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SCIENCE AND TECHNOLOGY IN AMAZON: ISSUES FOR SUSTAINABLE DEVELOPMENT¹

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Abstract:

In keeping with the terms of Amazonia 21: An Agenda for a Sustainable World, the purpose of this document is to analyze the “...current system of science and technology in Amazonia and its performance, from the standpoint of fulfilling the sustainable development requirements for the region.” On the basis of the outcome of this analysis, it is hoped to offer suggestions for implementing actions for the expansion and greater efficiency of this area with regard both to the academic priorities that prompt them as well as institutional management requirements at the local, regional and national levels, and even internationally.

Keywords: Science. Tecnology. Sustainable development.

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1. Introduction

In keeping with the terms of Amazonia 21: An Agenda for a Sustainable World, the purpose of this document is to analyze the “...current system of science and technology in Amazonia and its performance, from the standpoint of fulfilling the sustainable development requirements for the region.”³

On the basis of the outcome of this analysis, it is hoped to offer suggestions for implementing actions for the expansion and greater efficiency of this area with regard both to the academic priorities that prompt them as well as institutional management requirements at the local, regional and national levels, and even internationally.

This is not a simple task, as it is hampered by obstacles of both conceptual and empirical nature. To what extent can one speak of a “...current system of science and technology in the region? What exactly is sustainable development? Which structures, when reproduced, usher in trends that may result in a drop in the sustainability of social dynamics, and which will counter such inclinations? Who is (or could be) the subject meaning the agent whose actions would provide support for such development? Could “modern science” (industrialist) with its potential and current limits, with its contradictions, really foster such prospects? Or, putting this last question in a different way, how should “science” be adapted in order to deal with the challenge of sustainability here and elsewhere?

On the other hand, the problems deriving from the fragmentation, lack of systematicity and gaps in data on science and technology are not trivial in Brazil, particularly in view of its precarious regionalization. This also highlights the weakness of assessment tools for this situation in order to survey the empirical reality: how to describe the *status quo* properly? How to avoid the risks of overvaluing what is presented to us as absolute? And how can this be relativized or rather observed both relatively and dynamically?

2. The S&T Apparatus In Amazonia

The initial designation of the science and technology system in Amazonia will be treated as a plaster of institutionalized processes⁴, where people produce scientific knowledge and/or transform it into social potential, meaning productive power through either vulgarization in the region of theories and techniques mastered elsewhere or by the local incorporation in trail-blazing techniques of theories generated here or abroad or even through the incorporation in new techniques developed outside the

³ Cf. Lourenço, José Seixas - Official document UNAMAZ 292/96. P.1

⁴ It is correct to state that “the dominant characteristics of today’s science is the fact that it is developed within the context of the organization. The “single” scientist barely exists at present”. (Perino et alii, 1992:2)

region of know-how produced here. The field of Science and Technology - S&T - would thus be defined as a system for the production, circulation and consumption of scientific and technological knowledge shaped by the relationship structure between the three inter-related sub-fields that are nevertheless distinct: the sub-field of the production of new knowledge; the sub-field of transmission of knowledge in the public domain and the sub-field of pioneering productive incorporation of knowledge (either new or in the public domain). S&T activities are underwritten by social resources arranged either by organizations in the public sphere where the various spheres of the state stand out, or by private organizations. And they make available to society both the capacity to manage inventory of the knowledge as well as possibilities for tacit incremental innovations in productive or reproductive processes.

As the most elementary notion of system demands ongoing structural interrelationships among a set of elements with finalistic movements slanted towards the reproduction of the set, it may initially be established that the final purpose of the S&T system which we are examining is to develop *products and processes* that could develop into the means for boosting the sustainability and the reproduction of the entire social context within which it is located. Observed from this standpoint, *applied research activities* would be the stage immediately prior to the S&T process where the practical use of the results are *basic research* are tested; in turn, this is characterized as being slanted towards the decodification of the laws of the functioning of nature and society in its broad and generic dimension. Considering the production of *technological synthesis* as the immediate process of the system, its measure of success will be the level of effective social use of its results in view of the resources necessary for this.

With these benchmarks, the analysis of some of the fundamental variables of S&T, which are listed in Table 1 for a comparative reading for the major regions of Brazil, indicates the existence of major shortfalls for the system in the region with regard to:

- a) size;
- b) productivity;
- c) purpose;
- d) reproductive capacity; and
- e) social basis and roots.

