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TODO LO ILUMINAN
1942

"El saber de mis hijos
hará mi grandeza"

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RESEARCH

Comprehensive Economics and Policies in childcare in contexts of socio-environmental threat

Contexto económico y politicas públicas integrales en atención a la niñez en condiciones socio-ambientales de riesgo

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Abstract

A social group given priority in Mexico's political agenda is children; however, such attention tends to fade when it comes to those living in contexts of environmental threat and social vulnerability. The complex network of actors and institutions involved in processes such as nutrition, education, household income, and health demands the implementation of comprehensive policies that consider both structural and contextual factors that may shape these processes. To highlight the need for such comprehensive policies aimed at children, a non-experimental correlational study was conducted to show that living in conditions of social precariousness and environmental threat affects child neurodevelopment. The results revealed significant negative associations in working memory (r = -.396), verbal comprehension (r = -.406), processing speed (r = -.280), and perceptual reasoning (r = -.437). The findings confirm limited cognitive development among children living in environments of environmental threat and social precariousness, and therefore, underscore the need to promote comprehensive policies that directly address this issue.

Keywords: environmental threat, social vulnerability, cognitive performance.

JEL Codes: I-Health, Education, and Welfare; I14, Health and Inequality; I18, Government Policy; Regulation; Public Health.

Resumen

Un grupo social de prioritaria atención en la agenda política de México es la niñez, sin embargo, tal atención se disipa en el caso de aquella población que vive en contextos de amenaza ambiental y vulnerabilidad social. La compleja red de actores e instituciones involucrados en los procesos de alimentación, educación, ingreso familiar y salud, exige instrumentar políticas integrales que tomen en cuenta los factores estructurales y contextuales que pueden determinar tales procesos. Para evidenciar esa necesidad de instrumentar políticas integrales en atención a la niñez, se realizó un estudio de diseño no experimental de correlación con el fin de mostrar que el vivir en un contexto de precariedad social y amenaza ambiental afecta el neurodesarrollo infantil. Los resultados develaron asociaciones negativas significativas en memoria de trabajo (r= -.396), comprensión verbal (r= -.406) velocidad de procesamiento (r=-.280) y razonamiento perceptual (r= -.437). Se confirma un limitado desarrollo cognitivo en infantes residentes en contextos de amenaza ambiental y precariedad social y, por tanto, la necesidad de impulsar una política de carácter integral que atienda de manera puntual tal problemática.

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Palabras claves: amenaza ambiental, vulnerabilidad social, desempeño cognitivo.

Codigos JEL: I, I14,I18.

Introduction

Vulnerability as a consequence of social imbalances has increased and become ingrained in the culture of Mexican society (Águila et al., 2015). The accumulation of disadvantages in this regard has multiple causes and manifests in various dimensions. Among structural causes, notable factors include the global economic recession and the consequent decline in trade flows, reflected in a widespread drop in exports (in value and volume); dependence on remittances received; and low levels of foreign direct investment. Undoubtedly, the global structural recession has affected economic development expectations, which is reflected in low GDP growth, decreased national consumption and investment, deterioration of the labor market, increased unemployment rates, reduced employment, and rising poverty at both national and intra-regional levels. Since the 1980s, the Mexican government's economic policy has adopted neoliberal measures and focused on global markets. However, four decades later, the expected economic and social benefits of this approach remain unfulfilled.

While the possibility of overcoming the stagnation of the national economy (reactivating employment and reducing poverty) remains contingent on the behavior of structural factors in the global economy, particularly the country's ability to implement counter-cyclical policies (CEPAL, 2014), the situation has become even more complicated due to the effects of the Covid-19 pandemic on the national economy and, consequently, social welfare. Government measures to limit the spread of the disease have caused an unprecedented economic slowdown. More than a year after the health emergency, the situation remains concerning. The health emergency justifies greater public sector intervention, clearly and transparently, to support households, businesses, and the financial sector by providing liquidity (through credit grants and postponement of financial obligations) and economic solvency.

The problem addressed in this study is linked to these structural factors, since labor and social policies depend on and are determined by fiscal, monetary, financial, exchange rate, and foreign trade policies. Social policies related to education, health, and work involve this diversity of factors, institutions, actors, and processes interacting in each program, guideline, and policy action. It is no coincidence that the United Nations International Children's Emergency Fund (UNICEF) designed a comprehensive platform to facilitate the articulation of sectoral programs (social development, health, education, participation, and nutrition, among others) in an effort to gradually create a protective environment for children's rights. Countries are urged to incorporate a comprehensive care scheme for children into their national policy agendas, especially policies targeting early childhood populations and vulnerable groups.

This context justifies the research framing this document. It aims to show the socio-environmental risk conditions experienced by groups of children living in rural areas of Mexico, highlighting the need to promote the design and development of public programs based on comprehensive care schemes for childhood.

Conceptual and Referential Development. Contexts of social vulnerability, environmental threat, and cognitive assessment tests for children.

Two basic concepts are generally used when addressing socio-environmental risk conditions in specific socio-historical and population contexts: social vulnerability and environmental threat. The first, vulnerability, denotes the lack or absence of essential elements for survival and personal development, as well as insufficient tools to avoid disadvantaged situations (Sólomon, Villa, and Núñez, 2011). The second, environmental threat, refers to damage associated with natural or anthropogenic phenomena affecting the population. Below are some clarifications on both concepts from previous studies.

According to Lampis (2012), social vulnerability refers to susceptibility to harm and is used to study phenomena such as poverty and development (Chambers, 1995), disaster risk management (Wisner et al., 2004), and climate change adaptation in community contexts (Adger, 2006; O'Brien et al., 2009). Valencia (2016) focuses on aspects of organization, social relations, and social structure, which involves understanding prevailing social logics in risk situations. Brooks (2003), when conceptualizing vulnerability, states that it is usually related to risk, danger, exposure, sensitivity, adaptive capacity, and resilience. He distinguishes between biophysical and social approaches in conceptual and methodological terms. The biophysical approach stems from social vulnerability and disaster risk management studies and prioritizes natural hazards and their impacts, emphasizing exposure to a threat over the subject's response capacity (Brooks, 2003; Valencia, 2016). Biophysical vulnerability assessments are rooted in a positivist epistemology based on the nature of a physical-environmental hazard, as an extension of human system exposure and the studied system's sensitivity to impacts of such hazard (O'Brien et al.; Valencia, 2016).

The social vulnerability approach, on the other hand, comes from a more critical research tradition addressing disaster risk management from a political ecology perspective (Wisner et al., 2004) as well as poverty research (Barrientos, 2013). This perspective considers that social and political processes determine the impact of so-called natural threats (Fraser, 2014). Based on this idea, Cutter et al. (2003) argue that social vulnerability is partly the product of social inequalities, as these act as shaping factors of groups' sensitivity to harm and impact their ways of responding to environmental threats. In this sense, vulnerability includes social inequalities related to factors such as income, rural urbanity, occupation, infrastructure, education, family structure, among others. It is worth mentioning here the recognition of structural aspects as determinants, or at least conditions, of social vulnerability and, consequently, the need to implement comprehensive policies.

Regarding the term environmental threat, environmental studies use a wide range of terminology to address damage associated with natural phenomena or anthropogenic events, referring to different approaches to harm caused by environmental threats. Smith and Petley (2009:9) describe "…potential threats facing human society from events originating and transmitted through the environment," noting that human involvement tends to increase involuntary exposure to rare and uncontrollable natural events (asteroid impacts, earthquakes) toward more voluntary exposure to danger through common technological failures in the built environment (transport accidents, air, water, and soil pollution). In this logic, environmental threat constitutes the primary negative causal aspect of harm over short or long periods.

Whichever conceptual definition is adopted, this work recognizes that social conditions will amplify, limit, or mitigate the effects of a particular environmental threat. Both terms are useful and complementary to fine-tune the analytical lens for approaching the issues faced by a given population group. In this work, environmental threat is constituted by the presence of agrochemicals, and social vulnerability refers to social inequality caused mainly by income level, rurality-urbanity, occupation, infrastructure, education, housing, and access to services.

Regarding children's cognitive performance, various measurement methods (psychometric and neuropsychological tests) are used for vulnerable populations exposed to neurotoxins (Morales, 2016). Neurotoxicological studies focused on brain functioning use psychological measurement/evaluation methodologies (Anger, 2003) ranging from classical designs using standardized psychometric tools to assess global intellectual abilities/capacities, to cognitive psychology approaches employing neurobehavioral batteries to measure specific sensory and motor responses through computerized tasks. Other research in environmental neurotoxicology employs clinical compounds (concepts, knowledge, sequencing, and visuospatial organization) derived from the Wechsler scales, providing a spectrum of specific psychological/cognitive functions such as verbal comprehension, verbal fluency, number, space, speed perception, memory, and reasoning

For example, Calderón et al. (2001) used the WISC RM to assess the effects of arsenic and lead on neuropsychological functioning in school children living in a mining-metallurgical area in San Luis Potosí city through the Banatynne compound model. Their results reported high arsenic levels in children's urine and a significant correlation of these levels with low cognitive performance (in long-term memory and linguistic abstraction). Along these lines, Rocha (2008), using a clinical compound interpretation methodology, found associations between visuospatial organization and verbal reasoning tasks with high arsenic concentrations in urine, and low long-term verbal memory scores with high fluoride concentrations in urine.

Sarsour et al. (2011) studied independent and interactive associations between family socioeconomic status (SES) and single-parent status to predict children's cognitive functions related to inhibitory control, cognitive flexibility, and working memory. They also examined expressive language skills and the family environment as possible mediators of these associations. The study involved sixty families from California from various social strata, each with a school-age child (mean age = 9.9 years). Children's executive functioning was measured using a brief battery including the Wechsler Intelligence Scale for Children, Fifth Edition (WISC-V), and the Trail Making Test. Home environment quality was assessed using the Home Observation for Measurement of the Environment inventory. The authors found that family SES predicted the three executive functions of the children. Single-parent and family SES were interactively associated with children's inhibitory control and cognitive flexibility; children from low-SES, single-parent families scored lower. Parental responsiveness, enrichment activities, and family companionship mediated the association between family SES and children's inhibitory control and working memory.

Hackman et al. (2015) measured the effect of SES on 1,009 children in California regarding their cognitive functioning and found that family income and maternal education predicted planning skills for first grade and working memory performance at 54 months. Early SES effects remained stable through middle childhood, indicating that the relationship between early SES indicators and cognitive functioning emerges in infancy (1-3 years) and persists without narrowing or widening in early and middle childhood (5-10 years).

