaluation (Quispe, 2004), ex-dure (Quispe, 2004), ex-post (IDB, 1997) and impact evaluation (IDB, 1997). It was found that some of those evaluation methodologies are too generic and do not propose a set of specific indicators to monitor and evaluate CTeI plans.

Second, the pedcti created in Colombia were analyzed, which allowed us to understand the structure of the plans and the way they approach the monitoring and evaluation mechanisms. In all the eight pedcti we had access to, it was found that some of them had monitoring methodologies that were no sufficiently structured and some of them did not have a proper set of indicators aligned with the elements to be monitored; however, other plans did detail the methodology and the set of indicators to perform monitoring activities. In general, it was found that evaluation and monitoring methodologies were very different among them, because each plan was prepared using different methodological levels and details.

Third, a methodology based on the phva cycle (plan, do, check, and act) was developed. This cycle allows monitoring and evaluate in a holistic and reconcilable manner with several management systems, making their use easy.

Fourth, a set of indicators was built to facilitate monitoring and evaluation, a set that, along with the methodological proposal, was subject to revision by the department consultants of pedcti in terms of its economic, institutional (government), environmental, and social appropriation of science and technology components, ASCyT, as well as by regional consultants of the Administrative Department of Science, Technology, and Innovation, Colciencias, thematic area leaders of the Colombian Observatory of Science and Technology, OCyT, and an international consultant of such entity.

Finally, a series of recommendations and thoughts about the methodological elaboration of the monitoring and evaluation pedcti process based on experiences of preparing the plans for four departments in Colombia: Casanare, Boyacá, Quindío, and Arauca (figure 1) are also included.

The importance of this article lays on making it easier for decision makers and the people in charge of implementing pedcti a practical tool to evaluate them, which is reconcilable with different management systems such as the Public Management Quality Standard, gp1000, and the Colombian Technical Standard, ntc ISO 9001, widely used by public and private institutions to control processes and procedures. The foregoing makes it easy to adjust strategies and make timely decisions to reach expected results. Likewise, this methodology may be useful to Colciencias as a mechanism to monitor its regionalization strategy and know the progress made in terms of the actions aimed at strengthening the scientific and technology dynamics in the departments of Colombia.

Related Theory

Evaluation of Policies, programs, and planes of CTeI

The evaluation of policies, programs, and plans addressed to the development of CTeI is a wide universe that may be carried out from multiple approaches, several scopes, and according to the stage in which the evaluation is conducted. Choosing the best mechanisms to make it, depends on the political nature, program or plan and the context it is conducted in.

FIGURA 1. Posición geográfica

Source: BC MAPS

Type of Evaluation According to the Scope

A research conducted by González (2003), in which information about methodologies and experiences of evaluating policies, programs, and plans with emphasis on CRI was identified and collected, and the following types of evaluation are described according to its scope:

Evaluation at project level: refers to the evaluation of the set of activities or actions of a project, with the participation of their implementers and beneficiaries. Determining the results obtained to improve and strengthen the activities is part of its objectives. This type of evaluation is defined as an ordered, consistent, and systematic collection of information to be analyzed and used in decision-making processes (Kellogg, 1988, cited by González, 2003, p. 6).

Evaluation of a set of projects: refers to a regular evaluation of several projects to determine their results and performance at regional or sector level. The main purpose of gathering similar projects in clusters is to promote systemic changes that would not be possible considering just one single project or a series of projects with no common elements. Information collected with this type of evaluation allows making adjustments and improvements, having an overview of the partial or final results of the project and increase effectiveness in articulation processes. This type of evaluation focuses on estimating the progress made to meet global objectives. The implementers of the projects Benefit by knowing the experiences and lessons learnt in similar projects (Kellogg, 1988, cited by González, 2003, p. 7).

Evaluation of programs or policies: refers to a wider and macro type of evaluation, since it includes the evaluation of policies and programs, which may be transversal to several projects. It collects information of projects or project clusters to determine their progress, results, and decision-making processes in the political scope or their impact in readdressing programs (González, 2003).

