

CAPÍTULO 35

MINERAL PRODUCTION CLUSTERS EVALUATION THROUGH THE SUSTAINABILITY MATRIX

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ABSTRACT

Production clusters are well-located economic and geographic areas where a specific production chain is in operation and involves a variety of local enterprises (industrial, trade, services). Brazil released a public policy to incentive and build production clusters and, amongst them, the mineral branch. The sustainability matrix, as described in this papers, is a simple tool applied by the authors to provide a quick qualitative diagnosis of mineral clusters in order to check how the sustainability aspects (social, environmental, institutional and economical) are influenced by some of the most essential variables which controls the mineral activity, as for example: workers and managers skills, minerals prices, natural resource availability, banking loans, etc. This paper presents the obtained results from a given natural stone production cluster, thus exemplifying the usefulness of the sustainability matrix as a tool for checking public policies and threats to sustainability caused by production variables, among others.

INTRODUCTION

As pointed out by BRUNDTLAND [1] in her already classical book, a commitment to sustainable development means integration of policies and development strategies so as to satisfy current and future human needs, improve the quality of life, and protect the environment upon which we depend for life support services.

As for minerals resources there is a still open discussion on the degree to which they fit in, since not renewable. Notwithstanding, mineral resources are an integral part of any developed and modern industrial society. Thus, how to achieve a sustainable future, without the services they provide!

Again, BRUNDTLAND brings the answer to this: they need not to be renewable, in the sense that the biological systems are, to be sustainable. Or, lets put as this, several renewable species just vanished away, for one or the other reason, while no one single non-renewable has done so!

However, societies need to be able to track progress toward their sustainability goals, via some sort of indicators. In this way, Agenda 21 laid out actions to forward the goal of

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sustainability including a call for the development of indicators of sustainable development that could provide a basis for stages of the policy cycle, including decision making at all levels.

Indicators and indices package complex mineral information into understandable forms for stakeholders, decision makers and public use [2]. These mineral indicators must be useful as analytical, explanatory, communication, planning and performance assessment tools. Indicators help people understand the complexities associated with mineral resource management policy decisions, such as the interconnectedness of physical and environmental systems and the inevitability of making tradeoffs among conflicting management policy objectives [3]. Thus, the information contained in indicators can contribute to public understanding of the state of the world and the potential consequences of fulfilling various objectives, i.e., they can facilitate social learning [4].

Process democracy is one of the most important cornerstones of sustainability and so, as important as is the set of indicators, the process of creating, implementing and monitoring the set of indicators is crucial [idem]. There are many possible processes for defining indicators for various sectors on different scales; recommendations and even requirements for the group defining the indicator set are similar. The conditions are: (a) shared ownership of process, (b) fair decision-making processes, (c) transparency and accountability, (d) adequate participation and representation, (e) a mechanism for future revision, (f) clear grievance procedure, (g) clear structure, and (h) audit ability [5].

Initiatives within the Canada, the European Union, Latin America, the United Kingdom, and the United States, among others, have made substantial progress in creating sets of meaningful sustainable development indicators for. Each process has been unique with regard to its background, methods, and goals, and the indicators for each reflect these differences. This is to be expected for several reasons. First, sustainability is a value-based concept [6]. Values are an expression of culture, history, experience, environment and geography, and necessarily differ across societies. People measure what they want to sustain; sustain those things they believe are important; and decide what is important based on their values. Second, sustainability is a working concept, a process that focuses attention on existing social-environmental-economic realities and geopolitical constraints that are inherently different across societies and geopolitical regions of the globe. Finally, practical issues of data availability and collection costs necessarily drive the selection of indicators.

BRAZILIAN POLICY TOWARDS ARTISANAL AND SMALL SCALE MINING CLUSTERS

In Brazil, as in all Latin America, artisan and small-scale mining–ASSM, are mostly oriented towards high value minerals, gems and metals. Industrial minerals are receiving an increasing attention, lately. Amongst the 2,367 total mines that hold legal tenures in Brazil 1,706 (72.8 %) are small-scale operations [7]. Policy makers nowadays are closely following the overall contribution of ASSM to the Brazilian mineral economy due to the positive effects they bring on income distribution amongst poor communities. On the other hand, the generated social and environmental impacts are of great concerns, not only to the policy makers and government officials but also to the general Brazilian society.