Size. The indicators for northern Brazil are grouped into four blocks: one block consists basically of variables representing the *current S&T production capacity* focused on the proportion of PhDs - 1.6 % of the total in Brazil - and can possibly be explained by this; another looks at graduate education and approaches the proportions of the economy and the population; the third and fourth blocks consist of the extremes: at the upper level are the variables for federal government ventures (the

National Research Council - CNPq - and Ministry of S&T Institutes - MCT - and the institutes of the National Farming and Ranching Research System); at the lower end, with the smallest proportion of all is the production of *products and processes*, doctorate training and local S&T financing assets. Taking a) the proportion of PhDs as a basic reference for the installed S&T capacity and b) the proportions of the population and the gross domestic product - GDP - as indicators of economic and social requirements, it is clear that Amazonia features the worst ratios between the number of PhDs, the population and the size of the economy, taking into account that the proportion of the number of PhDs working in Northern Brazil (1.6%) is 0.2 % of the proportion of the population (6.8 % and 0.4%) of the proportion of the economy (4.4%) of the region in relation to the national total, with par expressed by ratios equal to 1 between these proportions. The absolute ratio between PhDs and the local population (0.04 per 1,000 inhabitants) would have to be multiplied by 4 in order to reach the average figure for Brazil (0.17 per 1,000 inhabitants) and by 7 to reach the best figure for Brazil in Southeast (0.3 per 1,000 inhabitants). The gaps - although less, are similar with regard to the economy.

Productivity. There is an imbalance between academic output and the number of PhDs in the region, with the ratio between the respective proportions at around 0.8%; 1% of the PhDs available in the Amazon region produces 8% of Brazil's academic output nationwide. This ratio is 1 to 1 in the Northeast and Southeast regions, and 1.1 to 1 in the South, indicating perfect balance in the first two and a positive disproportion for the latter. The situation is drastic and unparalleled in the regions of Brazil - when relating the same proportion of PhDs to the output of products and processes: the ratio between these variables is 0.2 for Northern Brazil, 0.8 for the Northeast and Center-West, 1 for the Southeast and 1.4 for the South. What this means is that 1% of the current research capacity has established 0.2% of the products and processes generation capacity in Amazonia, four times more than in the Northeast and Center-West, five times more than in the Southeast and seven times more than in the South.

Table 1. Proportions for Major Regions in Brazil in relation to the Total by variables links to S&T

	North	Northeast	Southeast	South	Center-West	Total
1. Institutes CNPq/MCT- US\$ 1,000	24.6%	0.0%	75.4%	0.0%	0.0%	122,141
2. Total Federal Institutions (1+3) US\$ 1,000	16.2%	14.5%	36.7%	18.6%	13.9%	448,264
3. SNPA = EMBRAPA+CEPLAC US\$ 1,000	13.6%	21.2%	21.7%	24.9%	18.7%	326,123
4. Federal Funding in S&T (2+14) US\$ 1,000	8.5%	12.1%	53.2%	16.7%	9.6%	952,090
5. Population of the Region	6.8%	28.9%	42.7%	15.1%	6.4%	146,825
6. Graduation (Gov. Education)	4.5%	19.0%	51.5%	16.9%	8.0%	1,198,316

7. GDP – US\$ 10 ⁶	4.4%	13.9%	59.3%	17.1%	5.3%	355,488
8.Total graduates (6+9)	3.9%	15.9%	55.1%	18.4%	6.7%	1,661,234
9.Graduates (Private Education)	2.1%	8.0%	64.5%	22.0%	3.4%	462,918
10.Total researchers	1.8%	10.4%	67.6%	15.2%	5.0%	35,621
11.Total grants in Brazil	1.6%	9.4%	68.7%	14.7%	5.3%	274,415
12. Total number of PhDs	1.6%	9.1%	72.7%	12.9%	3.7%	25,829
13. PhDs/researchers	1.6%	9.7%	71.8%	13.2%	3.7%	14,051
14. Current expenditures/CNPq-US\$ 1,000	1.6%	9.9%	67.8%	15.0%	5.6%	503,826
15. Study grants abroad	1.4%	10.4%	45.6%	14.5%	5.8%	34,192
16. Works at Congresses	1.3%	9.7%	70.6%	14.7%	3.6%	70,665
17.Articles in Brazilian publications	1.3%	8.6%	71.8%	15.3%	3.1%	20,622
18. Academic output (16+17+21)	1.3%	9.3%	71.6%	14.5%	3.3%	106,035
19. Registration for Master's Degree	1.3%	10.1%	70.3%	15.1%	3.3%	41,401
20. CNPq expenditures-Support for research	1.3%	12.0%	62.1%	17.0%	7.7%	26,994
21.Articles in foreign publications	1.1%	8.4%	76.1%	12.0%	2.4%	14,738
22. State/gov.expenditures - US\$ 1,000	0.9%	3.5%	71.6%	23.6%	0.5%	371,361
23. Registration for PhD-Programes	0.4%	2.0%	87.6%	8.6%	1.4%	16,264
23.Products and processes patented or not	0.3%	6.9%	71.9%	18.0%	2.9%	885