González (2003, p. 8) mentions other types of evaluation used to monitor and evaluate planning exercises and CTI policies, such as meta-evaluation, synthesis evaluation, strategic evaluation, and organizational evaluation.

Types of Evaluation according the stage in which a plan, program or project is evaluated

The types of evaluation may be classified according the stage of the policy, plan, program, or project in which the evaluation is conducted and the use given to the results of the evaluation.

***Ex*-ante evaluation, diagnostic evaluation, or feasibility study:** conducted before the approval and implementation of the policy, plan, program, or project (Quispe, 2004, p. 48); it aims at knowing their pertinence, potential efficacy, and viability (Vásquez et al., 2001), and helps identify the objectives of the project and other components before the project commences (IDB, 1997, p. 5).

Base Line Evaluation: it aims at establishing a framework of reference, and it is conducted when a program, plan, or project operations commence (Quispe, 2004, p. 48).

***Ex*-dure evaluation, process evaluation, or mid-term evaluation:** conducted during implementation to know if the initiative is being implemented according to plan (Quispe, 2004, p. 48); it may refer both to the management and the activities or products (IDB, 1997, p. 5) and provides information in a continuous manner by providing feedback during execution. Likewise, it also allows identifying partial and potential results to facilitate the timely modification of operations (Quispe, 2004, p. 48).

***Ex*-post evaluation or a posteriori evaluation:** conducted after the completion of a plan, program, or project in order to know the immediate results (Quispe, 2004, p. 48). Organizations such as the Inter-American Development Bank, IDB, conduct ex-post evaluations from 1 to 3 years after the completion of a project, and focus on efficiency, effectiveness, impacts, and purposes (IDB, 1997, p. 5).

Impact Evaluation: It refers to an ex-post evaluation conducted at least five years after a plan, program, or project has been concluded, and it focuses on their end and purpose, as well as on their sustainability and unforeseen effects (IDB, 1997, p. 5); in this evaluation, the economic, environmental, and social effects of the initiatives can be known (Quispe, 2004, p. 49).

PHVA cycle

It is a continuous improvement tool, introduced by Deming as of year 1950, based on a cycle of four steps: Plan, Do, *C*heck, and Act (Gestión empresarial, 2011). The tool was received as a methodology to put into practice the concept known as Kaizen, and then it was adopted by the family of ISO 9000 standards. This cycle was first suggested by Walter Shewhart in the early 20th Century, also known as Deming Cycle, in honor to the person who made it popular (Sarmiento, 2009).

Science and Technology Strategic Plan

This is a prospective planning document that seeks to guide future policies, programs, plans, and projects, to foster the productive transformation of the departments of Colombia, based on science, technology, and innovation as its basis. It addresses the potentials of the territory, is in line with the national development objectives, and agrees with world trends (OCyT, 2012).

Methodology Development and Elaboration of a Set of Indicators

Methodology Development

The pedcti monitoring and evaluation methodology was developed by having into account the following criteria:

a) Easy to implement: the methodology must be easy to understand and implement in those departments with heterogenous economic, social, and CTel characteristics; likewise, it must be clear and with no ambiguities.

b) Flexible: the methodology must be reconcilable with the administrative systems of the institutions in charge of implementing the plan.

By reviewing the literature related to monitoring and evaluation methodologies, the structure of other pedcti, the terms of reference of Colciencias to elaborate the strategic plans, as well as the suggestions made by different actors of the territorial entities, it was concluded that the methodology that best fits the easy-to-implement and flexibility criteria would be one based on the PHVA continuous improvement cycle, because of the following reasons:

c) The management systems implemented in public institutions, such as the Public Management Quality Standard, GP1000, and the Internal Control Standard Model, meo, are based on continuous improvement processes (Administrative Department of the Civil Service, dafp, 2009, p. 5).

d) It allows establishing joint monitoring and improvement actions with universities, government, and non-government entities, who implement management systems based the PHVA cycle.

e) It facilitates the continuous improvement of the processes that are carried out to implement the pedcti based on objective measurements.