Continuing with this line of research, Lawson and Farah (2017) conducted a study aimed at understanding the extent to which executive functioning (specifically in the dimension of working memory) mediated the associations between education, family income, and achievement in reading and mathematics in a sample of 336 children aged 6 to 15 years. They employed the Wechsler Intelligence Scale for Children, Third Edition (WISC-III), specifically the Digit Span subtest, and the *Cambridge Neuropsychological Test Battery* (CANTAB). For academic achievement in mathematics and Spanish, they used the Woodcock-Johnson III (WJ-III) battery. Using a structural equation model, they found that socioeconomic status (SES) predicted significant changes in reading and math achievements over a two-year period; moreover, executive functioning but not verbal memory partially mediated the relationship between SES variables and changes in math performance.

In Mexico, Morales (2015) examined the cognitive performance of 84 children living in socio-environmentally vulnerable conditions using the WISC-IV and the Woodcock-Muñoz battery. Participants were indigenous children residing in pesticide exposure risk contexts, considering parental education and occupation, as well as family income and nutrition. Results showed significant differences between children with low and very low SES in cognitive tests evaluating intellectual ability, crystallized intelligence, and visual intelligence. These findings align with those of Arán-Filippetti (2011), regarding the three socioeconomic indicators directly related to children's cognitive performance (parents' educational and occupational levels, and family income), with parental education marking the greatest differences (Noble et al., 2007).

Regarding social vulnerability and environmental threat in rural contexts, the literature reviewed indicates that in Mexico, the agricultural sector is one of the most affected by adverse economic situations; therefore, working in agriculture is synonymous with social vulnerability and marginalization. Mejía and Viveros (2016) state that precarious socioeconomic conditions bring harmful consequences for those who, due to low income, cannot meet basic needs such as food, housing, healthcare, education, or access to a decent pension system.

According to official sources (INEGI, 2016), most agricultural workers and their families live in poverty: by December 2015, the population aged 15 and over engaged in agricultural activities reached 5.5 million people, 56% of whom were farmers and 44% support agricultural workers (day laborers), with women representing 11 out of every 100 workers. In the state of Sonora, 14% of the population lives in rural areas, and 188,122 people work in agricultural jobs, accounting for 6.6% of the total state population (INEGI, 2016), a figure that rises during harvest seasons. For example, in 2015, over 60,000 workers were displaced in the central region alone due to grape production. Social and infrastructure researchers have reported in the local press the precarious living conditions of the population in the town of Miguel Alemán (López, 2018). Their reports recognize that the combination of environmental, economic, social, and poverty-related factors prevalent in the town are linked to an average mortality age of 51 years (twelve years less than the rest of Sonora's population). Regarding health infrastructure, between 1990 and 2014 there was one state health center and one IMSS clinic; in that same year, another care center opened but proved insufficient to serve a population that increased by more than 23,000 inhabitants during that period. Thirty-three percent of the population lacks access to public health services (INEGI, 2015). The lack of sanitary infrastructure worsens with large groups of migrants arriving, leading to higher poverty and marginalization rates. Tuberculosis prevalence in the town is three to four times higher than in the city of Hermosillo, a disease associated with poverty, especially among migrants, compounded by adolescent pregnancies, drug addiction, and sexually transmitted infections (López, 2018).

Studies in this region have found that workers do not use necessary protections when handling pesticides, chemical containers are often buried, children work in fields or play near them, there is no drainage system, and house floors are dirt, among other imminent risk conditions and practices (León, 1997; Leal, 2013; Ochoa, 2012; Gutiérrez et al., 2013; Silveira et al., 2016; Ochoa et al., 2018).

The presence of pesticides in agricultural localities within Rural Development District (DDR) 144 of Hermosillo is evident. Several studies have identified the use of pesticides banned by international agencies in this region (Gutiérrez et al., 2013; Leal et al., 2014; Silveira et al., 2018). Likewise, the presence of organochlorine pesticides has been detected in various soil samples (Cantú et al., 2011; Leal et al., 2014); and in human populations, exposure to agrochemicals has been detected in serum mixtures, breast milk, and semen of day laborers (Silveira et al., 2011; Gámez, 2007; Valenzuela et al., 2008; Limón et al.). All of this supports the conception of an environmental threat context in these DDR 144 localities.

Regarding family profiles, Ochoa et al. (2018) characterized the socioeconomic conditions of agricultural localities in central, southern, and northern Sonora, observing that most participating children came from vulnerable social sectors (parents with an average education level of primary school, main occupation as agricultural workers, and monthly incomes ranging from two to five thousand pesos). It is worth noting that this study considered rural localities in DDR 144 for the central region, which are also referenced in this work.

Analysis of the possible relationship between the physical-environmental context and child development: to date, the region of interest continues to face problems with aquifer contamination, air pollution due to smoke and dust, and inadequate drainage services (Implan, 2016–2018). Streets are often flooded with domestic and/or rainwater wastewater, leading to the proliferation of insect vectors of infectious diseases. With 75% of the town unpaved, these problems are associated with cases of salmonellosis and typhoid fever due to the pathway of open defecation (absence of toilets and latrines) from the street to food. Winds carry dust contaminated with various pollutants, including agrochemicals and fecal matter, to food exposed in the streets.

Diseases arise from this harmful interaction between social problems (insecurity, poverty, insufficient and poor-quality health and education services) and environmental problems (contamination by agrochemicals, dust, water scarcity, and saline intrusion, among others). Children are a population sector especially vulnerable to such adverse environmental conditions. Undoubtedly, this stage of life is crucial for human development, constantly evolving and sensitive to multiple impacting factors (Luria, 1978). An adequate environmental configuration can enhance individual abilities and, possibly, social progress (Lipina, 2016). However, in the DDR 144 localities, environmental and social conditions become limiting and even threatening to child development.

Childhood refers to a fundamental period in human life, during which psychological functions develop through a dynamic process of interaction between the child and the surrounding environment; this results in nervous system maturation with the consequent development of brain functions and, simultaneously, personality formation (Vygotsky, 1978). This development is a complex and precise process that begins very early in life and continues for several years after birth. Critical periods for normal development include the intrauterine phase and the first year of life (Lezak et al., 2004).

Given the study's variables of interest, the Historical-Cultural Model of Vygotsky was adopted due to its fundamental premise: the brain is an organ that configures its functional structures according to the complex interplay of biological and social factors. The brain's morphological structure alone does not guarantee the presence of all psychic aptitudes but provides the potential to forge them through sociocultural experience. Furthermore, for this functionality to manifest, it is necessary that, mediated by learning processes, the child internalizes the world of human objects and phenomena (Luria, 1995; Vygotsky, 1982). Higher psychological functions are the product of learning (Azcoaga, 1985) and are established during ontogeny (Vygotsky, 1978). According to Vygotsky (1982), each function in child development appears twice and at two different levels: first on the social plane and then on the psychological plane. That is, initially it is an interpsychological category and later an intrapsychological category. In agreement with this, Luria (1978) states that functional processes in the child begin as extrinsic by origin and social by nature, and over time become intrinsic. Therefore, the acquisition of cognitive functions depends on both genetic inheritance and the subject's historical experiences.

Based on Vygotsky's contributions, it can be said that the roots of any psychological function should be sought in the social interactions in which they are generated; it is also important to understand that these interactions and the resulting psychological functions are based on a reality mediated by cultural semiotic tools. Hence, the interest in studying psychological functions from a developmental perspective (Cervigni, Stelzer, Mazzoni, Gómez, and Martino, 2012).

Methdological deisgn of the research

The adoption of policies for comprehensive childcare begins by recognizing the diversity of factors, institutions, actors, and processes that can either support or limit child development, particularly in populations considered vulnerable due to living in contexts of social precariousness and environmental threat. Acting or failing to act in this regard marks the difference in the future of such children. The possibility of establishing comprehensive policy actions begins with demonstrating the presence of the problem and the need for attention in a specific population and context. These considerations justify the research purpose underlying this work: to show that children living in conditions of social vulnerability (social conditions) and environmental threat (physical context) exhibit more limited cognitive development compared to their peers. The hypothetical assumption is that social vulnerability, framed within a context of environmental threat, relates to cognitive performance. The general objective is to associate social vulnerability with the cognitive performance of children residing in contexts of environmental threat in Hermosillo, Sonora, Mexico, from which three specific objectives arise: a) to characterize the sample through the social vulnerability index; b) to describe the cognitive perfomance of participating children; c) to associate cognitive perfomance with the variables that make up the social vulnerability index. This is a correlational, non-experimental study involving populations from agricultural localities in the city of Hermosillo, representing 80% of the surface area of Rural Development District (DDR) 144 and 93% of its population. The agricultural area of DDR 144 is predominantly irrigated, mostly oriented towards commercial agriculture (about 94,000 hectares). Cultivated surface varies yearly, depending on water availability and crops planted (INEGI, 2014). According to official figures, this district has 310 localities with more than 100 inhabitants each, 90% of which are located near agricultural fields. Most of the population are agricultural laborers and their families. According to a study by Silveira et al. (2018), residents of these communities are exposed to contamination due to limited infrastructure and housing conditions, a precariousness also confirmed by the Ministry of Social Development (SEDESOL, 2015): 14% of homes lack piped water, 33% lack drainage, and 15% have dirt floors (SEDESOL, 2015). Most of these localities and their houses are surrounded by agricultural fields where various agrochemicals are commonly applied, including some used domestically, which facilitates the population's exposure to toxic chemicals that can spread through air, soil, or workers' clothing (Quandt et al., 2006; Fenske, Lu, Negrete, and Galvin, 2013; Remoundou et al., 2014; Leal et al., 2014; Ochoa et al.; Silveira et al., 2016).

Participants were residents of five localities in DDR-144 located on the Hermosillo coast: La Peaña, El Fundador, Ejido Salvador Alvarado, Los Pocitos, and El Ejido Ávila Camacho. A total of 115 children were selected via non-random convenience sampling, considering three inclusion criteria: 1) residing in a locality evaluated as socially vulnerable (Ochoa, 2018); 2) attending a primary school located very close to cultivation field; y 3) having parents employed in the agricultural sector. The average age of participants was 9.8 years, and 57.7% were girls.