Fonte: MCT/CNPq - O Fomento do CNPq nos Estados e Instituições de Pesquisa 1994. Brasília, 1995. CNPq - Dispendios Nacionais em Ciência & Tecnologia 1994 - Tabela 22. CNPq - Diretório dos Grupos de Pesquisa no Brasil - 1995. Tabela 7. MCT - Relatório Estatístico 1985 a 1994 Tab. 3.4.. EMBRAPA - Relatório Anual de Atividades da EMBRAPA - 1994. IBGE - Anuário Estatístico 1994 e 1995. UFPa/PROPESP - III Programa-Norte de Pós-Graduação. Tabelas 7 e 17.

Purpose. The marked difference in productivity with regard to the generation of production processes spotlights a striking imbalance in the purpose of the S&T system in Northern Brazil: the proportion of academic output is 3.8 times greater than the generation of products and processes. This is also an extreme situation in Brazil: this imbalance is at 1.4 in the Northeast and 1.1 in the Center-West. In the Southeast, products and processes are developed in the same proportion as academic output (with the ratio of 1 to 1) and in the South, reflecting a tendency to enhance technological output, the weight of products and processes developed in the region is greater than its academic output, for the national total.

Reproductive capacity. The endogenous reproduction capacity of S&T in the region can be assessed by its capacity to supply key elements in this reproduction: its capacity to provide itself with scientists is vital. This is handled in three ways: by training local staff, by upgrading its scientists outside the region and by importing trained staff. With regard to first of these possibilities, it is noted that the ratios between the proportions of those studying for Master's degrees and Doctorates compared to PhDs in the region is respectively 0.25 and 0.79. Once again, these are the worse figures

recorded for Brazil. The proportions of study grants in Brazil and abroad - a better indicator as it includes both grants financing graduate training in the region as well as elsewhere in Brazil and abroad - are just a little below those reflecting the presence of PhDs in the region. For training scientists, the system tends to reflect no more than simple reproduction maintaining the positions already mentioned.

Local basis. The lack of proportion in federal funding from all sources compared to local funding is: North, 9.3; Northeast, 3.5; Southeast/South, 0.7. These proportions become even more marked when the ratios are studied between local outlays and the budgets of federal research institutions in the regions: 18 - North ; 4 - Northeast; 0.5 - Southeast; 0.8 Center-West. Here the Center-West leads with 18.6 and 27 respectively for the first and second cases. It should be noted that these are inversely disproportionate to those noted for state expenditures on S&T and regional GDP: 0.21 - North; 0.25 - Northeast; 1.2 - Southeast; 1.4 - South. The lower the GDP, the lower the proportion of investments in S&T originating therefrom.

2.1. Low productivity and structural conditions

The S&T workers in this region feature low productivity with regard to the scientific output as well as academic production, in terms of development of production and processes. For this latter, the extent of this distortion additionally indicates some skewing of purpose, covered in another segment.

At the moment, we should reflect on low relative productivity *per se*, compared to the average and other parts of Brazil, as a generic phenomenon reflected in the above mentioned data⁵. This distortion is explained not only through often-mentioned relative shortage of resources, but also due to the density and connectivity of S&T actions.

Shortage of material resources. An indicator of this shortfall for research in the region as a whole is the outlay of research funding per researcher that is supplied annually by the National Research Council - CNPq. In 1994, this amount was US\$ 8,700.00 for Northern Brazil, compared to the nationwide average of US\$ 9,200.00. In 1995, this rose to US\$ 12,720.00 in the North, an increase that was far lower than the average for Brazil, now at US\$ 20,350.00. This increased the gap: if the average funding in the region reached 94% previously, now they represent only 62% of the national average.

