Formulation of Business Strategies to Strengthen the Competitiveness of Small-Scale Coal Mining in the Municipalities of Tópaga and Gámeza, Boyacá

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ABSTRACT
Small-scale coal mining in Tópaga and Gámeza (Boyacá) represents an essential component of the rural socio-economic fabric, although its development is compromised by marked technological and structural deficiencies. Through the analysis of 151 mining titles and a detailed characterization of 33 production units, critical factors limiting their sustainability were identified, notably the lack of administrative frameworks and a low financial culture that leads to operational vulnerability. The findings were categorized into four dimensions, economic, institutional, technological, and environmental, whose interrelation explains the low productivity levels recorded. Consequently, this study formulates business strengthening and innovation strategies aimed at evolving from a subsistence model toward formal competitiveness. By establishing key strategies, an integral intervention is proposed to achieve technical efficiency, occupational safety, and environmental responsibility, thereby consolidating a solid pillar for territorial development in the region.
KEYBOARD: business strategies, competitiveness, coal mining, Boyacá.

1. INTRODUCTION

The coal industry in the Colombian economy goes beyond the mere production of raw materials, it stands as a socio-technical axis representing a substantial source of employment, income and local productive dynamics (León, 2016). In the department of Boyacá, specifically in the municipalities of Tópaga and Gámeza, small-scale mining is the main driver of rural employment, however, this relevance has not been proportional to its institutional development (Corredor Agamez., et al 2024). Despite the efforts of entities such as the National Mining Agency (ANM) to advance in titling and regulatory processes, small-scale mining in these municipalities is not yet a competitive sector, derived from technical deficiencies and occupational risks that compromise its sustainability (Vargas, et al., 2024), leaving small producers in a state of structural vulnerability (Martínez Bernal, 2013).

Currently, competitiveness in the sector is no longer limited to basic operational efficiency, authors such as Rodríguez (2019) and Vásquez (2019) argue that the viability of the industry depends on an inseparable triad: innovation, environmental sustainability, and operational governance. However, the literature reports a variety of research on

issues related to occupational risks and environmental impacts in underground mining in Colombia, leaving aside a systemic vision that integrates human capital management, administrative formalization and productive efficiency, the central problem lies in the fact that the small producer of Tópaga and Gámeza operates under a subsistence logic that, although historically resilient, it is insufficient to face the standards of a globalized environment and the current demanding safety regulations (Manrique, 2020), Martínez Bernal (2013), reports significant gaps in business management, access to technology and market knowledge, in the mining district of northern Boyacá and also shows that the productive units face weaknesses in operational efficiency. access to capital and organizational capabilities, which limits their business competitiveness.

Under this premise, this study aims to formulate business strategies that contribute to the strengthening of small-scale coal mining in Tópaga and Gámeza, through an exhaustive analysis of the current state of these units, marked by technological precariousness and organizational gaps, this research seeks to design a management model that harmonizes productivity with sustainability and current legal regulations. allowing the transition of the sector towards an organized and competitive regional development model.

2. THEORETICAL FRAMEWORK AND METHODOLOGY

2.1. Theoretical Framework

Strategy and Organizational Management

Business strategy is defined as the set of plans and actions articulated to obtain a long-term sustainable competitive advantage (Ramírez Molina, et al., 2021), in this context, business management acts as the operational vehicle that optimizes resources through planning, organization, direction and control processes (Martínez, 2013), effective management allows the company not only to survive, but also to survive. but thrive in a competitive and constantly changing environment (González Marín, 2024). In addition to this, Rubio Domínguez (2006) states that organizational efficiency depends on the manager's ability to quantify progress and project the institution towards its external environment, in addition to proposing the roles proposed by Luther Gulick to achieve organizational efficiency: Plan, Organize, and Control

Strategic management

Strategic management integrates various functional areas, finance, production, marketing, and R+D, to respond to market fluctuations in order to achieve a competitive advantage (Zapata, et al., 2016). This cyclical process of formulation and evaluation seeks not only economic viability, but also the generation of profits above the industry average (González Marín, 2024), this implies looking both outside and inside companies to generate goals, objectives, and strategies which must be constantly monitored.