To describe participants' social situation, variables from the Social Vulnerability Index in Hazardous Environments (Cutter et al., 2003) were used: parents' occupation, mother's education level, family income, marginalization, and number of family members. Most data were obtained via a self-designed socioeconomic questionnaire. The only data sourced from official figures was marginalization, using an index ranging from 0 to 100 provided by the National Population Council (INEGI, 2010). The medical history section of the WISC-IV was used to exclude children who had experienced prenatal, perinatal, or postnatal complications that could act as confounding variables. The instrument used to assess cognitive development was the *Wechsler Intelligence Scale for Children IV* (2003), in its short form of 7 subtests. These generate a global score and four indices: 1) verbal comprehension (skills in verbal concepts formation, expression of relationships between concepts, richness and precision in vocabulary definition, acquired knowledge, verbal agility, and intuition); 2) perceptual reasoning (praxis-constructive skills, formation and classification of non-verbal concepts, visual analysis, and simultaneous processing); 3) working memory (capacity to retain and store information, mentally operate with it, transform it, and generate new information); y 4) processing speed (ability to quickly and efficiently explore, organize, or discriminate simple visual information). It is important to note that this work continues from prior research (Ochoa, 2018), which facilitated the identification of communities with precarious infrastructure and services as well as contact with the population of interest through primary school staff. Both teachers and mothers signed informed consent forms. Data collection logistics were arranged with specialized research center personnel. The WISC-IV subtests and socioeconomic questionnaire were administered individually, with an estimated time of 55 minutes per child. The Modern Manual's administration guidelines were followed to ensure reliable data collection. After evaluating children at each school, a briefing process was conducted to build a database using SPSS version 22. Statistical analyses to meet the objectives included frequency analyses to describe children's characteristics and Spearman's non-parametric correlation test for group contrasts.

Results and discussion.

To test the general objective associating social vulnerability with cognitive performance of children residing in environmental threat contexts in Hermosillo the first specific objective was addressed: characterizing the sample through the social vulnerability index. Table 1 describes the variables taken from the vulnerability index and the data for the study population. It can be observed that parental education was incomplete secondary school for both mothers and fathers. Notably, 15 fathers had no formal schooling. The average income was 5,171.20 pesos. The localities scored from medium to high marginalization on average.

Table 1. Description of the variables in the social vulnerability index

Variables	Mean	Standard deviation
Mother's education	7.5	3.35
Father's education	7.3	2.91
Monthly family income	5,171.20	477.42
Number of family members	5.08	1.46
Marginalization	10.54	3.6
Total	115	

Subsequently, the second specific objective was addressed: to describe the cognitive performance of the participating children. Table 2 shows the cognitive performance of the participating children. The lowest score was in verbal comprehension, placing most of the evaluated sample in the borderline category; in the other scales, they were in the low average range.

Finally, the third specific objective was to associate cognitive performance with the variables that make up the social vulnerability index. Table 3 presents the Spearman non-parametric correlations between cognitive performance and the variables from

Table 2. Cognitive performance of participating children

Variables	Mean	Standard deviation
Verbal comprehension	75.85	10.24
Perceptual reasoning	84.01	9.11
Working memory	85.35	9.40
Processing speed	87.45	12.70

Table 3. Non-parametric correlations of the variables studied

	WISC IV Indices			
Variables	**VCI**	**PRI**	**WMI**	**PSI**
Mother's education	.208*	.243*	.104	.270**
Father's education	.157	.175	.097	.241**
Monthly family income	.101	.095	.206*	.157
Marginalization	-.077	-.088	.106	-.045

p. 05*; p.000**.
VCI: Verbal comprehension index; PRI: Perceptual reasoning index; WMI: Working memory index; PSI: Processing speed index.

the vulnerability index. Significant correlations were found between mothers' education and verbal comprehension, perceptual reasoning, and processing speed.

Fathers' education was only correlated with processing speed. Among the purely economic variables, only working memory showed a correlation.

The results showed verbal comprehension to be one of the lowest-scoring cognitive functions among children living in rural contexts. Studies that examine the relationship between environment and language date back to Vygotsky (1978), who proposed that the environment acts as either a facilitator or an obstacle to such development. A correlation was also found between mothers' education and children's verbal comprehension, which aligns with the findings of Maggiolo et al. (2014), who identified a strong association between this factor and language development in both children with delays and those with typical development. It is worth noting that the mothers' average level of education was incomplete secondary school. Mazzoni et al. (2014) point out that even when giving punishment or praise, mothers in rural contexts tend to use fewer words. Similarly, working memory has been associated with social vulnerability. Studies like those by Lawson and Farah (2017) suggest that the greater the deprivation, the lower the performance of this function. It is important to reiterate that, while this study did not directly examine the relationship between pesticide exposure and cognitive function, it did consider residence in environments threatened by such chemicals. In that sense, the results were consistent with studies using dose-exposure designs (Martos et al., 2013; Rivero, 2012; Rowe et al., 2016; Vester & Claude, 2016). These findings are in agreement with Lipina (2016), who states that empirical evidence collected over the years across multiple investigations has indicated that during the early years of life, individuals in precarious socioeconomic conditions are at a disadvantage in maximizing their cognitive functioning.

Conclusions

The study confirms an association between socio-environmental factors and the development of executive tasks in children. These findings reaffirm the need to implement targeted support programs for this population group within the framework of comprehensive health, nutrition, and education policies. In this regard, the proposal recently made by UNICEF-Mexico in the 2019-2024 Agenda for Children and Adolescents is notable. This document explicitly aims to consolidate the National System for the Comprehensive Protection of the Rights of Children and Adolescents through five key areas of action: a) ensuring comprehensive development for children in early childhood; b) developing and implementing a national strategy to eradicate all forms of child malnutrition; c) ensuring that all children and adolescents attend school and learn; d) ending all forms of violence against children and adolescents and ensuring full care and restiitution of the rights of victims; y e) guaranteeing protection and access to rights for all migrant children and adolescents.

It remains to be seen, however, how the goals of such an agenda will materialize in the daily lives of children in Mexico, particularly those living in socially and environmentally precarious conditions who tend to show impairments in cognitive development, thus facing a future with limited opportunities to improve their quality of life. Undoubtedly, policies in health, nutrition, and education must consider not only the children but also their parents, rural families, teachers, and other social actors and institutions involved. A key issue is employment, the type of work, and corporate responsibility in the activities and processes that lead to environmental threats, hence the complexity of intervention efforts if the aim is to truly address the problem. It is urgent to implement policies for the comprehensive care of Mexican children, in order to break the so-called vicious cycle of environmental illness (Mergler D., 2012, 2014), which unfortunately tends to be normalized in the reality of populations living in conditions of social vulnerability and environmental threat.

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RESEARCH

University Social Responsibility in The Face Of The Challenges Of Climate Change: Towards A Post Covid-19 Agenda

La responsabilidad social universitaria frente a los desafíos del cambio climático: hacia una agenda post COVID-19

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Abstract

University Social Responsibility (USR) is a comprehensive university management policy that encompasses all its processes and evolves within the new context of globalization, innovation, and the knowledge economy. In the face of the challenges posed by climate change and the COVID-19 pandemic, this article analyzes the USR of universities in response to these twin crises. A qualitative social research methodology and documentary analysis were applied. Beyond their core functions (teaching, research, and outreach), universities also need to strengthen their internal and external linkages in order to implement USR as a policy of ethical quality through responsible educational, labor, and environmental management to promote sustainable development. Two priority areas of USR are explored in more detail: environmental education and communication, and the consolidation of a green campus. We argue that USR must also address inequities related to poverty and gender, as well as give voice to the most vulnerable social groups. Furthermore, we propose refocusing USR efforts in light of the major challenges currently faced by universities and society and incorporating this commitment into university planning through their mission, vision, and economic, social, and environmental strategies.

Keywords: University social responsibility, climate change, COVID-19, environmental education, communication, green campus.

JEL Codes: I23, I29, I39, Q54.

Resumen

La responsabilidad social universitaria (RSU) es una política de gestión integral de la universidad en todos sus procesos, que evoluciona en el nuevo contexto de globalización, la innovación y la economía de conocimiento. Ante los desafíos que representan el cambio climático y la pandemia COVID-19, este artículo analiza la RSU de las universidades frente a estas crisis gemelas. Se aplicó la metodología cualitativa de la investigación social y análisis documental. Aparte de sus funciones sustantivas (docencia, investigación y extensionismo), las universidades también requieren consolidar su vinculación interna y con su entorno, para realizar la RSU como una política de calidad ética mediante una gestión responsable educativa, laboral y ambiental para promover el desarrollo sustentable. Se exploran con más detalle dos vertientes prioritarias de la RSU: educación ambiental y comunicación, y consolidación de un campus verde. Consideramos que la RSU también tiene que enfocarse a las inequidades asociadas a pobreza o género, así como la voz de los grupos sociales más vulnerables. Además, proponemos reenfocar los

esfuerzos de RSU ante los importantes desafíos que actualmente enfrenta y la sociedad, así como incluir el compromiso en la planificación universitaria en su misión, visión y estrategias económicas, sociales y ambientales.

Palabras clave: Responsabilidad social universitaria, cambio climático, COVID-19, educación ambiental, comunicación, campus verde.

Códigos JEL: I23,I29, I39, Q54.

Introduction

University Social Responsibility (USR) is a comprehensive university management policy that encompasses all its processes. The USR model follows the one adopted worldwide, which understands the university's responsibility for its impacts and is reflected in international standards such as SA8000, AA1000, Global G.A.P. (for agriculture), and SGE 21–Ethical Management System–which require organizations to implement strict controls to ensure good practices (Vallaeys, 2014).

Reiser (2008) defines USR as "a policy of ethical quality in the performance of the university community (students, faculty, and administrative staff) through the responsible management of the educational, cognitive, labor, and environmental impacts generated by the university, in interactive dialogue with society to promote human development."

Many higher education observers have noted changing forces, trends, and challenges in the world. For example, Gibbons (2005) argues that universities today are affected by the new context in which they operate: "globalization, innovation, and the knowledge economy" (p. 124). Currently, climate change is one of the most pressing global environmental problems due to its significant impact on biodiversity and ecosystems, as repeatedly warned (IPCC, 2014). Associated dangers such as the melting of polar ice caps, rising sea levels, increasing temperatures, coastal flooding, wildfires, and droughts underscore the importance of promoting environmental education for climate awareness among current and future generations. The Global Risks Report 2021 ranks the failure of climate action and other environmental risks as the second greatest threat globally, following pandemics (World Economic Forum, 2021).