⁵ This generalization may be assumed through the exercise of assuming that the proportion for academic output and the production and processes are balanced in the region. In this case, the effort needed to produce balance would be taken from that assigned to academic output, thus creating a disproportion equivalent to the two variables in relation to the corresponding figures in other regions. Although real, it is difficult to calculate this disproportion with the available data, but it would be equivalent to the difference in productivity under consideration in this segment.

In a more limited manner, although nevertheless quite clear, the impact of the shortage of resources can be assessed through the all-documented case of the National Farming and Ranching Research System - SNPA. In 1994, of the total number of PhDs working at the SNPA, 5.4% were in various units scattered throughout Amazonia. The scientific and technical output did not exceed 3.2 % of the total, indicating that the levels of productivity noted for researchers as a whole also prevail here. A detailed study in 1992 (Quirino et alii, op.cit.) reveals that only 19% of the projects of the region saw the resources approved at the strategic levels of the SNPA in amounts considered sufficient, while for the other parts of Brazil, the percentage of projects assigned adequate funding varied from 51% to 66%. The infrastructure was considered sufficient for the implementation of 36% of projects in the North (compared to the average of 52% of a maximum of 73% in other parts of Brazil), and so. This report also indicates that the figures noted in Northern Brazil for 6 groups of variable determining success (approved funding, infrastructure for implementation, interdisciplinarity of staff, size of staff, time dedicated by staff and qualifications of staff) compared to the national average are the worst in Brazil: all the items are negative, contrasting strongly with the Center-West where they are all positive and the South and Southeast, where only one and two items respectively fell below the average.

Density and connectivity of S&T actions. It should also be recalled that in addition to effects on productivity due to the level of agglomeration and density of S&T activities, they may also erode efforts made within a context of wide geographic dispersal and the rarification of activities, just as factors fostering S&T work are concentrated in areas with highly dense activities. On the other hand, the difference in demonstrative capacity endows the production in differentiated context with varying levels of visibility and appropriability. This means that there is not only the existence of the activities in themselves, which is important, but also the capacity to communicate among them which has a qualitative and quantitative influence on joint results.

Such capacity is lower among us. Taking as a reference the universe of research programs and projects developed by the EMBRAPA⁶ throughout Brazil, it is noted that only 7% of the projects in North are carried out in cooperation with *state* research institutes, 10% with the universities and 17% have some form of partnership with international research institutions. The Brazilian average for these percentages is respectively 50%, 43% and 46%, and for the Southeast: 52%, 59% and 21%.

The variation in relation to the average is negative in Northern Brazil for all the institutional projects with a marked level of dependence on in-house output (meaning highly endogenous). In Southeast Brazil, the level of endogeneity is low, while links with the universities are very close and also

⁶ It should be noted that the FNPA here is a reference mirroring the problems of the cluster of S&T institutions in this region.

with state institutions. It is only with regard to international institutions that the variation in its position is negative in relation to the overall situation.

2.2. Skewing of purpose and institutions i: imbalance between academic output and the development of production and processes

The S&T actions take place in institutional environments that differ with regard to the conceptualization of scientific undertakings and the stress on the various processes of introducing these results into society. With regard to the conceptualization of science, two basic types of institutionality are noted: one we will call *universalistic* and the other *finalistic*. With regard to the manner of presenting the results of scientific undertakings, some strategic guidelines do so by stressing *scientific impulse* and others which rely more on market attraction.

The universalistic institutional environment is characterized by preserving the independence of the individual in research efforts with regard both to practices that can be immediately located as well as external controls in the scientific field. The scientist is its agent, with the training acquired at a certain school forming the basis for his judgment; with knowledge of the universe and nature in general constituting the objective of this science; with a keen vision of the pertinence of a universal knowledge project - organized by the dominant paradigms in the various subjects -, as a way of easing his conscience.

The finalistic institutional environment. is characterized by having regulatory conditions for the quest for knowledge, meaning that this is linked to a social requirement and is thus *objectively* established. This is not the place to discuss on a generic nature for itself, rather the conditions of its appropriateness for the reproductive needs of social systems which are established in given historical context. In this case, the scientist is not the sole player of the scientific undertaking; adaptations to practical requirements should shape the purpose of the science; the idea of the purpose of *lay* projects of territoriality (in the sense that modern geography uses this term which intends to express a synthesis that is *only* located in nature and society) which should shape its awareness.