Diagnosis and Business Environment

Organizational diagnosis is the preliminary analytical phase of strategic planning, it allows the identification of the internal architecture (strengths and weaknesses) and exogenous variables (opportunities and threats) that condition performance (Correa, 2021).

In this process, mere operational identification is transcended, constituting an in-depth audit of the corporate culture, this tool allows the evaluation of critical dimensions such as market and customer orientation, as well as the focus on process optimization and the achievement of results (Acosta & Loaiza, 2025). By decoding these cultural patterns,

senior management can align human behavior with strategic objectives, for a technical and rigorous execution of this analysis, the management literature highlights the use of two complementary methodological frameworks:

- SWOT Matrix: It facilitates an introspective examination of internal capabilities (strengths and weaknesses) in contrast to external reality (opportunities and threats), allowing the formulation of reactive and proactive strategies (Vistrain Díaz & Patrón González, 2025), becoming a key tool for decision-making that evaluates distinctive capabilities in the face of resistance to change or risks in the environment (Poveda, et al., 2024).
- PEST Analysis: It focuses on the scrutiny of the macro-environmental factors (Political, Economic, Sociocultural and Technological) that condition the viability and competitiveness of the organization in its sector, this tool is essential for risk control and the alignment of business models in sectors of high uncertainty, such as extractives. (Thompson & Strickland, 2004).

Context of Mining Activity in Colombia

Colombia's mineral wealth has evolved from a colonial exploitation of precious metals to a diversified industry that, after the industrialization of the twentieth century, incorporated coal, nickel, and steel (Cuartas, 1994). Although the armed conflict limited growth at the end of the twentieth century, the first decade of the twenty-first century marked an unprecedented boom with the awarding of thousands of mining titles and foreign investment that exceeded USD $11,900 million (Ronderos, 2011; Amaya Vargas, 2018), this derived from the climatic and operational problems faced by the main coal exporters China, Australia, and South Africa, which positioned Colombia at that time as a substitute supplier of this mineral (Figueroa Becerra, 2008). . This phenomenon boosted prices, specifically coal, which reached $160 USD per ton in 2010, and consolidated Colombia as a leading producer worldwide. To regulate this expansion, the State implemented legal frameworks such as Law 141 for the collection of royalties, which exceeded 10 billion pesos, projecting the sector as an axis of long-term sustainable economic growth (Martínez, 2013; Plazas Díaz, 2016; Benítez Ibagué, 2013).

Thus, mining economic activity in Colombia has transitioned from artisanal exploitation to a phase of intensive foreign investment, especially in coal, where the country is among the top ten world producers (Arenas, et al., 2015), however, this growth has generated tensions between economic profitability and socio-environmental impact (Amaya, 2018; Pérez & Betancur, 2016).

According to the Ministry of Mines and Energy (2003), mining is classified according to its legal status and scale:

- Formal/Legal: Protected by mining titles and accounting records.
- Informal/Subsistence: Developed by natural persons with rudimentary methods for survival income.
- Illegal: Exploitation without mining title, outside the regulations in force.

2.2 Methodology

A qualitative line of research was considered in which the factors that are considered as the main sources of incidence in terms of socioeconomic impact of coal producing

companies in the municipalities of Tópaga and Gámeza, in Boyacá, were described and characterized.

The selected population were companies dedicated to the underground exploitation of coal with mining title, environmental license and environmental management plan, located in the municipalities of Tópaga and Gámeza, for which according to the national mining agency 91 companies are reported in Tópaga and 50 in Gámeza. The research was limited to a sample of 33 companies, due to their availability in the study.

3. RESULTS

In the first instance, it was analyzed on the Anaminera platform how many mining titles existed in the departments of Tópaga and Gámeza that met the formality requirements, that is, companies that are holders of mining titles and that have their environmental license in force, Additionally, another filter was established, based on Decree 1666 of 2016, which establishes that in order to consider a company as a small mining, it must produce at least 2400 tons per year or 200 tons per month and that the mine must be located in an area less than or equal to 150 hectares. This is how 151 mining titles were identified, 60 in Gámeza and 91 in Tópaga, which will be the object of analysis for the development of the investigation.