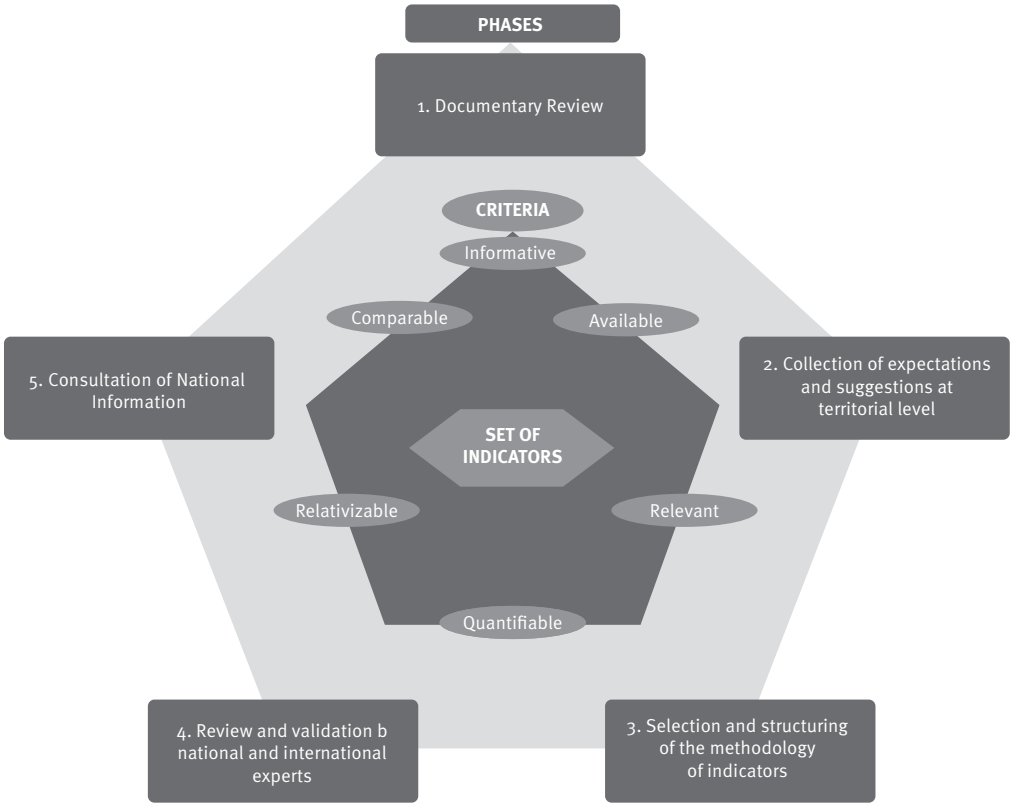
f) Since the focus of the methodology is based on facts, data analysis, and other information, effective decisions, not only based on intuition, can be made.

g) It promotes social transparency and control because in order to implement the methodology it is necessary that the organizations provide information on the progress made in terms of strategies and programs or projects derived from them.

Preparation of the set of indicators

The set of indicators to monitor and evaluate plans was prepared through a multi-critera procedure, which considered several elements and phases (figure 2): 1) national and international documentary review of indicators; 2) regional evaluation and monitoring documents containing CTeI planning exercises; 3) review and analysis of the Structure of some strategic plans we had access to; 4) recommendations made by regional consultants of Colciencias, international consultants and experts on economic, environmental, education, institutional (government), and social components of the departments of Boyacá, Quindío, Arauca, and Casanare through over 120 interviews conducted between May and September 2012; 5) finally, the set of indicators was subject to review and validation by experts in investment, innovation, bibliometrics, human resources, social appropriation of science and technology, and regions of the Colombian Observatory of Science and Technology, OCyT (table 1).