The dichotomy between the demands for shaping the progress of science as a generic global undertaking and demands deriving from the regionalized sectoral needs of social life tend to spark important conflicts in the relations between actions and structures, revealed in clashes marring the relationships of individuals and institutions. This being the case, the institutionalities of the S&T undertaking are also characterized by the way in which they act on such disputes. Within the finalistic institutional environment they will tend to be effective in organization and strategies that seek to

establish *a priori* the roles of the various players (particularly scientists and technologists) , as well as priorities for the use of resources and mechanisms for blending different interests.

In this type of institutionality the relations between individuals and institutions take place through *actions mediated by rules* and implemented by institutional *planning* and *management*, which will tend to firm up into mechanisms that are more or less essential through coordinating S&T activities and which thus have a *technocratic* evaluation: meaning in function of the compliance by finished products with what was decided earlier - often unilaterally - by the field agents of power as necessary for the social context and this regionalization (territoriality). In contrast to the *universalistic* institution which shelters mainly efforts and ventures where individual *strategic actions* find their place within contexts coordinated by assessment mechanisms that are strictly meritocratic.

Meritocratic assessment is initially what establishes the scientific value of another of the undertaking as the outcome of the additive conjunction of two basic variables: one which varies directly in proportion to the adjustment in the dominant paradigm for disciplines, and the other which varies inversely with the distance of the venture in relation to the limits within which each discipline moves around. Second is the link between the intentions of the venture and S&T capital, which are tangible - equipment, laboratories, etc. - and intangible - scientific and technological capacity of the entrepreneurs. This means that meritocratic judgment - which can only be carried out by scientists in their own areas - *acknowledges and ratifies* the scientific value of the undertaking, as well as their products and producers. It does this seeking (an assumed) objectivity in the location of the paradigm, in such a way that higher values are assigned to those undertakings, products and producers that are best adapted to the schools recognized in normal science, as well as those acting along its border, solving the “jig-saw puzzles” (Kuhn, 1982) that have been occupying *scientific community* in such an intensive way. This process of adding value, the accumulation of agents through merit bonuses obtained through past papers and productions, as well as the equipment and collection to which they have access, are becoming more important as this constitutes a solid basis effective implementation.

It is noted here that, in the lack of meritocratic judgment centered in the scientific field, the assessment of the probability of the scientific aspects becoming (or being included in) a technological asset, whose initial characteristic is an immediate possibility of becoming taken over by society as a productive force. The capacity of specialize scientific committees for proceeding with this equivalence is limited, as this in fact builds up through interaction between the scientific field and other spheres of social life - economic, political and cultural - and appears in the material aspect of this interaction at the local, regional, national and global scales.

Outstanding among the principal S&T institutions in Amazonia are the research institutes ran by the National Research Council (CNPq) and the Ministry of Science and Technology (MCT) as

well as federal universities, with clear universalistic characteristics and the SNPA institutes with finalistic characteristics. However, these latter are strongly guided by an emphasis on scientific trust where the offer of scientific and technological assets slanted by technocratic conditioning factors, which are moving increasingly the fore in its activities.

Universalistic Institutions in Amazonia. The Emilio Goeldi Museum in Pará state (MPEG), the National Amazon Research Institute (INPA) and the federal universities, particularly Pará Federal University, all have in common the fact that they run scientific ventures that are clearly slanted towards the global dynamics of the subjects (and the paradigm that support them) as well as having their S&T activities fundamentally linked to meritocratic valuation of their agents and products, based on advisory and report-back committees of the S&T financing agencies in Brazil. Lacking other intervening factors, what stands out is that this context strengthens the global character of scientific undertakings in the region and fosters mechanisms that maximize individual efforts through adjusting local actions to the paths and constraints outlined globally. In response to these tensions and indications, the scientists calling for resources answer their efforts in activities whose results ensure the maximum *correspondence* in merit certificates to be capitalized for continuing research activities.