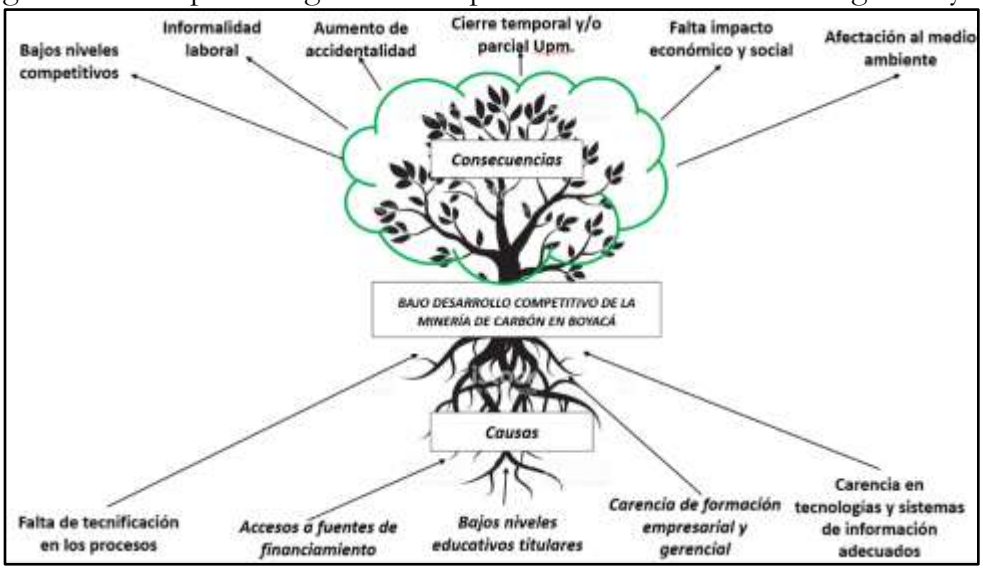
As a result of the analysis of the current state of the production mode of the sample companies, it is identified that they contribute 2% of the country's total production in terms of coal extraction, registering 54500 tons of production by 2024. Regarding the methods of commercialization of coal, it was identified that small miners usually have only one customer for the sale of their coal or, failing that, they sell to the owners of the means of transport and these in turn take larger customers as in the case of the department of Boyacá Termopaipa. or collection centers that become as such the great distributors of this mineral.

The low production recorded can be attributed to different factors that were found from the business analysis, the first of these is the lack of organizational structure, this is mainly attributed to the fact that most companies are led by individuals who have a basic degree of schooling and do not have sufficient knowledge to make a defined structure that can guarantee the correct functioning of a company. The second factor identified is the lack of financial education, a factor that goes hand in hand with the previous one, these companies, by not having trained people, consequently do not have an investment vision, do not have clear concepts about cash flow, about controlling the inflows and outflows of money and do not see the need to have savings or reinvest to generate a greater flow of money.

The lack of technological investment is another factor that directly affects the low production of the mines in the department of Boyacá, it is reported that 70% of mining is carried out in an artisanal way, without automation in processes, picks and shovels are mainly used, and as a means of transport wheelbarrows or wagon units on rails and even winches are still used. In addition to this factor, there is another very important one which is the lack of hiring or hiring professionals, it is very rooted in these small mining companies the fact of hiring technicians or technologists from the National Learning Service of Colombia (SENA), the importance of having mining engineers, geologists, environmental engineers, lawyers and administrators for the management of companies, which means that artisanal mining continues to be the best option for them.

The last factor identified is the lack of industrial safety, this factor is perhaps the one that generates the most implications, since the absence or non-compliance with industrial safety measures brings with it very negative effects such as occupational accidents (falls, blows, entrapments and burns) and occupational diseases (Morales, 2017), which is generated by not having a safety and hygiene structure at work and lack of training of personnel. All these implications have brought quite significant consequences such as economic losses to the owners of mining titles, legal effects since sanctions are generated for non-compliance with safety regulations at work, deterioration of the work environment since people see that they are not safeguarded under a system that protects them, reduce their commitment, in addition, a negative image of customers is created. Figure 1 presents a descriptive diagram of the problems identified in mining in Boyacá.