Although difficulties still prevail, a major shift is in process and first results can be detected in many places of the country. The background conditions that pushed the federal and some regional governments to establish a more adequate relationship with ASSM are:

- A strong commitment of the present Federal Government to poverty alleviation and job generation;
- Natural and mineral resources weight considerably for a positive external trade balance
- Micro and small enterprises are playing an increasing role in the economy of the country.
- New ASSM are activities, such as dimension and ornamental stones, are raising at high rates and spreading throughout the country

As a response to these facts a new industrial policy was set, by the Federal Government, in March 2004 which contains, definitions and tools to render possible strong support to small and medium enterprises, in general, specially those located on the defined production clusters. The classical Porter's definition of an industrial or production cluster [8] was slightly changed to render it more suitable to Brazilian SME's conditions.

For the mineral sector, the possibility to promote ASSM was quite positive since new funds were proposed and created. Also, with the help of government and/or NGOs many mining communities might, from now on, change their ways of organization and production to reach better technical, market and socio- environmental standards. Another important fact was the renaming of such mineral sites: before this new policy, almost all of them were named "*garimpos*", which bears an undesirable informality and even lack of law enforcement. Many of them are now recognized as "mineral-based local clusters".

Mineral-based local clusters (apls)²

Such mentioned new industrial policy, known as PITCE₃, determines the objectives and policy tools to enhance SME competitive conditions, especially for those located on predefined clusters sites. A governmental working group defines the sites where such clusters could be developed and/or enhanced. Four hundred sites were found suitable, where at least one of the working group agencies was developing some previous supporting activity.

There are clusters in almost all industrial sectors of the economy and many features such as size and number of enterprises or level of technological development can define them. Not only the Federal Government and its SME Support Agency, SEBRAE, are undertaking special programs, but many local state governments now have their own policies and activities for APL implementation.

Even before the new policy, the Brazilian Ministry of Mines and Energy has had a specific study on mineral clusters and selected 200 small-scale mining sites. Twenty-nine were considered as having good or very good conditions to improve their situations and raise their

² APL or *arranjos produtivos locais* are the economic clusters in the Brazilian policy definition (for details see www.redesist.ie.ufrj.br)

³ External trade, technology and industrial policy - PITCE

local communities' social and economical benefits. Figure 1 shows the location of some clusters included in the selected twenty-nine.

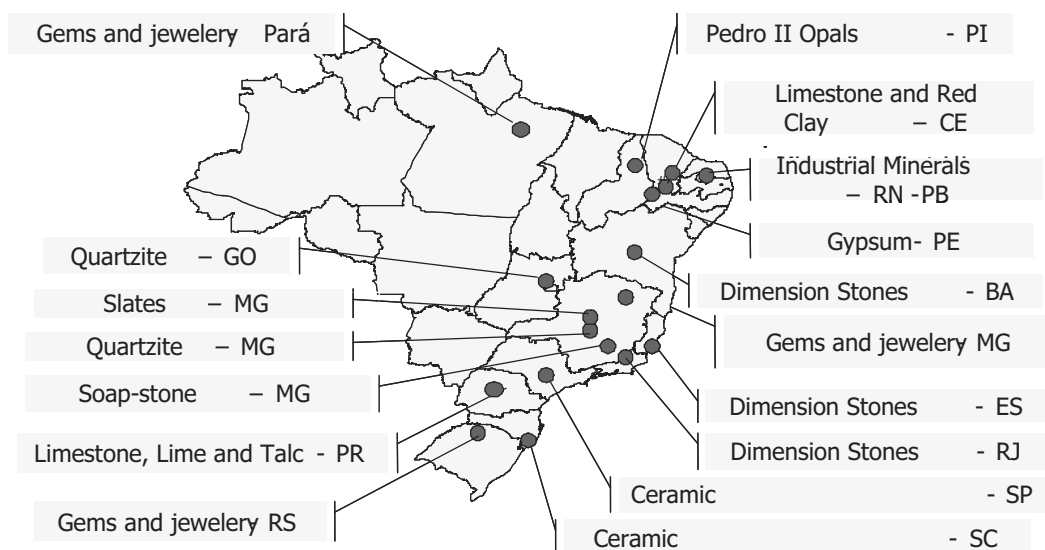


Figure 1: Some mineral clusters through the Brazilian territory

Technological support to mineral clusters

Previous analyses pointed out some of the clusters' weaknesses and many initiatives were then proposed and implemented to support most of the selected APLs, gathering contributions of high-level research and academic institutions throughout the country.