Judging by the trends noted in the respective areas of production, these are the rules which have been obeyed by researchers of the above mentioned institutions. Those at MPEG and INPA seem to - foreseeable enough - to have concluded that the restrictions prevailing in the region with regard to fixed resources (laboratories, etc.) needed for successful analytic research; in the other hand, given the lack of knowledge of most of the species found in the regional bioma (the largest reserve of biodiversity on the planet), this boosts the probability of scientific acknowledgment (and with this the *total value of the merit bonuses* of the respective scientific heritage) as focused on classificatory and descriptive work. This results not only in a strikingly (and unbalanced) academic output, as already noticed, compared to the development of products and processes. This above all results in an academic output with a marked imbalance between *basic academic research* and *applied academic research*. Taking as an indicator the entire accumulated output from 1958 through 1994 by the Botany Department of the Emilio Goeldi Museum⁷, it is noted that 53% resulted from basic classificatory research; 38% from fundamental studies on species already classified; and only 9% guided by the possibility of use of the object of the research projects.

With regard to the INPA, taken as a reference the production of its staff published in the periodical entitled *Acta Amazonica* (394 articles), around 63% resulted from basic research. Over half

⁷ The selection of the Botany Department of this museum was not random. Based on the assumption that faced with massive presence - compared to other areas - of forest and farming research and the weight of these sectors in the local economy, this would be the field of research under the most tension to slanting it towards applied research.

of this (37% of the total) focus on the classification and characterization of fauna and flora, and around 1/3 of the limnological and pedological studies. Of these publications, 37% focus on applied research, with less than one third specializing in agriculture, a little less than 1/4 on fish-farming, 1/5 on timber production, etc. For the Pará University, it is possible to infer from the data available a 30% share for applied research, considering - in general terms - that half the output of the Earth sciences, all the output of the Technological Center, 10% of the output of the Biological Sciences and 20% of the Social Sciences studies fall into this category.

Finalistic Institutions in Amazonia. The institutions of the National Farming and Ranching Research System - SNPA (the EMBRAPA and CEPLAC units) have operated with strikingly finalistic characteristic. The finalistic character of these institutions as first defined by a commitment to a specific area of application for scientific knowledge: agriculture and silviculture. This purpose is split into sub-purposes that are established specifically to “generate theoretical knowledge relevant for the advance of science and generate technologies with positive impact on the production and/or productivity of farming and ranching activities (...)” (Quirino et alii, 1992:7). This dichotomy takes on increased importance - in fact, the generic expression that the poles represented by the dimensions of science as autonomous and subordinate knowledge, generic knowledge and knowledge that is spatially and socially specific and useful, etc., - in agriculture which depends more than any other activity on specifically for characteristics. In this regard, a comparative overview of the region in 1993/1994 specifically for the output of the SNPA units features striking disproportions between most strict academic output and the output of products and processes. As in other comparisons, Northern Brazil featured the greatest unfavorable imbalance among these two factors, while the Southeast was in the most favorable position for this, followed by the Northeast and the South⁸.

2.3. Skewing purposes and institutions ii: odd factors in local production.

The finalistic institutional, which appeared with the development of capitalistic industrialism and was sponsored by this, is utilitarian by definition. In the final instance, it has two objectives: to increase frequency with which the inventory of knowledge -generated by the universalistic undertaking - is transformed into a productive social force for reducing the time needed for this transformation. Over the past few decades, this has been the type of scientific undertaking that has expanded most and which by all accounts, will also grow most rapidly in the future. This does not mean that it will replace universalistic research as S&T undertakings as a whole depend on two procedures: the first covers vital analysis including the separation and dissection of natural systems, reductions which have boosted *knowledge about nature* to unprecedented knowledge; for the second

type, synthetic exercises are carried out producing techniques which thus lead to the *mastery* of nature. At this point, the observation of Edgar Morin (1996) is stressed, whereby the fragmentation inherent in the undertaking that we call universalistic corresponds to an anonymous process of knowledge (and the consequent alienation of its producer) which only reappears and is not immediately recognized in technological synthesis produced by the “manipulatory instances...” found in the *finalistic undertaking*. This process is thus not neutral as transforming fragmented anonymous knowledge into technical power which is open for economic and political appropriation, which will always happen with concrete territorial divisions.