Figure 1. Descriptive diagram of the problems identified in mining in Boyacá.



Source: Own elaboration

As a result of the identification of factors that limit the competitiveness and sustainability of small-scale mining, 4 dimensions were identified by which coal miners are affected in Tópaga and Gámeza, the first of them, the economic dimension in which a lack of access to formal financing is detected, since it is identified that most of these companies act with their own capital or even with informal lenders, which makes that all costs rise in uncompetitive figures, in the same way under this same approach, too unfavorable unit costs are reported, mainly in transportation and processing, which reduces the profit margin. The next dimension identified is the regulations, legal or institutional in this, the main axes of incidence are bureaucracy and very expensive and slow requirements for small-scale mining, as well as the absence of initiatives that promote competitiveness in the sector such as, for example, training days, incentives, technical assistance or investment funds of immediate access.

The third dimension is technological, in which limiting factors for mining are detected, such as low technification and the use of inefficient equipment or machinery, which reduces productivity and increases risks, as well as limitations in waste management processes, water treatment and tailings costs. And finally, there is the environmental dimension which causes negative impacts to the entire department since it generates water pollution, soil degradation, deforestation and inadequate management of tailings that affect territorial sustainability, this due to the high costs in environmental impact

studies and the lack of accompaniment and financing from the government for help in environmental closure plans. in processes of formalization and energy transition.

The comprehensive diagnosis carried out in the municipalities of Tópaga and Gámeza allows us to conclude that small-scale coal mining in Boyacá faces critical structural barriers that limit its competitiveness and sustainability, factors such as technological precariousness, lack of financial culture and the absence of robust industrial safety frameworks have configured a scenario of low productivity and high operational vulnerability. That is why 4 strategies have been designed to propose solutions aimed at strengthening the sector and its alignment with national quality standards. The first focused on the promotion of mining formalization, For this it is proposed to create a regional mining one-stop shop that goes hand in hand with the national mining agency, mayors and autonomous corporations in order to speed up procedures, costs and formalization times, in the same way the creation of a formalization scheme is proposed in a progressive way, with compliance with goals and that in conjunction with this, tax incentives are created for companies that comply and finally the implementation of a comprehensive technical assistance program for the two municipalities in legal, environmental, occupational health and safety and regulatory issues is considered important.

The second strategy is focused on business strengthening and administrative management, training is proposed in topics such as production costs, accounting, negotiation, project management and marketing, for this, it is proposed to rely on government entities such as SENA, universities in the region such as the Pedagogical and Technological University of Colombia, the chamber of commerce and the environmental corporations of the department, this with the aim of developing individual business plans that are oriented towards improving profitability and projecting better investments in small-scale mining. To achieve this strategy, a model of associativity between companies is also proposed, in order to standardize prices, buy shares, obtain better prices in equipment maintenance and contribute to the synergy of the sector in the region.

The third strategy is aimed at technological innovation and productive efficiency, for this it is proposed the creation of a regional mining innovation center that acts as a miner's office where companies can access technological demonstrations, technical assistance and pilot tests of new tools, in the same way training in preventive maintenance programs is proposed to reduce failures, accidents or downtime in production and finally seek foreign investment alternatives through associativity to improve technological aspects that have been detected as points that negatively affect the activity such as ventilation systems, extraction equipment and gas monitoring tools.

The fourth strategy is based on environmental and social sustainability, for this it is proposed to execute environmental management plans adapted to the reality of small-scale mining in Boyacá where solutions are provided in terms of water management, emissions, waste, landscape changes and recovery, which are viable for the execution of the companies. In the same way, the formalization of a training program in environmental education is proposed and hand in hand with government entities to develop mining restoration and recovery programs.