This calls for increasingly local actions aimed at mitigating and adapting to the impacts of climate change, and contextualizing the 2030 Agenda and the Sustainable Development Goals (SDGs) promoted by the United Nations since 2015 (Velázquez Labrada et al., 2021). Sustainable development means meeting the needs of the present generation without compromising the ability of future generations to meet their own (UN, 1987). An economic and social model in which the well-being of some is guaranteed at the cost of present and future impoverishment of others is therefore "unsustainable." In this sense, among the 17 goals, Goal 4: Quality Education, aims to ensure that all learners acquire the theoretical and practical knowledge needed to promote sustainable development (UN, 2015), including responses to the challenges of climate change through education for sustainable development and sustainable lifestyles. Goal 13: Climate Action seeks to improve education, communication, and human and institutional capacity for mitigation, adaptation, early warning, and reduction of the impacts of climate change.

By mid-century, climate challenges are expected to seriously disrupt daily activities and change the way people live around the world. In fact, many countries are already experiencing the first waves of these challenges, and many organizations are planning for projected risks (e.g., limited access to clean water, expensive and unreliable energy, floods, and natural disasters).

Even before the discovery of infectious agents in the late 19th century, it was known that climate conditions affect epidemic diseases. "The emergence and spread of COVID-19 was not only predictable but predicted [in the sense that] another viral emergence from wildlife would pose a threat to public health," said Professor Andrew Cunningham of the Zoological Society of London. A 2007 study on the 2002-03 SARS outbreak concluded that "the presence of a large reservoir of SARS-CoV-like viruses in bats, combined with the culture of eating exotic mammals in southern China, represented a ticking time bomb." Bill Gates also joined these warnings in a 2015 conference, affirming that "the next big risk of a global catastrophe" would be "a pandemic caused by a highly infectious virus that spreads rapidly worldwide and for which we are not prepared" (Ivanova, 2020).

This is further exacerbated by certain conditions and deficiencies, such as insufficient access to clean drinking water; mass food production; livestock and poultry farms where bacterial and viral mutations occur, creating new diseases; the rapid growth of the global population; uncontrolled expansion of urban areas with little or no sanitation services; uncontrolled deforestation that brings humans closer to pest habitats; insufficient state investment in disease surveillance, prevention, and control; and the lack of public health infrastructure and personnel needed to treat infectious diseases not only in poor and developing countries but also in wealthy nations. Furthermore, globalization and the rise of international travel and transport have become ideal vectors for rapid disease transmission.

The post-COVID-19 world must not aim to return to the "normality" that led us into this health crisis and accelerated climate change. It cannot be the same or even more unequal; and if it is, it will be a grim sign that everyone will lose. Addressing global problems at multiple levels also helps reveal disparities in how different population groups experience these effects. The COVID-19 crisis has once again shown how inequities related to poverty or gender among others, in terms of access to resources, options, and voice lead to a disproportionate burden of vulnerabilities and consequences on specific groups in society. In this sense, the role of university social responsibility is crucial.

Given this, the objective of this article is to analyze university social responsibility as a concept, its growing importance in the holistic formation of students, and to emphasize two aspects of USR that are increasingly impactful in the university's efforts to promote sustainable development and climate action in different regions and countries. These efforts aim to contribute to building a post-COVID-19 future that is more inclusive, greener, and fairer. Through a qualitative social research methodology, various methods and techniques were applied, such as analysis-synthesis, inductive-deductive reasoning, and document analysis, during the processing of bibliographic data related to university social responsibility and climate change. To achieve this goal, the first section analyzes the evolution of the concept of university social responsibility, the second presents the challenges of climate change that demand strengthened USR, and the third explores two USR branches considered as its top priorities: environmental education and communication, and the consolidation of a green campus both within and beyond the university. The article concludes with a brief set of final reflections.

Concept of University Social Responsibility (URS)

Universities have undergone a series of reforms aimed at addressing new challenges: globalization, sustainability, the knowledge society, innovation, and technological development, along with a growing emphasis on market forces as influential factors in shaping the university's identity and organization (Vasilescu et al., 2010).

Universities fulfill their responsibility to educate young people and conduct research (Martí Noguera et al., 2017). However, to these two core missions, a third one has been added: universities' commitment to society (Howard & Sharma, 2006). Today, more and more universities aim to promote and practice USR, and it is becoming one of the priority issues on the Latin American university agenda (Vallaeys, 2016).

However, we must reflect carefully on what University Social Responsibility really means and above all, what changes it implies in the traditional way universities have understood "social outreach and engagement."

The two mains purposes of the university are:

i. Human and professional development (academicista purpose) and

ii. The construction of new knowledge (research purpose), knowing that these two goals are closely interrelated, as it is through faculty research that the university builds the academic content it delivers to students for their formation.

In terms of the impacts generated by the university through its daily operations, these can be grouped into four categories:

a. Organizational functioning impacts: Like any labor organization, the university affects the lives of its administrative, academic, and student personnel (which should be managed through social welfare policies), and it also pollutes the environment (waste, deforestation, vehicle emissions, etc.).

b. Educational impacts: The university has a direct influence on the formation of young people and professionals, on how they understand and interpret the world, behave in it, and what they value. It also influences professional ethics by shaping (consciously or not) the ethical framework of each discipline and its social role (Giuffré & Ratto, 2014).

c. Cognitive and epistemological impacts: The university influences the production of knowledge and technologies and shapes what society recognizes as "Truth, Science, Rationality, Legitimacy, Usefulness, Teaching," etc. It reinforces fragmentation and specialization in knowledge by defining disciplinary boundaries. It mediates the relationship between technoscience and society, enabling social control of science. It may promote scientific elitism and "expertocracy," or alternatively foster the democratization of science. It also influences which issues are prioritized on the scientific research agenda.

d. Social impacts: The university influences society and its economic, social, and political development. It shapes the future by training professionals and leaders, and acts as a social reference point and change agent, promoting progress, creating social capital, and linking student education with real-world issues. In doing so, the university's surrounding society forms a perception of its role and capacity to be a valid interlocutor in solving problems (Lo, Pang & Eqri, 2017).

These four impacts define four axes of socially responsible university management (Vallaeys, 2016):

1. The socially responsible management of the organization itself, particularly its human, material, and environmental resources.

2. The socially responsible management of academic training and teaching.

3. The socially responsible management of research and the epistemological models it promotes.

4. The socially responsible management of participation in sustainable human development of the community.

If USR is a university management strategy, it is

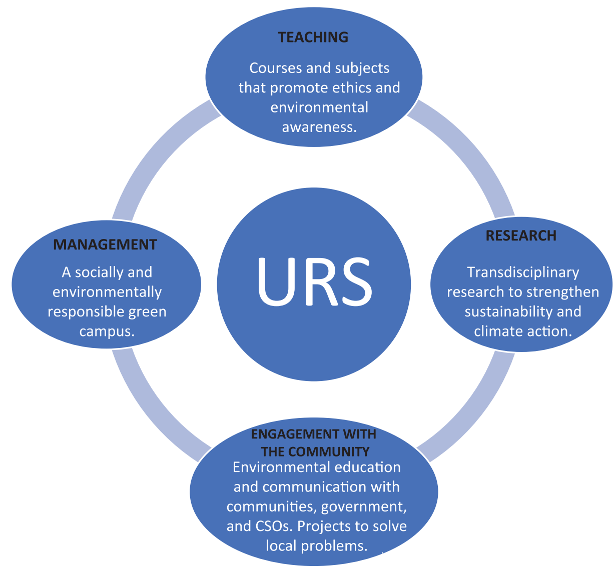

Figure 1. Main areas of USR. Prepared by the authors.

necessary to maintain as much as possible a holistic approach to the university organization itself and to conceive initiatives that are both interdisciplinary (in that they create synergy between various degree programs or academic departments) and intra-institutional (in that they associate several functions of the university institutional structure: administration, teaching, research, and social engagement). In this context, the concept of the green campus and its consolidation is included.

We can mention four challenges that all protagonists of University Social Responsibility initiatives will necessarily face.

a. The challenge of the "return" of the initiative for the benefit of the university: this involves solid work in institutionalization, shared leadership, and internal communication. The question is: To what extent does our social good initiative contribute to the teaching and research work of our university?

b. The challenge of including central administration in the academic dynamics of the university: this requires convincing administrative staff and authorities of their genuine educational role, and ceasing to separate academia and research on one side from organizational management on the other. It demands understanding that "ethics" means caring for the common space and what people do in it, not just delivering nice speeches from the lectern.

c. The challenge of creating learning communities: this implies decentralizing and relocating the teaching-learning process by opening education to new spaces and actors outside classrooms and campus. It is not just about opening the university to society but rethinking pedagogical activity and trusting that non-university actors and non-academic situations can genuinely constitute meaningful learning dynamics for all. Social project-based learning shifts the teacher's role: from instructor to facilitator (Vallaeys, 2016).

d. The challenge of socially managing knowledge: this means realizing the university's fundamental role as an actor for social and economic progress in the "knowledge era." The new technoscientific organization of production and the enormous social impact of science require creating links between specialized scientific activity and civil society to achieve proper social control of science through a knowledge society one where citizens know and can learn continuously and are not victims of social uncommunicability of science. Currently, the university is the most appropriate organization to facilitate these articulations.

However, University Social Responsibility (USR) starts at home because the university is not immune to negative social and environmental impacts. USR is a policy of continuous improvement of university routines toward the effective fulfillment of its social mission through four processes:

1. Ethical and environmental management of the institution to avoid negative impacts;

2. Formation of conscious, innnovate, and supportive citizens;

3. Generation and communication of socially relevant knowledge and learning.

4. Social participation in promoting a more equitable and sustainable development with local actors, fostering the exchange of knowledge and learning.

The specific socially responsible strategies to achieve this improvement are: integrated participation of internal and external stakeholders in the university's mission; articulation of curricula, research, outreach, and teaching methods with solving societal problems; regular institutional self-diagnosis using appropriate measurement tools for continuous improvement; and accountability toward stakeholders.

Challenges of Climate Change

The Intergovernmental Panel on Climate Change (IPCC, 2013) in the report titled Climate Change 2013: The Physical Science Basis describes the very high probability by the end of the 21st century of increased temperatures and more heatwaves over most land areas; increased frequency, intensity, and/or amount of intense precipitation; longer and more intense droughts; increased tropical cyclone activity; and extremely high sea-level rise. Regarding water, the World Resources Institute (2015) provides a global water risk map; with sea level rise, coastal freshwater reserves are expected to become saline, flood risks will increase, and large coastal populations will be displaced. Regarding food production, warmer temperatures threaten crop production as plants need more water while fostering more insect proliferation, increasing rates of vector-borne diseases (IPCC 2014). Food costs and scarcity are expected to rise.