The level of complementarity with which universalistic and finalistic institutions operate in a given social reality indicates the level of autonomy of its S&T system and its local retention capacity for research efforts, even if strictly in the S&T field. It is possible to observe the skills of a system in this regard by assessing the explicit links for scientific and technical output at various institutions. For the case of Amazonia, the output of two leading institutions has been taken one more universalistic and the other finalistic, but both producing in the same field of research: the CPATU and the INPA. Publications have been selected (for the former, the *Boletim de Pesquisa* and *Circular Técnica*, with “*Acta Amazonica*” for the latter) by its style on the six most-researched products, since the 1970s in the case of the INPA and since 1980s for the CPATU. This takes as a sample the intersection of the sets of works published on the products most-researched over this period in both institutions: rubber-tree, beans, guaraná, manioc, Brazil-nuts and urucu. This intersection is also an appropriate window for observing the connectivity of all the institutions which in one way or another focus on S&T in the region. This has resulted in the selection of 33 publications by CPATU researchers and 24 of their peers at the INPA, noting references to 1,106 bibliographic quotes, in order to observe the measure of interdependence among the surveys carried out at these two institutions and between them and the other S&T institutions of the region. Of the works produced by the CPATU, of the 614 in reference only 3 had any link to research being carried out at the INPA and 1 work was carried out at MPEG, thus showing that by this indicator, the two federal research institutions in this region together underwrote 0.65% of the research conducted at the CPATU on the above mentioned products. In turn, researching the same products, the INPA researchers referred to only two more works produced then at CPATU (0.41% of its references), notwithstanding the fact that information had been requested on knowledge produced by their institutional predecessors: 5 references at the North Agriculture Research Institute (*Instituto de Pesquisa Agronômica do Norte*) and 2 at the North Agronomy Institute (*Instituto Agrônomico do Norte*). In all 10 references were found (2% of the total) to institutions in the National Farming and Ranching Research System (*Sistema Nacional de Pesquisa Agropecuária*).

⁸ In this case, the indicator was the sum of the products and processes of the researchers of the SNPA involved

There are also very few references by INPA staffers to work at the Emilio Goeldi Museum (2 references or 0.41% of the total). On the other hand the CPATU references made no less than 108 references to the works carried out thereby (17.6%), of which little less than half (59 references) did so as self-citation of the authors involved, showing a high level of endogeny in comparison to outside references which is also explained by self-centering of the researchers. Having removed the mentions to the authors' own works, less than 8% of the CPATU research refer to work by the institution itself. This phenomenon is repeated in the case of the INPA, although to a lesser extent: there were 10% of the references made to the center itself, and of this just over half referred to self-citations. Other research institutes acting at the regional level, such as FCAP and IPEAOC, did not score more than 8 mentions, the first outstanding with 6 mentions - 0.33% of the whole. No works conducted at the university were mentioned, nor at state research institute.

2.4. Skewing the purpose and institutions iii: discrepancies between finalistic output and real dynamics

Noting the development of the finalistic institutionality through the indicators supplied by the main agricultural research institutions in this region⁹, it is clearly noted three different periods. The first lasting from the late 1950 until the start of the 1960s did not suffered any clear intervention by a "strategic center" for planning and coordination which would be binding, either exogenous or endogenous. The researchers have tended to follow their own assessments of what would be the purpose of agricultural research and candidly followed their climatic and disciplinary inclinations. Output at this period is dominated by basic research, followed by works focused on agriculture and agri-industrial processes. Output focused on agriculture, in turn, was centered almost exclusively on the rubber-tree following the incentives offered by the founders of the IAN.

During the second period, while on the one hand efforts focused on researching the rubber-tree shrank, on the other work began to appear covering a wide range of more diversified products particularly beans, rice, pepper and manioc. Of the 15 works published in the period, no less than 13 focused on these products. It is also noted that at this phase no less than 37% of all the works focused in agriculture. This is closely linked to the regional development strategy pursued by SPEVEA and outlined in its I Five-Year Plan. On this topic, Mahar (1978): "In the original formulation of the I Five-Year Plan top priority was assigned to agricultural development. In this sector the objectives of

in the research groups surveyed by the CNPq.