The last strategy is focused on marketing and productive chains, for this the creation of a joint collection and marketing center is proposed with the aim of achieving better negotiation conditions and reducing unit costs such as transportation and logistics, in the same way the establishment of alliances with industries that demand regional coal is proposed. such as thermoelectric, cement or lime kilns in order to ensure the sale of coal

and fair prices for all companies, this can be done in coordination with companies with agents such as the State and academia and finally maintain quality control programs in processes of benefit and transformation in order to guarantee the confidence of buyers.

CONCLUSIONS

Supporting small-scale coal mining in Boyacá, specifically in Tópaga and Gámeza, involves transforming a traditional activity into an efficient, legal and profitable business model, by integrating modern management schemes, technical training and formal financing channels, these mining units not only raise their competitive level in the market, but also consolidate themselves as sources of stable employment and well-being for their communities. This advance towards business maturity is the only way to guarantee operations that balance industrial safety with environmental responsibility, allowing the sector to adopt clean technologies and comply with current regulations, achieving organizational strengthening and ensuring that coal extraction ceases to be a subsistence task and becomes a pillar of sustainable and forward-looking territorial development.

BIBLIOGRAPHY

- León, N. R. (2016). Study of the competitive dynamics of the coal subsector in Colombia, applying the Systemic Competitiveness model of the German Development Institute (GDI). [Master's thesis, Universidad Nacional de Colombia], Institutional Repository: https://repositorio.unal.edu.co/handle/unal/57190.

- Corredor Agamez, M, Huertas Angulo, J and Giraldo Ocampo, J. (2024). Elements that add value to mining-environmental consultancies in the Carbonero de Tópaga sector Boyacá. [Specialization thesis, EAN University], Institutional Repository: http://hdl.handle.net/10882/13975.
- Martínez Bernal, M. S. (2013). Determination of the productivity and competitiveness of small-scale mining in the mining district of northern Boyacá. Journal of Research, Development and Innovation, 3(2), 72-86.
- Rodríguez, C. A. (2019). Strategic management and operational efficiency in small-scale mining in emerging economy contexts. [Master's thesis, Pontificia Universidad Católica del Ecuador], Institutional Repository: https://repositorio.puce.edu.ec/server/api/core/bitstreams/0ef7e028-d967-4762-9018-994683ca4f44/content.
- Vásquez Quispe, J. R. (2019). Proposal of intervention strategies of a mining company for the business sustainability of its local suppliers. [Master's thesis, Universidad Peruana de Ciencias Aplicadas], Institutional Repository: https://repositorioacademico.upc.edu.pe/bitstream/handle/10757/625631/VasquezQ_J.pdf?sequence=4&isAllowed=y
- Manrique, R. A. (2020). Characterization of the current state of mining in the municipality of Paipa (Boyacá) and its relationship with the Sochagota Integrated Management District (DMI). [Research project, National Open and Distance University]. Institutional Repository: https://repository.unad.edu.co/handle/10596/36852