FIGURE 2. Phases and Selection Criteria for the Set of Indicators



Source: prepared by the authors

Methodological Proposal for Monitoring and Evaluation of PEDCTIs

To monitor and evaluate the actions developed within the framework of the PEDCTI, the PHVA cycle[1] has been suggested as a continuous improvement tool (Icontec, 2005, p. 12), which in a cyclical manner focuses on four phases: Plan (P), Do (D), Check (C) and Act (A) (Calidad and Gestión, 2012). With this methodology, besides evaluating and monitoring the progress of the pedcti, we look to redirect the actions as the dynamics in the departments vary, and to establish a continuous improvement process that concludes in the successful implementation of a strategic plan and the achievement of the desired results.

Planning

This phase involves the strategic architecture of the pedcti, in which the future, the objectives, actions, and possible persons in charge or people involved are defined therein (Fukui, Honda, Inoue, Kaneko, Miyauchi, Soriano & Yagi, 2003, p. 25).

It also involves the forecasting process carried out after the first implementation stages, monitoring and adjustments to the strategic plan. In this phase, the continuous improvement program, the objectives, periodicity, resources, people in charge, and scopes are established.

Doing

In this stage, processes are implemented and the initiatives proposed to meet the proposed objectives are developed (Fukui et al., 2003, p. 25) so that the results foreseen in different pedcti action scopes can be obtained, involving the actors who have participated in the process and those who are being affected by it. The

1 This continuous improvement methodology was presented by Edward Deming based on the concepts by Walter A. Shewhart, and it is common to use it in the implementation of several management systems (Calidad y Gestión, 2012).

TABLE 1. Monitoring and Evaluation Set of Indicators

ANALYSIS SCOPE	INDICATOR	SOURCE
AVAILABLE BASIS: SET OF HUMAN RESOURCES	Literacy Rate	DANE
	School Attendance Rate	DANE
	Number of programs offered by the level of training	MEN, Snies
	Number of programs offered by knowledge area and training level	MEN, Snies
	Number of graduates from higher education institutions -IES- per training level	MEN, OLE
	Number of graduates from IES per knowledge field	MEN, OLE
	Number of lecturers per knowledge field	ÍES
	Number of lecturers per training level	ÍES
	Number of researchers per knowledge field	GrupLAC, OCyT and Colciencias
INFRASTRUCTURE	Dedicated Internet penetration index	MinTIC
	Number of Community or departmental radio stations	MinTIC, ANE
	Telephony penetration index	MinTIC
	Electricity consumption index (Kw/h) per type of use	sui
	Number of libraries	Sinic
	Number of museums	Sinic
	Number of botanical gardens	Red Nacional de Jardines Botánicos
	Number of new IES Number of IES with high-quality institutional accreditation	MEN, Snies
	Infrastructure in CTeI ascribed to higher education and research institutions per type (teaching labs, research labs, computer rooms, experimental farms, etc.)	IES
POTENTIAL AND EFFORTS TO GENERATE SCIENCE AND TECHNOLOGY	Percentage of investment in education	DNP
	Investment in ACTI per type of activity. Investment in ACTI per executing entity	OCyT
	Number of projects per amount and socio-economic purpose[2].	IES
	Number of research groups (according to Colciencias and OCyT categories)	GrupLAC, OCyT and Colciencias
	Number of research hotbeds. Number of students in research hotbeds Number of young researchers	IES
	Number of children, youngsters, and professors in the program called Ondas/ Number of children, youngsters, and professors in pre-school, basics and medium education programs. Resources invested in the project Ondas	Colciencias
	Number of academic activities (workshops/diploma courses/annual forums carried out) related to social appropriateness of science and technology programs, ASCyT	Coordinating entity of the National Week of CTeI at territorial level.
	Number of programs in mass media related to CTeI per type (radio, television, press, etc.)	IES, MinTIC, Territorial Government Agency
	External knowledge acquisition for innovation	DANE
	Acquisition of machinery, hardware, equipment, or software for innovation	DANE
	Contracting of consultancy services for innovation	Companies