CETEM (Centre for Mineral Technology) was asked to lead three mineral APLs and to furnish technical support on other two; they are: the APLS of Natural Stone of Santo Antonio de Padua (State of Rio de Janeiro), the Limestone of Cariri (State of Ceará) and the Opal cluster at the State of Piauí, all three located on poor or very poor regions. The other two are the Soap-stone cluster at Minas Gerais and the Ornamental Travertine (Marble) Cluster of Ourolandia, State of Bahia. An important step now is to evaluate if the political, legal, financial and technological support is effectively changing (or not) the clusters sustainability levels. As a contribution to set a suitable and less complex sustainability diagnosis for clusters, the authors suggest a methodology based on stakeholder consultation and opinion gathering, synthesized on a qualitative cross impact matrix, so called "sustainability matrix".

The sustainability matrix for cluster diagnosis

As known, a bunch of sustainable indicators may be used on mathematical models to establish sustainability levels, but on the other hand it has to be taken into account that sustainable development is built over political commitments, on moral aspects and concepts as well, and some scientific knowledge, as stated by SHIELDS [3]. If we consider that representatives of the main stakeholders are conscious of their contributions to the cluster, have an adequate knowledge on how the cluster works and have the perception about what are positive contributions and negative impacts, it seems that an average opinion amongst them should provide some direction for action for many purposes, for instance to evaluate if government aid programmes and policies are contributing, or not, to improve sustainable development.

That means that a stakeholder consultation process may give a good diagnosis on the cluster sustainability situation. The sustainability matrix is a simple way to organize and present a qualitative diagnosis of mineral clusters regarding sustainable development⁴.

Figure 2 shows the proposed matrix framework. The purpose is to evaluate the contribution, or the level of impact, that production factors pose to sustainability aspects. On the first row the sustainability elements are placed split on the social, economical and environmental aspects. On the first column a set of selected production factors is placed and resumes the cluster organization and needs. For the present case study, the following were chosen:

- Raw material/ore: the main reason for a mineral cluster to exist
- Technology (production) model: it is the most widespread production processing path/flow sheet adopted by companies at the cluster
- Labour skill level: reflects the average level of education and/ or technical skills of working people in the cluster
- Entrepreneurial model: must reflect usual production/trade organization procedures at play
- Government intervention/aid: reflects the ways institutions and government agencies intervene in the cluster
- Finance institutions participation: encompasses all credit and loan organizations contributing to the cluster (banks, development agencies, etc).

The evaluation of each intersection cross between production factor (column) and sustainable development aspect (row) depends not only on the stakeholders' opinion, but as well on opinion balancing, made by a facilitator, what produces, as result, a consensus appraisal and an average grade that reflects those given understandings. The authors suggested a scale of five grades, that goes from high negative impact (grade minus 2 or - -) up to high positive contribution to the respective sustainability aspect (plus 2 or + +). The sum of the grades per row reflects each production factor contribution to the cluster sustainability, while the cells grades sum of each of the three columns represents the situation of the specific sustainable development aspect in the cluster. The authors suggest, to help an easier result overview regarding sustainable levels, that the overall sustainability grades that goes from -36 to +36, can be split into 6 classes of 12 grades each and one neutral: three negative (-36 to -25, -24 to -13, -12 to -1), the neutral (Zero) and three positive (+1 to +11, +12 to +23, +24 to +36).

Sustainability matrix on a mineral cluster: a case study

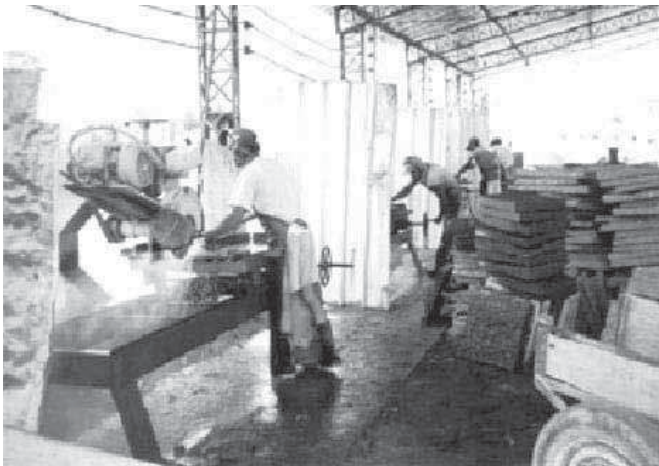
- Characteristics of the mineral cluster:
- Raw material: natural building stone (gneiss gris and yellow).
- Location and operational aspects: Santo Antonio de Pádua, 250 km N of Rio de Janeiro; at least 80 stone quarries and about 70 stone tiles production units (stone tiles cutting facilities) generating 4,000 jobs.