Global climate change presents the most urgent problems for industry, government, and civil society this century (Okereke et al., 2012). Related environmental meta-trends (e.g., reduced access to freshwater and global climate change) threaten to disrupt organizational operations due to reduced resource supply (e.g., inadequate water) and the potential displacement of the workforce and customer base (Shen et al., 2011; Wei & Fang, 2012). Climate change is expected to increase healthcare costs, disrupt access, raise costs for supply chain materials, and alter fiscal structures as the public sector attempts to cope with intensifying weather conditions and its capacity to provide infrastructure and social services support (Allen, 2016). Climate change challenges increase risks for insurers and insurance costs for organizations and individuals (Tucker, 1997; Wei & Fang, 2012). By 2050, economic impacts from extreme events and climate variability are projected to increase financial losses by up to 3.9 times current levels (Preston, 2013).

limate change is linked to carbon emissions, and dependence on fossil fuels is the main driver of rising carbon levels. Between 1854 and 2010, most emissions negatively impacting global temperature rise are attributable to large energy-producing organizations (Heede, 2014; IPCC, 2014). Climate change is also positively associated with electricity consumption, which is expected to increase along with changing climate variability and extreme weather events (McFarland et al., 2015).

When functioning properly, solar radiation passes through our atmosphere, some is trapped, but most is reflected back into space. Increasingly, the accumulation of carbon trapped in our atmosphere hinders solar radiation from reflecting off the earth's surface and escaping our atmosphere. This change effectively allows heat in but reduces its ability to leave. The system is further complicated by the melting of more reflective ice, which allows additional heat absorption in the world's oceans and less solar radiation to be reflected (United Nations Environment Programme, 2013). Scientists worldwide have warned that the consequences for humanity could be very dangerous if global temperature rise is not kept below 2°C.

Awareness of the imminent challenges of climate change and the need to limit fossil fuel use and other carbon emissions were discussed in 2009 at the United Nations Climate Change Conference in Copenhagen. These discussions set the stage for a historic meeting in Paris in winter 2015. Before December 12, 2015, 186 countries published their nationally determined commitments on how they intend to reduce their greenhouse gas (GHG) emissions. "This agreement marks a change in direction toward a new world. It confirms the goal of keeping temperature rise below 2°C... The agreement even sets, for the first time, that we should aim for 1.5°C to protect island states, which are most threatened by sea-level rise" (Open Letter, 2015).

Two functions of University Social Responsibility: role for climate action

Environmental education and communication

Today, environmental problems are no longer independent but interconnected. Therefore, we must study the different social constructs of each culture regarding the environment and explain the roles acquired by the various agents involved in environmental conception and management.

Thus, environmental education, which integrally includes education for climate change, is a social practice in permanent construction aimed at providing values, strategies, and adequate knowledge to each sector of the population, responding to the needs and contingencies of the complex transitions of our time. Environmental education increases citizens' awareness and knowledge of environmental issues or problems (Parsons, 2014).

In doing so, it provides communities and policymakers with tools to make informed decisions and take responsible actions.

The main objectives of environmental education are:

- Awareness to recognize everyday problems;
- Acquisition of knowledge to develop a critical understanding of reality;
- Attitudes to promote social values and greater active participation in environmental protection and improvement;
- Development of capacities to provide the necessary problem-solving skills;
- Evaluation capacity to provide objective assessment of actions performed regarding social, ecological, political, and educational aspects;
- Participation capacity to adopt measures to solve environmental problems (Zabala & García, 2008).

The international community, governments, and citizens are realizing that the technological development that has made life comfortable can be reversed and made impossible. Pollution and conservation, once considered purely environmental issues, have become social problems linked to forms of organization, culture, and human values (Calvo & Gutiérrez, 2007).

Environmental problems humanity has witnessed in recent decades proclaim the limits of the Western civilization project and its development model based on an economic worldview. This signals the deep crisis of capitalism, which has measured its progress only through "quantitative indicators and economic growth" (Sauvé et al., 2008).

Climate change education for sustainable development began being increasingly implemented internationally during the second half of the United

Nations Decade of Education for Sustainable Development, 2005–2014 (Shek et al., 2017). The Sustainable Development Goals (SDGs) adopted by the global community recognize the importance of education in achieving their 2030 targets. The Global Action Programme (GAP) on Education for Sustainable Development (ESD), developed from 2015 to 2019, aimed to generate and expand ESD and accelerate progress toward sustainable development (UNESCO, 2015). Through its Education for Climate Change for Sustainable Development program, UNESCO aims to make climate change education a more central and visible part of the international response to climate change. The program seeks to help people understand the current impact of global warming and increase "climate literacy" among youth (UNESCO, 2010). To do this, it strengthens the capacity of its member states to provide quality climate change education; fosters innovative teaching approaches to integrate climate change education in schools and raise climate awareness; and improves non-formal education programs through communication, networking, and partnerships.

Researchers and professionals must think more broadly about the role of communication. Given the challenges associated with climate change, effective communication is absolutely essential for mobilization; achieving acceptance and reaching consensus on priorities. Therefore, a measure of "consensus and synergy is required across all domains; from the boardroom to the boiler room; and from federal to municipal governments" (Okereke et al. 2012, p. 26). Communication is always present "when issues related to sustainability are conceived, defined, discussed, planned, initiated within and among organizations, modified and, perhaps, terminated… and when various stakeholders engage and react to the initiatives" (Allen, 2016, p. 25). Communication is pragmatic when it educates, alerts, persuades, and helps people implement sustainability initiatives within and across organizations (Cox, 2013; Allen and Craig, 2016). Theories and research exist to guide communicators at all levels in the creation of University Social Responsibility (USR) and its dissemination throughout an organization and within interorganizational collaborations (Allen, 2016).

Communication and awareness must also be developed within universities for employees and faculty. For example, in a study on universities in Spain, Serrate et al. (2019) argue that students do not perceive that their professors are prepared to understand sustainability, and therefore even less to integrate it into classes in a transversal or specific way. Our approach focuses on how communication can be used to change the behavior of a corporate actor so that its operations better respond to key stakeholders in terms of USR and sustainability.

To promote transparency, it is important to generate reports on the medium- and long-term outcomes and plans of USR. These reports provide a mechanism to present the university's values and management model, and to demonstrate its commitment to climate action and sustainability. Going through the reporting process can help universities set and measure goals, understand the social and environmental impacts of their actions, and communicate on economic, environmental, social performance, and management issues. Senior decision-makers can use the information in the report to shape organizational strategy and policy and improve performance. However, evidence suggests that such reports are rarely read within an organization (Mitchell et al., 2012). Therefore, more studies are needed in the future to investigate how management can use the report content to drive true USR or sustainability-related changes.

One of the most powerful tools we possess is our ability to collaborate as we solve problems, plan, implement, evaluate, and redesign in a continuous process. Communication is key to successful collaboration in the areas of climate action and sustainable development (Allen, 2016). However, further research is needed on how successful cross-sector communication can lead to the creation of more resilient communities and more sustainable supply chains.

Green Campus

The importance of promoting a green campus has considerable influence on University Social Responsibility (USR) for a number of reasons. First, it promotes sustainability and climate action within the university area, while increasing efficiency and reducing management costs (Henderson et al., 2017). Second, new technologies are implemented, such as renewable energies, clean transportation, smart buildings, and waste processing, which prove useful within the campus, leading to energy savings, reduced greenhouse gas emissions, and resilience to the impacts of extreme events developments that can later be scaled up in the broader university environment. Third, experimental use is made of new research conducted at the university, driving the development of transdisciplinary research projects related to sustainability and climate change. Fourth, students can empirically observe and participate in the implementation of solutions to climate and environmental issues; in other words, they can see the theoretical knowledge acquired in various courses or research projects applied in practice. Fifth, ethical behavior and environmental values are promoted among students, faculty, and university staff. Sixth, the positive outcomes observed in the green campus serve as examples that can be presented to politicians, decision-makers, investors, and community members to encourage the large-scale implementation of environmentally friendly and climate-action-contributing solutions in the university setting. Seventh, positive practices can be shared and implemented in other universities through the exchange of experiences between national and international institutions.

A Green Campus presents and implements measures mainly for:

• Productivity in the agricultural sector, with the environmentally responsible cultivation and growth of plants and trees, as well as sustainable practices in livestock farming, fisheries, and marine studies.

• Environmentally efficient use of potable and non-potable water on campus.

• Management of solid and non-solid waste to prevent negative impacts on the geology and air quality on campus, which could affect the health of academics and nearby communities.

• Sustainable use of alternative and non-alternative energy. This requires not only applying, practicing, researching, and creating alternatives, but also efficiently using public energy sourced from petroleum-based fuels.

• Mobility and transportation management. Universities should promote the use of sustainable transportation within their institutions through electric vehicles or infrastructure that supports walking and cycling; they should also demand quality public transportation from relevant authorities, as such services are heavily used by large captive audiences for over nine months each year.

• Conferences, concerts, training sessions, and workshops for the community. Most of these measures focus on saving resources, improving health, and addressing the sustainability of planet Earth.

In their study of Canadian universities, Henderson et al. (2017) point out that key institutional policy statements outline several more or less concrete objectives to reduce the total fossil fuel consumption by the institution. Institutions have developed energy plans aimed at reducing total carbon dioxide emissions, including policies that aim to achieve "carbon neutrality" or a "net-zero carbon footprint."

The same study shows that many institutions also included plans related to energy-efficient buildings and changes in transportation systems within their policy statements. In the context of planning, they considered modernization of heating, ventilation, cooling, and lighting systems, as well as energy performance in the construction of new campus buildings and in campus transportation systems (Ibidem).

Conclusions

If there's one thing we must be convinced of, it is that after the pandemic, we cannot continue doing things the same way. It must be an inflection point that does not overlook the social and transformative impact that solidarity and collective cooperation demonstrated by millions of citizens around the worldhave had and can continue to have. Universities, as well as governments, must have learned enough to give appropriate responses to a population whose desire for change will be strengthened when this nightmare ends.

The economic model must change. The political model must change. The energy model must change. The energy transition must be forcefully pushed toward a global energy transformation. The stimulus packages that governments are announcing around the world should not only benefit large corporations but also the disadvantaged masses who need a different system and way of life.