Continue

ANALYSIS SCOPE	INDICATOR	SOURCE
SCIENCE AND TECHNOLOGY RESULTS	Number of patents, industrial designs, and utility models. Vegetal varieties.	SIC, OMPI, UPOV
	Invention coefficient	SIC
	Introduced innovations	DANE
	New or significantly improved goods or services	DANE
	Bibliography and Technical Production	ISI, Scopus, Redalyc
	Number of services offered by type (consultancy, labs, clinics, etc.) and revenue reported by them	IES
	Number of science and technology shows carried out	IES, Offices of Education, Coordination of the CTeI Week
CAPITAL RELACIONAL (MOLINA Y SÁNCHEZ, 2012)	Agreements signed by IES with other institutions (commissions, foreign visitors, artistic residency programs, etc.)	IES
	Academic mobility destination	IES
	Geographical distribution of signed agreements	IES
	Resources invested in national and international mobility of professors, students, and researchers.	IES
	Number of articles published in cooperation or co-authorship	ISI, Scopus, Redalyc

Source: prepared by the authors, OCyT, 2012

universities-companies-State-society articulation and joint efforts are key in this stage, since through a synergic work, resulting from an elaborated planning, it is possible to reach higher levels of economic progress and social wellbeing based on CTeI.

Checking

This phase relates to the measurement process that allows control and facilitates the purpose of the actions and the objectives set in the pedcti strategic platform; thus, this is one of the main stages of the cycle. The evaluation and monitoring process is performed through indicators and their continuous checking, so that behaviors, trends, or variations can be identified and can evince the obtained results with the progressive implementation[2] of the plan, (Icontec, 2005, p. 16).

Checking must be performed in an integral manner; thus, specific indicators are proposed (table 1) in order to monitor projects as they can materialize the strategic guidelines that compose the possible thematic axis of the strategic architecture. It is much easier to monitor and evaluate the pedcti by monitoring the projects derived from it, since they have a higher level of detail (Fukui et al., 2003, p. 25).

Results in science, technology, and innovation

For the monitoring and evaluation of the strategic actions, we have proposed to employ the results in terms of CTeI capacities (table 1), which foster the development, application, and dissemination of knowledge, and constitute one of the basic economic and development elements (Rosenberg, 1982; Castells, 1986, Archibugi & Coco, 2005). This approach allows a more global vision of the results obtained with the implementation of pedcti.

It is important to highlight that, because of the multicausality[3] of the impacts, the results in CTeI could not be designated only to the execution of this plan, since the impact of the departmental, national, and international dynamics may affect the indicators of the pedcti achievements. In order to determine the evolution, trends, or ruptures in

2 Capacity to follow the history, application, or location of all that that is under consideration.

3 Multicausality of impacts means that each one of the results generated by the implementation of policies, plans, programs, or projects depend, or may depend, on many causes, some of them explicit and some others implicit, some of them well defined and some others unknown. Thus, if the local impact of science and technology has to be analyzed, it is necessary to isolate, within such multicausality, the fraction of interest, which is a challenging task, and sometimes an impossible task (Villaveces, Orozco, Olaya, Chavarro & Suárez, 2005, p. 5).

terms of science, technology, and innovation, we recommend monitor and evaluate the indicators (table 1) every other year, based on the base line of CTeI capacities performed by the OCyT (OCyT, 2011) in all the departments, which may be complemented with the diagnosis of the capacities of the pedcti.

Since the capacity indicators mentioned above should be monitored every other year, their traceability ad calculation of their variation in the ten years of development and implementation of the pedcti would be given by equation:

$$\Delta c \cong C_n - C_{n-2}$$

Being:

Δc = variation of the specific capacity indicator
C_n = capacity indicator value during the year n
C_{n-2} = capacity indicator value in the previous cohort (2 years)

In order to calculate the variation of the capacity indicators in terms of CTeI during the 10 years of pedcti implementation, we have:

$$\Delta c \cong C_{final} - C_{inicial}$$

C_{final} = capacity indicator value at the end of the implementation of the PEDCTI
$C_{inicial}$ = capacity indicator value at the beginning of the implementation of the PEDCTI.