⁴ Internet search (Google) showed some useful applications of sustainability matrixes, but we did not find any focusing industrial clusters.

- Some historical data: since 1999, a persistent work is being carried out by a group of institutions⁵, involving the participation of the majority of the mineral producers and local community. Such joint and interdisciplinary initiative was a unique opportunity to test a multi-stakeholder approach to a mineral cluster formed by several small producers, most of them artisan and informal, operating without legal tenures and licenses ⁶. The Padua cluster diagnosis and the multi stakeholder approach were reported by PEITER (2000) and PEITER, VILLAS BOAS & SHINYA (1999).



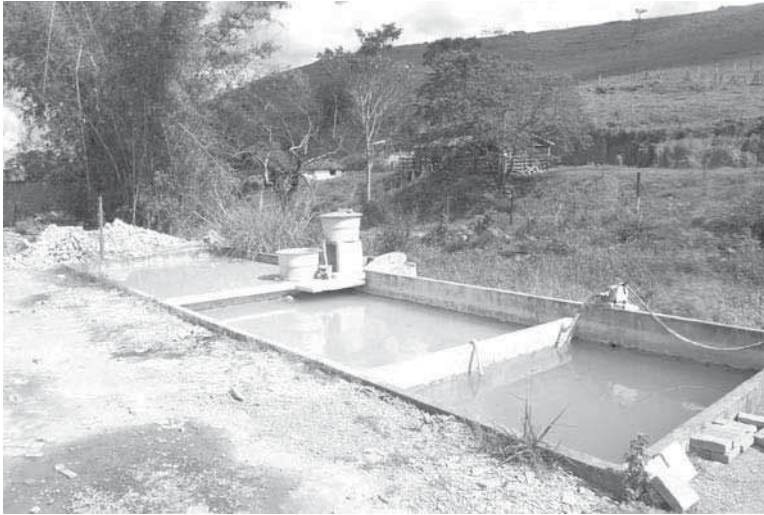
Picture 1: Typical quarry



Picture 2: Typical tile cutting shop

⁵ Many institutions have been collaborating at the Pádua cluster: the mineral producers union SINDIGNAISSSES, DRM, FEEMA and CODIN (which are local state government institutions), CETEM and INT(R&D federal institutions), FIRJAN, SEBRAE and SENAI (Industrial sector and job training institutions), and the Federal Public Attorney responsible for diligent application.

⁶ Many more aspects and features regarding the Padua natural stone cluster can be found at www.cetem.gov.br/retecmin.



Picture 3: Stone saw-cutting mud tailings recovery

Table 1 shows the matrix done for the year 2000 cluster situation.

Table 1: Sustainability matrix for the Pádua natural stone cluster, year 2000. (PEITER,2000)

Production factors	Sustainable aspects			Factor contribution
	Social	Economic	Environmental	
1. Raw material	(+) wide spread and available	(+) Unique material	(-) Excessive losses	1+
2. Technology (production) model	(++) Labour intensive	(-) Operation costs with low market prices stopped new developments	(- -) Promotes high environmental impacts	1-
3. Labour skill level	(-) Low skilled workers	(o) Workforce cannot improve quality of products	(o) Low skills also promote impacts	1-
4. Entrepreneurial model	(+) Better salaries in a jobless region	(--) Low trade management skills	(-) LOW ENVIRONMENTAL CONCERN	2-
5. Government intervention/aid	(-) Only seldom workers safety monitoring	(+) Support from the industrial agencies	(+) Provincial mineral and environmental agencies acting permanently	1+
6. Finance institutions participation	(o) Special labour funds exist but still do not support workers	(-) Loans almost inaccessible due to high interest rates and informality	(o) Technological support well kept by agencies	1-
Sustainability aspects and overall evaluation	2+	2-	3-	3-

The important conclusions were:

- The “entrepreneurial model” factor is considered to be the most negative to impact sustainability. The main reason is the selfish way quarry owners behave promoting price drop and fostering further increase on informal activity to avoid taxation.
- The “raw material availability” factor, on the other hand, has a positive effect, mainly due to the widespread and homogeneous type of stone (a sort of gneiss), which gave opportunity to several poor people to start its own quarry or to grant work in a jobless region.
- The “finance institutions” factor, amongst them commercial and development banks, as well industrial or job aid agencies, did not offer suitable conditions for small producers to apply even for small loans. One more reason to keep informality.
- The “evaluation of the sustainability aspect” (columns) grade summed up shows that the environmental aspect was the worse, specially due to the bad grades given on the technology model, which revealed the lack of knowledge on good practices in quarry exploitation, thus generating high losses of resources favoured by the need to lower operating costs.
- The “economic aspect” was also revealing a threat since stone price fell down more than 50 % due to the raise of stocks offerings made by extensive informal production and to the lack of actions in getting producers together to discuss ways to solve their common problem.
- The “social aspect”, in terms of jobs generation, was the one that showed the best evaluation and the main reason for the government institutions and agencies to keep trying to organize and help in many ways quarry owners and workers.

As an overall evaluation, taken from a scale for sustainability situation that goes from the worst grade (-9) to the very best (+9), the result obtained grade 3- (minus three) indicates a slight unsustainable situation. On the other hand, certainly the grade was not bad enough that might not be reversed.

How is the situation in 2007, after 6 years after? Many activities were performed during those years to support such a cluster and to address solutions against its main weaknesses. New economy policies emphasized the importance of clusters in the country’s economy and proposed special financial aid and technical support⁷.

Other stakeholders joined, not only to offer solutions but also to pose new challenges, such as the one by the Federal Public Attorney who asked the provincial agency to start immediately a protocol to set out a public commitment with mineral producers to improve environment features levels, otherwise their quarries should be shut down and the owners prosecuted under the Environmental Federal and Minerals Law and Code. As a reaction to this threat, the producers association and Union, known as SINDIGNAISSES, under the leadership of a new

⁷ The economical policy known as PITCE was set to foster not only high technology sectors, but also clusters as a new focal point to be supported due to the beneficial impacts they create locally and some nationally as well.

president, started negotiations to set adequate targets and better conditions to be followed by the small producers. In the meantime, support projects and negotiation initiatives started to help the producers to get to know what it should be done in every quarry and every stone cutting shop facility to follow the Public Attorney/ Union agreement.⁸

On the other hand, a recent provincial industrial development policy created lower taxation and other subsidies for companies to build their facilities in the Padua cluster region.

One important result came from one building materials company, devoted to prefabricated mortars, which is installing a factory that is going to recover one of the tailings produced by the cutting shops, mixing it to the mortar composition and almost eliminating totally this kind of polluting material. The use of very fine particulates that come out of the grinding of stone was developed by CETEM and INT and disseminated through most of the Padua's stone saw-splitting facilities, promoting 90% water recycling and a sharp decrease of solids release on brooks and small ponds used also by cattle farmers.

Other successful initiative was performed to improve trade and commercialisation skills to promote exports. A group of producers are now partners to meet exports scale contract needs that would not be feasible without a consortia formation.

To evaluate how those initiatives have interfered in the Padua natural stone cluster the new stakeholder consultation was conducted and twenty people, among technical staff from government agencies, clusters subject experts and the president of the mineral producers union, were asked to give their opinions. From them, six gave their complete views by fulfilling an individual matrix. From those, two of them participated in the first exercise and four have been deeply involved in technical projects and/or in political aspects regarding the cluster. Other two extra experts made comments on specific topics since they had not a broad view from the cluster.

The contributions were put together on a larger matrix framework in order to reflect the mean stakeholders opinion and translating it into a grade. The previous 2000 year matrix was very useful since made possible to compare specific features inside each sustainability aspect according to the related production factor.

Table 2 shows the "Year 2007" matrix together with the "Year 2000" results to provide easier comparison.