All of the above will help us address social and environmental issues, because even after COVID-19, climate change will remain. In any case, a small light at the end of the tunnel tells us that something good is happening: universities and cities are declaring a climate emergency; citizen organizations, youth, and students around the world are mobilizing against climate change; climate litigation is increasing, and courageous judges are halting misguided policies.

The post-COVID-19 world is not about recovering the "normal" that led us into this health crisis and accelerated climate change. It cannot remain the same, nor unequal; if it does, it will be a bad omen in which we all lose. Addressing global problems at multiple scales also allows us to reveal the disparities in how different population groups experience impacts. The COVID-19 crisis once again reveals how inequities linked to poverty or gender among others, in terms of access to education, opportunities, and voice lead to a disproportionate burden of vulnerabilities and consequences on specific groups in society. In all these tasks, USR has a key role, by communicating knowledge, raising awareness, and collaborating with governments and communities to solve environmental and social problems (often caused by climate change).

Although evidence suggests significant movements toward climate action and sustainable development in universities, they face various obstacles in fulfilling their social role. These include a weak USR culture, lack of internal USR organization within institutions, a weak culture of giving, lack of ethical commitment to development, and the absence of specific USR measures. Today, universities should have assumed their social responsibility, as well as promoted awareness and instilled in individuals the values that make USR a natural behavior and moral obligation for all. This article proposes refocusing USR efforts in light of projected climate challenges, strengthening the role of communication and environmental education in such efforts.

Finally, the university's commitment to its social role requires the incorporation of USR into the institution's mission and vision. The university should ensure internal institutional support for USR by including it in its economic, social, and environmental dimensions within its strategic objectives and plans.

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RESEARCH

Impact assessment of forestry technologies for the humid tropics of Mexico

Evaluación de impacto de tecnologías forestales para el trópico húmedo de México

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Abstract

The purpose of this research was to carry out an impact evaluation, in the humid tropics of Mexico, of the forestry projects and technologies generated at the El Tormento Forest Technology Transfer and Research Center. This was achieved through a longitudinal descriptive research, which covered the period from 1961 to 2007; For this, different types of documents and publications were consulted, interviews were conducted with key informants (researchers and producers); Likewise, different bibliometric indicators were calculated to analyze the scientific productivity of the Center; The information collected was systematized in Excel format and the interviews were analyzed with the statistical package Predictive Analytical Software and Solutions (PASS) version 22. It was identified that 49.8% of the documents corresponding to summaries published in reports and conferences, which facilitated the dissemination the results of forestry research; there is a tendency towards individual publication of the authors, rather than the collaborative one. Most of the projects identified were financed by Fundación Produce Campeche A.C., CONAFOR and INIFAP. 19 technologies were identified for different forest species. 35% of the producers stated that they knew INIFAP and, of them, half had applied INIFAP technology.

Keywords: indicators, forest productivity, tropical species

JEL Codes: O33, O22, Q20

Resumen

El objetivo de este trabajo es el de realizar una evaluación de impacto, en el trópico húmedo de México, de los proyectos y tecnologías forestales generados en el Centro de Investigación y Transferencia de Tecnología Forestal El Tormento. Lo anterior se logró mediante una investigación descriptiva longitudinal, que comprendió el período de 1961 a 2007; para ello se consultaron diferentes tipos de documentos y publicaciones, se realizaron entrevistas con informantes clave (investigadores y productores); asimismo, se calcularon diferentes indicadores bibliométricos para analizar la productividad científica del Centro; la información recabada se sistematizó en formato Excel y la entrevistas fueron analizadas con el paquete estadístico Predictive Analytical Software and Solutions (PASS) versión 22. Se identificó que 49.8% de los documentos correspondieron a resúmenes publicados en memorias y congresos, mismos que facilitaron la difusión de los resultados de la investigación foresta; se observó tendencia a la publicación individual de los autores, más que a la colaborativa. Los proyectos identificados en su mayoría fueron financiados por Fundación Produce Campeche A.C., CONAFOR e INIFAP. Se identificaron 19 tecnologías para diferentes especies forestales. El 35% de los productores manifestó conocer al INIFAP y, de ellos, la mitad ha aplicado la tecnología.

Palabras clave: indicadores, productividad forestal, especies tropicales

Códigos JEL: O33, O22, Q20

Introduction

The analysis and evaluation of results and information derived from any scientific or technological research project in general, and particularly in the agricultural and forestry sector, are necessary for both those involved in it (researchers and beneficiaries), as well as for those who must make decisions regarding it (funding sources or institutional authorities), and for the decision-makers themselves (public policy) (Vázquez et al., 2010).

This evaluation may be carried out at two levels: the first related to the producer and their production unit, which implies measuring the changes resulting from the application of technology, production costs, productivity, profitability, sustainability, and competitiveness, as well as the producer's income. The second level involves measuring the changes in society due to the application of technology, in addition to improvements in the well-being of both consumers and producers (Alston et al., 1995).

Likewise, the evaluation of a research project must be conceived as a process of activities; therefore, depending on the period in which the review is conducted, it may be an ex-ante, process, ex-post, or impact evaluation (Bobadilla et al., 1998; Medianero, 1998; Pérez, 1999; Vásquez et al., 2001). The ex-ante evaluation is carried out before the project is approved and examines its relevance, feasibility, and potential effectiveness; the process evaluation is conducted during the project's execution to monitor the progress of objectives or results in order to improve or identify critical points; the ex-post evaluation is conducted when the project has concluded to determine the degree of objective fulfillment and to demonstrate that the changes produced are the result of the planned activities. In turn, impact evaluation investigates permanent changes as well as improvements in the quality of life of the beneficiaries (Aramburú, 2001; Vélez et al., 2013).

In this regard, one of the primary activities of the Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP), an institution of scientific and technological excellence, is the generation of scientific knowledge and technological innovation in agriculture and forestry in response to the various demands of the sector. This is achieved through the development of research projects in its various experimental fields distributed throughout the country, which address the priorities of agri-industrial chains to contribute to the sustainable rural development of each region.

These projects have occasionally undergone the corresponding evaluations, particularly ex-post and impact evaluations (e.g., Espinoza et al., 2018); however, this aspect of evaluation has not always been fulfilled, which implies a lack of understanding regarding the impact of these projects on science, technological innovation, economic progress in a given entity, the quality of life of its beneficiaries, and the conservation of natural resources.

Among the projects and technologies pending evaluation are those developed at the current Centro de Investigación y Transferencia de Tecnología Forestal (CIyTTF) El Tormento, formerly an INIFAP Experimental Field, which was founded in 1961 with the objective of developing techniques for the management of the forest resources offered by the humid tropical forests of Mexico (Uzcanga et al., 2018). Therefore, the objective of this study is to carry out an impact evaluation, in the humid tropics of Mexico, of the forestry projects and technologies developed at the CIyTTF El Tormento.

Theoretical Development

Impact evaluation: The impact evaluation of scientific or technological research projects must be conducted sometime after their completion; for example, Medianero (1998) recommends that the waiting period to carry out an impact evaluation be five years. On the other hand, Hueso (2007) defines impact as a process that allows understanding the effects of a project or program in relation to the proposed goals and assigned resources. Therefore, this evaluation seeks to validly and reliably verify whether a program or project produced the desired effects on the beneficiaries and whether the cause of such effects is attributable to its implementation. The impacts derived from projects may be:

Scientific: analysis and evaluation of the knowledge resulting from scientific activity, conducted through disciplines known as metrics: bibliometrics, scientometrics, and informetrics (Gorbea, 1994).

Technological: refer to intellectual property, defined as the exclusive proprietary rights granted by the State to individuals or legal entities that carry out inventions, creations, or innovations (Prat, 2009).

Economic: evaluate the effects of research and extension investments on economic, productive, social, and ecological indicators. The main evaluation methods include scoring, cost-benefit analysis, and economic surplus (Vélez et al., 2013).

Social: changes that occur for employees as a result of the use of technological innovations derived from a project, expressed in improvements to the employee's work environment, the sanitary and nutritional quality of the product obtained, the target population's capacities to form or strengthen organizations or support networks, or at the macroeconomic level if the impact provides better opportunities and access to markets for the target population.

Environmental: impacts related to the use of technology aimed at reducing the use of inputs (agrochemicals, energy, natural resources, etc.) and are analyzed based on the quality of environmental components, such as water quality, atmosphere, soil, biodiversity, etc. (Vélez et al., 2013).

CIyTTF El Tormento : The Campo Experimental Forestal El Tormento was established on April 21, 1961, according to the Diario Oficial Tomo CCXLV No. 44, with the objective of developing techniques for the management of forest resources offered by humid tropical forests (Cedeño, 1981). It remained an Experimental Field until 2006, when it became an Experimental Site and functioned as such until the signing of the loan agreement between the Nacional Forestal (CONAFOR), and INIFAP in 2015, to establish Centro de Investigación y Transferencia de Tecnología Forestal "El Tormento". The research work carried out at this site at the time can be grouped into forest plantations, multiple uses, wood industry, and forest management.

For forest plantations, technological packages were developed for the production of species in nurseries, seed orchards, and clonal banks of species such as Gmelina arborea (melina), Tectona grandis (teak), Swietenia macrophylla (mahogany), Cedrela odorata (cedar), Calophyllum brasiliense (barí), Manilkara zapota (sapodilla), and Cordia dodecandra (ziricote); as well as research in forest health, particularly for the control of Hypsipyla grandella. In the case of multiple uses, exploitation models were developed for Chamaedorea elegans (parlor palm), as well as the implementation of agroforestry and silvopastoral models. For the wood industry, studies were carried out to determine the anatomical and physicomechanical characteristics of tropical wood species, wood properties and uses, as well as the determination of pulp quality indices for paper. In the area of forest management, activities included forest inventories, phenological data of 70 species, implementation of Permanent Silvicultural Research Sites (SPIS), analysis of tree diameter dynamics in secondary vegetation and forests, latex production tables for sapodilla, and training for technical groups (Uzcanga et al., 2018).

Methodology

Study area: The CIyTTF El Tormento is located at kilometer 292 of the Escárcega - Villahermosa highway, 8.5 km from the city of Escárcega, Campeche, México; at latitude 18°16´25" N and longitude 90°43´55" W. The climate in the region is tropical, A(w) l´g, according to Köppen's classification as modified by García (1988), with average annual temperatures ranging from 23 to 25°C, maximum temperatures reaching 42°C, and minimums of 4.5°C. The average annual rainfall is 1145 mm, with the highest precipitation occurring from May to October. The predominant soils are rendzina and vertisol (yax´hom and kan´cab), according to the FAO soil classification system.