These values can be represented in an absolute or relative manner according to the specific capacity indicator to be analyzed, and their resulting symbol, positive (+) or negative (-), would indicate increases or decreases.

Acting

During the final phase of the cycle, the necessary actions to continuously improve the processes that lead to an effective implementation of the pedcti, having as a basis the information obtained in the previous step (Check), are performed, since the reading and necessary interpretation on the progress status and the results obtained in the progressive implementation of the pedcti can be made. In this phase (Act) the necessary activities to re-address those actions that did not produce any of the expected results during the implementation (Do) phase are performed, the proposed initiatives continue being performed, and the barriers impeding the implementation of the pedcti are identified, eliminated, or reduced to the maximum.

Reflections and Recommendations

Recommendations to implement the monitoring and evaluation model

Figure 3 shows the process flow to manage the monitoring and evaluation process based on the phva cycle, and the actions to be performed in each one of the four phases in the PEDCTI implementation process are described (plan, do, check, and act). Having into account that different mechanisms are proposed for the monitoring and evaluation process (indicators, interviews, audits, and review of reports), they may be implemented in a combined manner, using them in a proper manner depending on the availability of the information and the complexity of the projects to be monitored.

Reflections based on the methodologies of monitoring and evaluation of the pedcti of Casanare, Boyacá, Quindío, and Arauca

Based on the experience of preparing methodological proposals to evaluate and monitor the pedcti of Arauca, Boyacá, Casanare and Quindío, the interviews, and reviews by potential people in charge of implementing such plans, and pedcti departmental consultants in charge of the economic, environmental, institutional (government), components, as well as the social appropriation of science and technology, ASCyT, a group of reflections can be presented below. In Casanare and Arauca, there are several universities that were created no long time ago and, therefore, no research capacities have been built, there are few researchers, and bibliographic and technical production is low. Likewise, cooperation and execution of joint projects between companies and the State is scarce. On the other hand, there is a strong impact exerted by enclave economies (oil), high dispersed population, lack of manufacturing and service provision companies, which make local endogenous development processes slow. In addition, the business sector lacks knowledge of the advantages of investing in science and technology, and a substantial institutional weakness to support and streamline the business sector. In such context, the proposal of monitoring and evaluate, as well as the indicators to monitor, derived from

strategies focused on the development of CTeI capacities, generation of added value for products, sustainable harnessing of natural resources and consolidation of a solid institutional support to promote science, technology, and innovation.

The following are some recommendations for monitoring and evaluating the pedcti of departments that share some of the characteristics mentioned above: first, support the implementation process of this evaluation and monitoring evaluation proposal in higher education institutions, since those institutions know more about the different scientific and technology dynamics, as well as the continuity of the processes they manage regarding government entities; second, collecting and systematizing information collected during the monitoring and evaluation process of the pedcti, since in some cases, in Casanare and Arauca, the information showed in the national information systems (Platforms of the Ministry of National Education, Colciencias, Single Information System, SUI, among others) does not reflect the reality of the department.