⁸ Professional teams from SENAI, a huge technical school institution, and from CETEM made individual quarries and cutting facilities diagnosis according to what was asked by the agreement

Table 2: Sustainability matrix for years 2000 (blank) and 2007 (shaded)

Production factors	Sustainable development aspects			Factor contribution
	Social	Economic	Environmental	
1. Raw material	(+) Wide spread and available	(+) Unique material	(-) Excessive losses	1+
	Many areas were legally required by few companies reducing availability for new small miners Negative change (o)	Unique material what still does not improves market prices No change (+)	Extensive diagnosis made for every quarry and saw facility disclosure the problems and show possible solutions for obtaining environmental licensing Positive change (o)	1+
2. Technology (production) model	(++) Labour intensive	(-) Operation costs with low market prices stoped new developments	(- -) Promotes high environmental impacts	1-
	Still labour intensive Unchanged (++)	Introduction of few new technologies did not changed profitability yet. Slight positive change (o)	Environmental performance is improving through negotiations and enforcement for obtaining operational licenses. Tailings new technology recycling caused a positive impact Positive change (-)	1+
3. Labor skill level	(-) Low skilled workers	(o) Workforce cannot improve quality of products	(o) Low skills also promote impacts	1-
	Workers stays low skilled but a the Quarry Training School will operate soon. Positive change (o)	Stays unchanged (o)	Stays unchanged (o)	(o)

Table 2: Continued

	(+)	(- -)	(-)	2-
4. Entrepreneurial model	Better salaries in a jobless region	Low trade management skills	LOW ENVIRONMENTAL CONCERN	
	Some advances were made through management training while salaries are almost unchanged (+)	Management training and the formation of an export consortium brought positive results. Slight positive change (-)	Much more environmental concern due to the requirements of the Environmental Performance Agreement signed. Slight positive change (o)	(o)
5. Government intervention/aid	(-) Only seldom workers safety monitoring	(+) Support from the industrial agencies	(+) Provincial mineral and environmental agencies acting permanently	1+
	Government support succeeding on keeping jobs. Health/safety will improved because are included in the Environmental Performance Agreement (o)	Government developing agencies are providing special conditions and subsidies to SMEs to operate in the region (++)	Federal Attorney, the Environmental and Mineral Agencies implemented diligent work. (++)	4+
6. Finance institutions support	(o) Special labour funds exist but still do not support workers	(-) Loans almost inaccessible due to high interest rates and informality	(o) Technological support well kept by some of the gov. agencies	1-
	New investments are creating jobs. Slight positive change (+)	Special loan conditions are being offered to SME. Slight positive change (o)	Special loans can only be taken by SMEs that have signed the Environment Agreement Slight positive change (+)	2+
Sustainability aspects and overall evaluations	2+	2-	3-	3-
	4+	2+	2+	8+

Comments on the "year 2007" matrix results

The previous list of improvements and/or supporting activities were well reported by stakeholder's contributions and carefully transferred to 2007-year matrix. The overall "sustainability value" increase indicates a significant positive shift in the cluster sustainability situation.

The matrix reveals that almost all factors underwent positive changes, while only factor 1 kept unchanged. The main push clearly came from the government/private institutions intervention and cluster supporting projects. Despite the minor influence, "finance support" and "entrepreneurial model" factors are closely connected and are expected to be the factors that will soon improve the sustainability indicators in the cluster, due to present day initiatives undertaken by development agencies and the Union of the producers.

The "Year 2000" overall result shows 3- grade meaning that the cluster was at a "slight unsustainable level". The "Year 2007" result (8+) revealed a positive trend in cluster development towards sustainability, despite still requiring several steps before reaching a truly sustainable situation. Three sustainability aspects showed positive trends but the environmental was the one that undertook more improvements in the stakeholders' opinion. On the other hand, the social aspect kept the main contribution (4+) to the overall sustainability result showing that jobs in the mineral sector still are the better alternative for wealth distribution.

The "economic aspect" has to be seen in a broader way, since the natural stone production is connected to housing, buildings and infrastructure sectors on which recent Brazilian growth rates were very low, what reflected on the low stone selling prices in the domestic market. Exports are another alternative to trade but still very modest if compared to other similar clusters, such as the slate one in Minas Gerais state⁹.

CONCLUSION

The sustainability matrix is a heuristic model that provides a good appraisal on a cluster situation regarding sustainable development concepts.

Although it works very well for an individual cluster analysis, it may not be useful for a comparison among several clusters. The consultation procedure would be weakened by the fact that it relies on individuals or groups of people "expertise", which may vary from cluster to cluster.

The result obtained in this paper will help to bring more focus to those production factors that need more attention in order to produce a better balance of their contribution and aiming to enhance local sustainable development.

⁹ Brazilian slate cluster exported 84 million dollars in 2006, from a total stone products trade of 1 billion.

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