Research design: The research was descriptive and longitudinal, covering the period from 1961 to 2007, and data collection was carried out using various techniques:

1) Documentary research: Electronic documents of descriptive project files, technological records, forestry publications, and articles were consulted, as well as printed documents and bibliographic collections from the libraries of the Centro de Investigación Regional Sureste del INIFAP, and

a compendium of publications compiled by the authors of this study.

2) Interviews with key informants: Interviews were conducted with active and retired researchers from the forestry area of INIFAP, as well as with producers who benefited from the technology. For this, targeted sampling was carried out in communities involved in any of the projects.

3) Calculation of bibliometric indicators for the analysis of scientific productivity (Machado and Hernández, 2015: pp. 339-340), applying the following indices:

Productivity index, calculated using the natural logarithm of the total number of original documents: IP= log (Td)

Where:

IP= Productivity index

Td= Total number of original documents included in the sample

Associativity index (IA): This indicator was calculated to identify group formation according to productivity. It measures the average number of authors per document within the set of documents under analysis, classifying them as: a) Large (10 or more publications), b) Medium (from two to nine publications), and c) Small (a single publication).

Transiency index: This is expressed as the percentage of transient authors within the analyzed sample. A transient author (AT) is one whose name appears only once in the bibliographic source indexes.

IT= (AT/Ta)* 100 %

Where:

IT= Transiency index

AT= Transient author

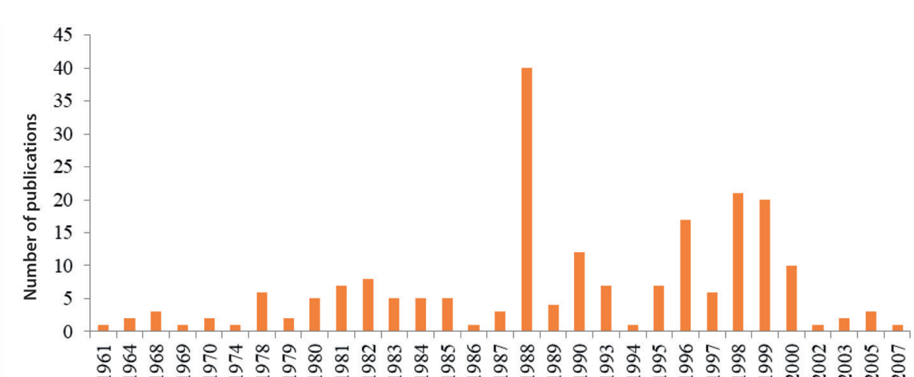
Ta= Total number of authors identified in the sample

Systematization of information: The documentary information was systematized in Excel format, arranged chronologically, and classified by research program and responsible researcher. The technologies were classified by thematic focus, and their benefits were identified. The interviews, both with researchers and producers, were tabulated and entered into an Excel format and analyzed using the Predictive Analytical Software and Solutions (PASS) version 22 (IBM, 2015).

Discussion or argumentation of results

Documentary research and bibliometric indicators :A total of 209 forestry publications from 1961 to 2007 were compiled and classified as follows: 27 journal articles, 15 bulletins, 6 flyers, 17 brochures, 12 technical reports, 1 book, 6 manuals, 1 special publication, 104 compilations and proceedings, as well as 20 theses. In this regard, INIFAP stands out as one of the leading institutions for its contributions to technology transfer, reflected in field guides, brochures, and pamphlets containing practical application information (CONAFOR, 2014). Likewise, it was observed that 1988 marked the period of highest scientific output, with a total of 47 contributions (Figure 1).

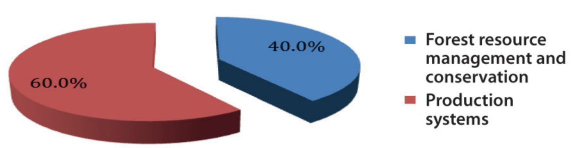
Figure 1. Number of publications analyzed 1961-2007



Out of a total of 92 identified authors, 7.6% were classified as large, 33.7% as medium, and 58.7% as small. Authors in the large category published 10 or more documents, among whom Castillo V., J.C., Gómez T., J., Hernández G., G., Jiménez C., J.M., López T., J.L., Sánchez M., A., and Sarmiento, M. stand out. Overall, a productivity index of 2.3 publications per author was estimated. The associativity index was 0.7, suggesting a stronger tendency toward individual publication rather than collaboration. This trend was also confirmed by the fact that 52.6% of the analyzed documents were published by a single author.

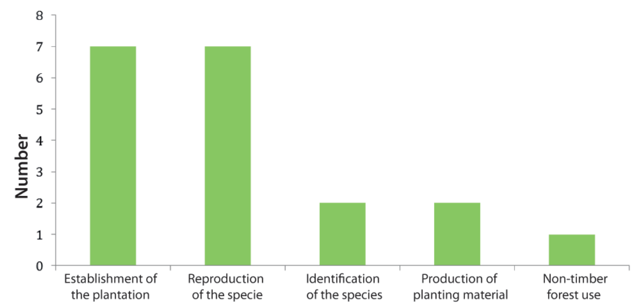
Regarding the projects in operation from 1996 to 2009 linked to the Campo Experimental El Tormento, 10 projects were identified, most of which (80%) were funded by Fundación Produce Campeche A.C., 10% by CONAFOR, and 10% by fiscal funds from INIFAP. Of these, 60% were developed within the production systems program, addressing topics such as forest plantations, genetic resources, the use and exploitation of forest resources, and multiple use. The remaining 40% were classified under the forest resource management and conservation program, dealing with topics related to silviculture and forest planning, commercial plantations, characteristics, and management of forest resources (Figure 2).

Figure 2. Classification of projects by research program



Most of the projects, 70%, were successfully completed, lasted an average of 48.3 months, and were oriented toward the research of various sistemas producto, such as: 40% other forest species, 30% *S. macrophylla*, 20% tropical timber species, and 10% other forest species. Additionally, 19 technologies were identified (Annex 1), among which the most notable topics were the establishment of plantations of *G. arbórea, S. macrophylla*, and *C. odorata*. Other aspects included the reproduction of the species *S. macrophylla, G.arbórea, Delonix regia* (framboyán), *Leuceana sp* (huaxin), *Enterolobium cyclocarpum* (pich), *Piscidia piscipula* (jabín), *Lysilomalatisiliquum* (tzalam), and *Bursera simaruba* (chaká) (Figure 3).

Figure 3. Classification of forestry technologies generated in El Tormento by topic



The development of technology for the control of *H. grandella* in *G. melina*, whose distribution spans tropical zones in México, Central America, and South America—with the exception of Chile (Whitmore, 1978)—was important for México, as this species was introduced in 1971 for the first time at the Campo Experimental El Tormento, from seeds originating in India, plantations in Sierra Leone, Nigeria, and South Africa, and from commercial suppliers in the Netherlands. That same year, four plantations were established to assess its adaptation and behavior. By the third year, they showed fructification, giving rise to a series of research studies on the following topics: species trials, technology, seeds, propagation, plantation establishment, and genetic improvement (Patiño, 1982).

Regarding *S. macrophylla*, in 1990 a seed orchard was established with 25 selected clones originating from the Escárcega, Campeche region, with ten repetitions of each clone, on land belonging to the Campo Experimental El Tormento. Later, in 1996, provenance and progeny trials with *S. macrophylla* and *C. odorata*, established in 1988, were reported, from which genetic parameters were obtained for 36 progenies of both species (Patiño, 1997). Likewise, the review identified that similar studies were carried out on the established orchards of *S. macrophylla* and *C. odorata* in other experimental fields of INIFAP, in order to quantify genetic diversity and relate it to population characteristics, as well as to better understand the reproductive biology of the former species and the biological agents involved, flowering phenology, pollination type, pollinating agent, presence or absence of incompatibility systems, and to determine the fertilization systems and genetic flow occurring among populations and individuals of the species. However, in recent years, the exploitation of these tropical species has shown a downward trend in harvested volumes. In the state of Campeche alone, production decreased from 6,845 cubic meters of roundwood in 1990 to 2,783 in 2012 (SEMARNAT, 2013). Other studies carried out by INIFAP in the field of agroforestry involved collaboration with institutions such as the Centro Internacional de Investigación en Agroforestería (ICRAF), Universidad Autónoma de Yucatán (UADY), El Colegio de la Frontera Sur (ECOSUR), Universidad Autónoma de Quintana Roo, Universidad Autónoma de Chapingo, University of Iowa, United States, and the Ford and Rockefeller Foundations, which funded several projects (Navarro, 1999). These studies aimed to characterize the agroforestry systems of the Yucatán Peninsula and Chiapas, to offer farmers a viable alternative to subsistence. In this regard, studies were carried out to determine farmers' species preferences and to prioritize alternatives, with *S. macrophylla* and *C. odorata* standing out for their high value and interest, which is why they were included in agroforestry processes in the region (Patiño, 1997).

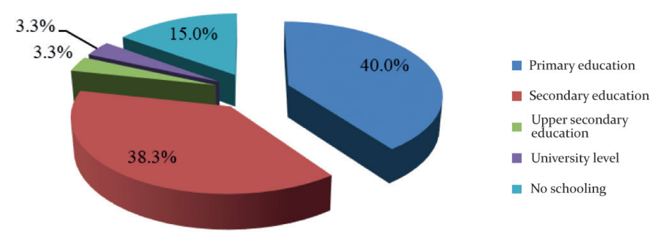
Among the agroforestry timber plantation systems, CONAFOR (2014) refers to the Taungya system in a study on agroforestry systems in México. This system was first used in 1962 at the Campo Experimental El Tormento to establish the first experiment on a four-hectare site with *S. macrophylla, C. odorata*, and corn (Mas and Borja, 1974).

Regarding the impacts of the technologies generated at El Tormento, the current production of *G. melina* is destined for plywood panels, flooring, paneling, and various furniture pieces demanded by the hotel industry. Meanwhile, melina plantations in the state of Campeche, established since 1998, cover 2,000 ha and are mainly located in the Entre Hermanos property, in the municipality of El Carmen, while the industry is located in the municipality of Escárcega, Campeche (CONAFOR, 2013).