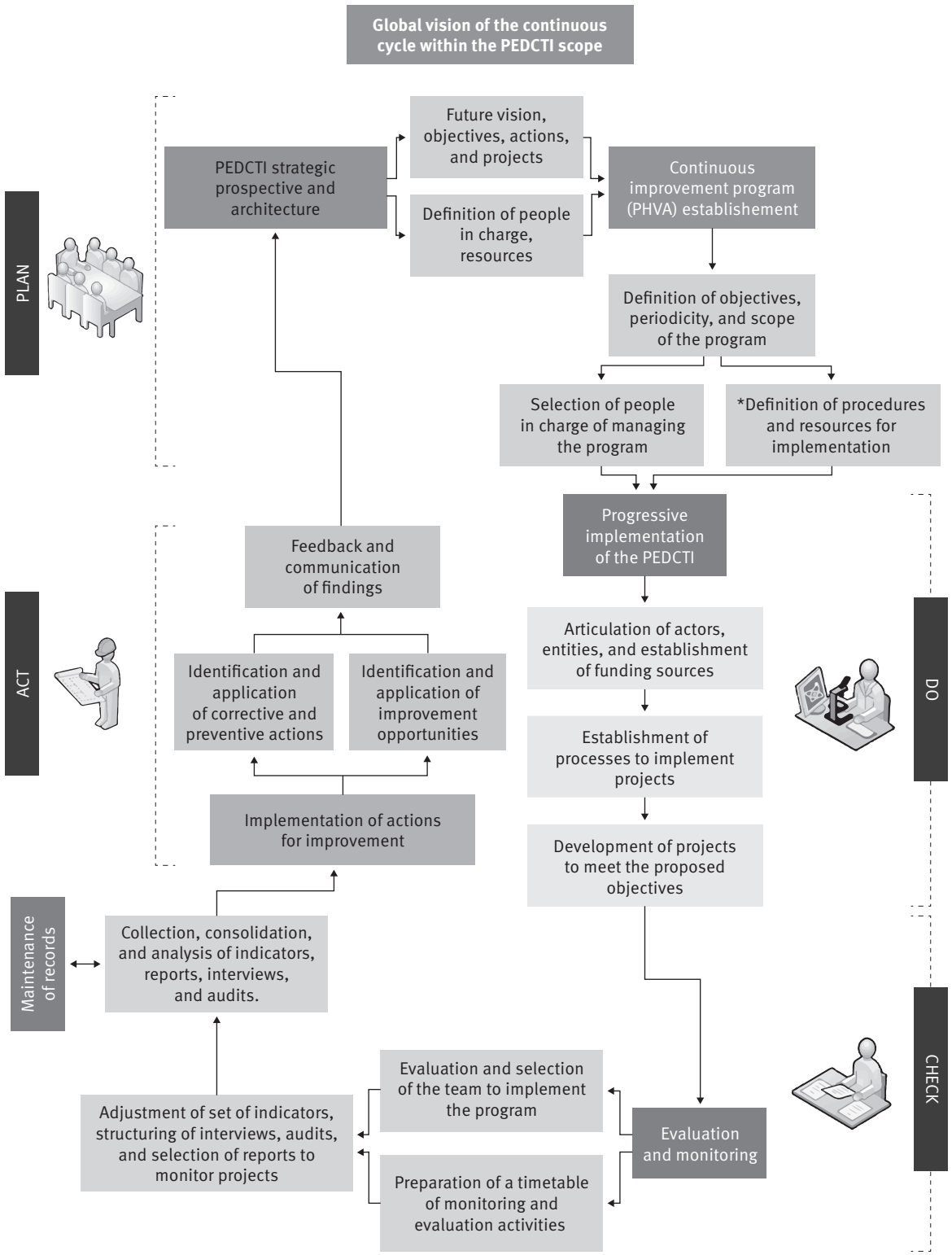
The departments of Boyacá and Quindío have scientific and technology capacities more developed than the previous departments. This is evinced in the fact that their universities have more experience, more research groups and researchers, as well as more scientific production and techniques; besides, they have a better infrastructure to develop scientific activities and more investment in scientific, technology, and innovation activities. On the other hand, in comparison to Arauca and Casanare, cooperation between higher education institutions is wider, companies and government entities; however, it keeps being weak. Boyacá and Quindío were not significantly affected by the enclave economies, and their economies are slightly diversified; however, these departments show high labor informality rates. In a context like this, the strategies and actions of the plans were focused on the consolidation of