- Vargas, M. C. O., Rincón, E. C., Forero, G. A. P., Delgado, S. F. S., & Mendoza, O. T. A. (2024). NATIONAL MINING DEVELOPMENT PLAN 2024–2035 PHASE III. Available in: https://www1.upme.gov.co/simco/PlaneacionSector/Documents/Fase_III_Plan_Nacional_de_Desarrollo_Minero_2024_2035.pdf
- Ramírez Molina, R, Ríos-Pérez, J, Lay Raby, N, Ramírez Molina, R and Ramírez Molina, R. (2021). Business strategies and value chain in sustainable markets: a theoretical review. . Corporación Universidad de la Costa. Available at: https://hdl.handle.net/11323/8929.
- Martínez, A. (2013). Study on the socioeconomic impacts of the mining sector in Colombia: sectoral chains. Association of the Large-Scale Mining Sector, Bogotá.
- Rubio Domínguez, P. (2006). Introduction to business management. European Institute of Business Management.
- Zapata, L. F. B., Pérez, I. A. P., and Taboada, F. H. (2013). Strategic management of the company's functional areas: an international competitive perspective. Journal of Research, Development and Innovation: RIDI, 4(1), 56-68.
- González Marín, Y. O. (2024). Management skills for the development of organizational knowledge management. [PhD thesis, Polytechnic University of Valencia]. Institutional Repository: https://riunet.upv.es/handle/10251/201577
- Correa Aguilera, J (2021). Organizational diagnosis and strategic plan in the Management of Rural and Urban Development, Provincial Municipality of Tumbes – 2019. [Master's thesis, National University of Tumbes], Institutional Repository: https://repositorio.untumbes.edu.pe/server/api/core/bitstreams/7e042168-d19e-4544-a225-b0f1aae2bd75/content
- Acosta, D. A. & Loaiza, J. (2025). Evaluation and adaptation of operational and cultural diagnostic tools in Colombian companies. [Master's thesis, National Open and Distance University]. Institutional Repository: https://repository.unad.edu.co/handle/10596/77859
- Vistrain Díaz, S. A., & Patrón González, E. (2025). Strategic SWOT: A Fundamental Tool for Strategic Planning in the Modern Business Environment. Revista Veritas de Difusão Científica, 6(2), 5601–5628. https://doi.org/10.61616/rvdc.v6i2.903.
- Poveda, M. L. P., Velepucha, G. S. A., Yagual, A. A. V., & Parrales, J. V. F. (2024). Classic models in the development of strategic planning. Multidisciplinary Peer-Reviewed Journal of Accounting Sciences, Auditing and Taxation: CORPORATUM 360-ISSN: 2737-6443., 7(13), 145-163.
- Thompson, A., & Strickland, A. (2004). Strategic Management: Concepts and Cases (13th ed.). McGraw-Hill.
- Arenas, J. A. C., Cardona, C. A. P., Gomez, F. H. G., & Guevara, J. E. R. (2015). Development of Competitive Strategies for the Coal Industry in Norte de Santander. ESPACIOS Magazine| Vol. 36 (No. 15) Year 2015.
- Amaya Vargas, A. P. (2018). Analysis of the sources of digital geographic information on the subject of mining in Colombia. [Master's thesis, Francisco José de Caldas District University]. Institutional Repository: https://repository.udistrital.edu.co/items/2664b93e-9f88-44e0-ad3a-8dc91e06aaf4

- Pérez, M. M & Betancur, A. (2016). Impacts caused by the development of mining activity on the natural environment and current situation in Colombia. Revista Sociedad y ambiente, (10), 95-112.
- Cuartas, R. C. (1994). Bibliography of Colombian mining history: balance and perspectives. Revista Historia y sociedad, (1), 27-55.
- Ronderos, M. T. (2011). Mining fever took hold of Colombia. Revista semana, 6, 246055-3.
- Plazas Díaz, F. A. (2016). Analysis of the evolution of foreign direct investment in the coal mining sector in Colombia from 2004 to 2013. Apuntes del CENES, 35(61), 51-84.
- Benítez Ibagué, N. Y. (2013). Characterization of the new general system of royalties and its fiscal effect in the municipalities of the sixth category of the department of Boyacá, Colombia. Finance and Economic Policy Journal, 5(1), 151-178.
- ANM, 2013. National Mineral Production 2013. In http://www.anm.gov.co/?q=regalias-contraprestaciones-econo
- Figueroa Becerra, D. (2008). The behavior of coal export prices 1985-2005. [Undergraduate thesis, Universidad Autónoma de Occidente] Institutional Repository: http://hdl.handle.net/10614/5638.
- Ministry of Mines and Energy. (2016, October 21). Decree 1666 of 2016. By which the Single Regulatory Decree of the Administrative Sector of Mines and Energy, 1073 of 2015, related to mining classification, is added. Official Gazette No. 50.034. https://www.funcionpublica.gov.co/eva/gestornormativo/norma.php?i=77883
- Morales, J. I. (2017). Legal Risks in Colombia for Non-Compliance with Occupational Health and Safety Standards in Coal Mining. [Specialization thesis, Francisco José de Caldas District University]. Institutional Repository http://hdl.handle.net/11349/7430