Like *G. melina*, the area planted with *T. grandis* has also gradually expanded. Agropecuaria Santa Genoveva S.A. P.I. de C.V. planted approximately 12,374 ha of this species from 2002 to 2014, with a projected annual growth of 1,200 ha, aiming to reach about 20 million trees to be harvested in approximately 18 years, positioning it as the leading teak producer in México (Martínez, 2009).

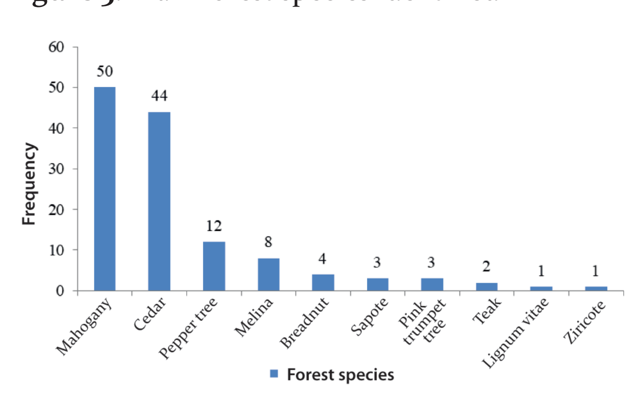
Interviews with key informants: Regarding the beneficiaries of the technologies generated, 66.6% of interviews with forest resource users were conducted in ejidos of the municipality of Calakmul (Nueva Vida, Valentín Gómez Farías, Álvaro Obregón, Heriberto Jara, 20 de Noviembre, El Refugio) and 33.3% in ejidos of the municipality of Escárcega (Haro, Km. 36, and Libertad), for a total of 60 interviews. Most of these producers (40%) had completed primary education, 38.3% had completed secondary education, 15% reported no schooling, 3.3% had completed high school, and 3.3% had a university degree. The estimated average age was 58 years, with 16.6 years of experience in forestry activities (Figure 4).

Figure 4. Education level of forestry producers in the municipalities of Calakmul and Escárcega, Campeche



Regarding the number of hectares established, an average of 5.03 ha per producer was estimated, with plantations approximately 15 years old, and an average density of 608 trees per hectare, where S. macrophylla (39.1%) and C. odorata (34.4%) stood out once again (Figure 5).

Figure 5. Main forest species identified

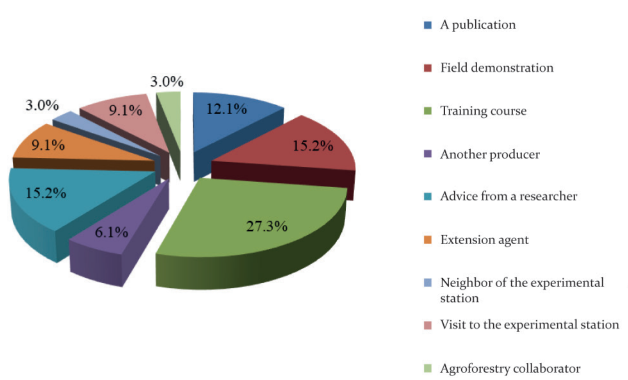


Source: Own elaboration based on research results

Although most of the producers interviewed

(65%) stated that they did not know which institution developed the forestry technology they use, 35% indicated that the technology they use was developed by INIFAP and that they became aware of the institution's work through a training course, a demonstration day, a publication, or technical assistance. The following topics stood out: establishment of agroforestry systems (17.6% of those interviewed), forestry species (29.4%), agricultural species (17.6%), fruit trees (23.5%), planting methods (5.9%), and beekeeping management (5.9%) (Figure 6).

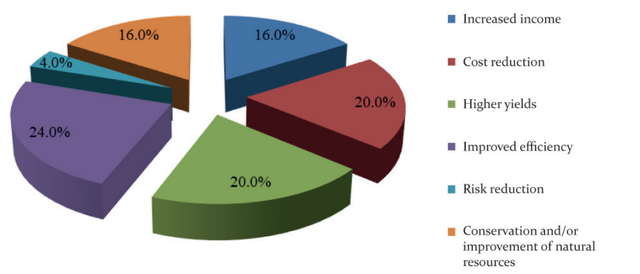
Figure 6. Means by which producers became familiar with INIFAP



The process of technology dissemination is slow, particularly in the forestry sector, due to the time required to evaluate forestry systems. To accelerate dissemination and acceptance, long-term technical assistance is needed. Additionally, the involvement of local individuals, such as technicians, is essential for success and for reducing dissemination costs, as well as for developing local capacities and human resources so that dissemination goes beyond individual projects (CONAFOR, 2014). Nevertheless, the producers stated that the information provided was useful for applying technical criteria, pruning in forestry and citrus crops, soil diagnostics and pest management, crop establishment and planting methods, as well as alternative feeding for bees. Likewise, they reported having applied the technological recommendations at least once, on an average area of 2.5 ha.

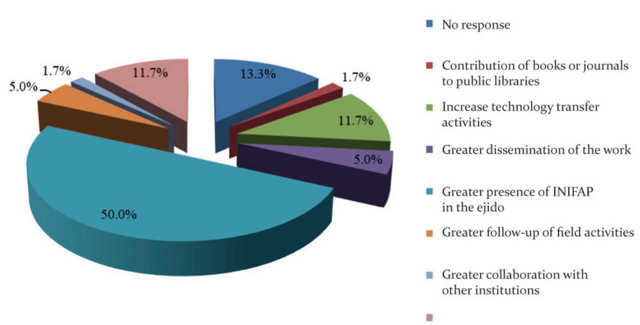
Among the factors limiting the adoption of available technology are the deficient dissemination mechanisms of institutions and the lack of continuity or follow-up in community activities. In general, producers' perception of the benefits of the generated technology highlights improvements in efficiency, cost reduction, and higher yields (Figure 7).

Figure 7. Producers' perception of the benefits of using technology



Finally, some strategies were identified to increase the adoption of technologies generated by INIFAP, among which stand out that dissemination activities and the active presence of researchers in the communities, as well as community involvement, are indispensable for the technology transfer process (Figure 8).

Figure 8. Strategies identified to increase technology adoption



Conclusions

Forty-nine-point eight percent (49.8%) of the analyzed documents corresponded mainly to abstracts published in conference proceedings, and it was observed that this type of event facilitated the dissemination of forestry research results, albeit at a technical level. The trend of the analyzed contributions indicates the authors' preference for individual rather than collaborative publication, as 52.6% of the documents were published by a single author.

Between 1996 and 2009, a total of 10 projects were identified, mostly funded by Fundación Produce Campeche A.C., CONAFOR, and by fiscal funds from INIFAP. Most of these projects focused on topics related to forest plantations, genetic resources, use and exploitation, multiple use, as well as silviculture and forest management, commercial plantations, characteristics, and forest resource management.

Nineteen forestry technologies were identified addressing species such as *C. odorata, S. macrophylla, G. sepium, C. elegans, D. regia, Leucaena sp., E. cyclocarpum, P. piscipula, L. latisiliquum*, and *B. simaruba,* aswell as technologies generated for orchids and agroforestry systems.

Thirty-five percent (35%) of the producers interviewed stated that they were familiar with INIFAP, and of this proportion, just over half had applied technical recommendations at least once, mainly regarding the establishment of forest plantations such as Cedar and Mahogany, as well as crops.

Community presence and work are vital for technology transfer and adoption.

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Appendix 1. List of forestry technologies generated at El Tormento from 1998 to 2009

Technology	Species	Topic	Benefits
		1998	
Fatty acids in Mahogany seed, a limiting factor for its conservation	*S. macrophylla*	Species reproduction	Seed conservation for up to one year in a cold chamber without losing viability, quality, or vigor
Mahogany plant production in nursery	*S. macrophylla*	Production of material for plantations	Production of plants with progenies of good quality
Proposal of signal grass combined with Melina and Mahogany	*G. arbórea* y *S. macrophylla*	Plantation establishment	Integrated pasture management with forestry species as live fences
Melina forest plantations for cellulose production	*G. arbórea*	Plantation establishment	Greater growth compared to other species; pulp has excellent properties for paper production
Melina seed germination	*G. arbórea*	Species reproduction	Germination percentages higher than 90%
Red cedar plantations for sawn timber production	*C. odorata*	Plantation establishment	Wood of this species has various uses: boards, veneer for plywood, furniture, turned articles, cigar boxes, crafts, etc.
Treatments to break dormancy in forest seeds	*D. regia*, *Leucaena* sp, *E. cyclocarpum*, *P. piscipula*, *L. latisiliquum* y *B. simaruba*	Species reproduction	Timely seed germination through hot water scarification to promote germination
Use of organic compost in cedar plant production	*C. odorata*	Production of material for plantations	Improves the physical and chemical properties of the substrate, besides being low cost. Plants showed over 40% superior growth, stem vigor, and greater coverage compared to conventional substrate
		1999	
Spacings with thinning regimes for sawn timber production of *Swietenia macrophylla* (mahogany)	*S. macrophylla*	Plantation establishment	Greater wood production
Quality seed of *Swietenia macrophylla* King (mahogany)	*S. macrophylla*	Species reproduction	Plantation quality control through selection of trees from which seed is collected
Collection, storage, and handling of tropical forest seeds	*C. odorata* y *S. macrophylla*	Species reproduction	Characteristics specific to each species for seed collection: tree height, fruit size, fruit type, dispersal form
Quality seed of *Cedrela Odorata* (Red cedar)	*C. odorata*	Species reproduction	Specifications to guarantee greater genetic viability
Location, identification, and establishment of wild orchids of the State of Campeche	Orquídeas	Species identification	Information for silvicultural planning of ecosystem management and utilization of wild species
Use of Chamaedorea elegans leaf	*C. elegans*	Non-timber forest use	Species valued in national and international markets as floral decoration
Technologies for clearing, chopping, and sowing	Sistemas agroforestales	Plantation establishment	Alternative for sustainable management of cultivation areas to reduce slash-and-burn practices
Management and establishment of live fences	*G. sepium* y *B. simaruba*	Plantation establishment	Provides shade for livestock, post rehabilitation for fences, forage, extraction of energy products such as firewood or charcoal, windbreak, helps reduce extraction of posts from the forest
		2009	
Collection and handling of *Cedrella ordorata L.* (Red cedar)	*C. odorata*	Species reproduction	Selection of seed with better genetic quality for commercialization, as well as to promote and conserve in situ and ex situ the genetic resource of the species