TABLE 2. Recommendations to implement monitoring and evaluation activities*

	RECOMMENDATION
PERIODICITY	Conduct monitoring and evaluation activities every other year for prevention and corrections, as well as for timely improvements and adjustments. Likewise, it is possible to determine the evolution of the changes and trends or ruptures generated by the implementation of the PEDCTI.
SOURCES OF INFORMATION	Interviews, indicators, audits, administrative records, and reports, depending on the complexity of the projects and the availability of the information, always depending on the evidence that show the status of the progress made. For the indicators, it is possible to use percentages that allow to relativize them to facilitate comparisons; adjustments or combinations of the potential indicators may depend on the dynamics of the territorial CTeIs and the scope of the monitoring and the evaluation.
PEOPLE IN CHARGE	It is recommended that the people in charge of monitoring and evaluating to be different from the people in charge of implementing the plan in order to guarantee the autonomy, objectiveness, and veracity of the results. It is necessary to choose a leader for such processes and, if possible, the people in charge of the monitoring process must know about quality or a professional profile that allows them to monitor projects in an effective manner. Business administrators, industrial engineers, people holding diploma courses or postgraduate specialization courses in quality management are suitable for this purpose.
SCOPE	The scope of the evaluation and monitoring of the PEDCTI depends on the priority and needs of the people in charge of its implementation, the stakeholders, the legal requirements, and the number, importance and complexity of the projects that are going to be monitored.
OPERATIONAL ASPECTS	It is necessary to guarantee and retain the recording of the monitoring and evaluation activities (results report, improvements to be made, capacity of the system to meet the objectives and efficacy evaluation to meet the initially proposed objectives), as well as the competence of the people in charge of implement them, who, in addition, must have well defined duties and responsibilities and must have access to all the information, time, and cooperation that allows them to perform their duties in an effective manner.
COMMUNICATION ASPECTS	Effective communication channels must be established among the people in charge of monitoring and evaluating, and the people in charge of implementing the PEDCTI, so that the former have timely in situ access to relevant documents and the latter are effectively informed of the activities timetable to be performed and their results so that feedback is provided.

*This table includes some recommendations included in the ntc-iso 19011 standard.
Source: created by the authors.

FIGURE 3. Global vision of the continuous improvement cycle within the pedcti scope



Source: created by the authors

scientific and technology capacities, strengthening of knowledge networks and services offered by higher education institutions (ies) to satisfy the demand of the companies and make productive processes more effective; thus, the indicators that were generated for monitoring and evaluating are addressed to monitor initiatives such as the ones above.

In such a context, it is recommended that the monitoring and evaluation process is jointly performed by all those in charge of implementing the plan, since they have the experience enough to execute it, but to focus the attention of the activities on higher education institutions or chambers of commerce, since they have a higher degree of independence from government entities. It is also recommended to establish proper communication mechanisms for the monitoring and evaluation activities, an expert work team and timely feedback for the findings obtained, due to the high number of institutions that would participate in the execution of the plans.

Conclusion

The evaluation and monitoring of the CTeI planning exercises at territorial level is increasingly relevant as it facilitates timely decision-making processes, the implementation of strategic and accurate actions and the monitoring of the results and resources invested in CTeI. However, the execution of this type of monitoring processes is not always easy, since the substantial number of actors involved makes the implementation difficult. In this article, a methodological proposal was developed in order to facilitate the monitoring and evaluation of the pedcti, since it is based on the continuous cycle, phva, which is highly practical, flexible, and based on evidence. Since the pedcti were created using different methodologies and levels of details, the monitoring tools proposed are highly heterogenous; in this sense, a methodological proposal based on the phva cycle may benefit the homogenization of the evaluation and monitoring of these plans.

The methodological proposal and the set of indicators in this article are focused on the evaluation and monitoring of the pedcti, and they were validated by experts. This makes it more specific and adjusted to the monitoring needs of the results of the CTeI plans, in comparison to other generic methodologies found in the review of the literature.

Even if this methodological proposal represents a progress in terms of evaluation and monitoring of the pedcti, it is important to keep researching for alternatives that allow evaluating in real time the results of the science and technology activities. For such purpose, it may be valuable to explore the use of ICTs, big data, and data mining, which are tools common to the digital era, which may have an enormous potential to conduct monitoring exercises. Likewise, it is also important to keep researching mechanisms that allow relating, with higher precision, CTeI activities to the results and impacts they generate.

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