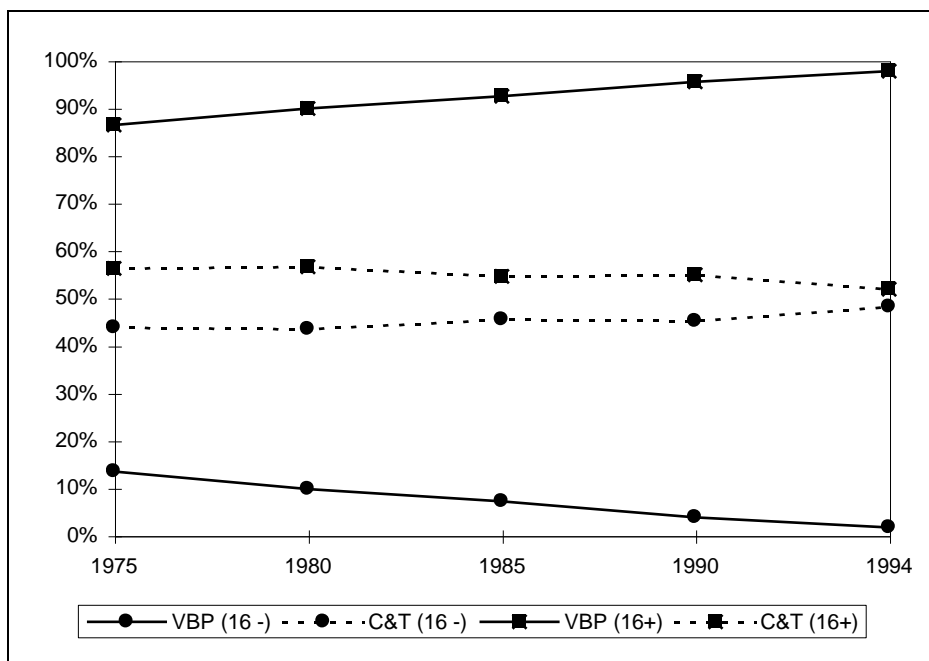
⁹ All the publications brought up by this institution were taken in the following series: Boletim de Pesquisa, Circular Técnica, Comunicado Técnico, Estudos sobre Bovinos, Estudos sobre Bubalinos, Estudos sobre Forrageiras, Culturas da Amazônia, Fitotecnia, Botânica, Fisiologia e Tecnologia. It is felt that this offers not the universe, but a significant sampling of the output of the researchers, which as such mirrors the structure and dynamics of such output.

the SPEVEA was make this region self-sufficient in food products and expand the production of raw materials for export and/or domestic consumption. These targets were to be achieved through research, settlement and various incentives for production”. Additionally on this occasion the SPEVEA seemed inclined to encourage agricultural development based on heightened efficiency for structures already found in the region, such as the peasants of the Bragantina region, which was clearly intended to expand by means of settlement mechanisms (lecture by Menezes, 1958 and Bouhid, 1958).

The third period, which began during the second half of the 1960s, and has consolidated during the first half of the following decade was characterized by agricultural S&T activities arranged by projects defined in sectoral and regional terms by the central government which attempted to introduce a project designed to overlay the structures found in the region with large scale farming and cattle raising ventures. During this phase characteristics as research into farming and cattle-raising found throughout Brazil on the whole also appear in this region. As seen by EMBRAPA itself, “until the 1960s, agricultural S&T in Brazil worked only with implicit policies (...). It was only from the 1970s on that the military governments established S&T plans with explicit policies for the [farming and ranching] sector.” (Flores e Silva, 1992:23). The distinctive characteristic of this period in the region, however, is the rapid development of studies on cattle-grazing, in parallel to very sluggish growth of basic studies and irregular development of works on agriculture. They were relatively important during the early 1980s, when they began to stagnate, resuming growth only in the 1990s.

These inflections resulted in conflicts of purpose which on one hand appeared in the disproportion between the budget allocations for research and the relative importance of agricultural and ranching sectors in the region. Covered by only 3% of works produced until 1970, cattle-raising have risen to 26% of the output by the mid of the 1970s, 22% from 1980 through 1984, 56% of publications from 1985 to 1989 and 41% for the first half of the decade underway. Judging by this indicator, the reshuffling noted during the early 1970s grew so much more marked over the past ten years (1985-1995) that half the energies of the CPATU have been directed to cattle-raising and buffalo ranching. This, as productive sector, in Pará state, for instance, with ample grazing activities, represented less than half of the figures for agriculture (24% of the Gross Value of Farming and Ranching Output in 1980 and 28% in 1985, for ranching, and, respectively, 50% and 57% for agriculture).

Graph 1. Dynamics of the S&T production Structure and the Gross Production Value (GPV) of agriculture (the 16 most and least important crops)



Additionally, a number of disparate trends among the institutional energies allocated to research into agricultural products and the social and economic reality for these products. It would be expected that research into farming and grazing activities - even if following no principle other than productivist availability - would focus over the long term on the economic importance of the product by either seeking to boost the efficiency of the production structural already present in the region and foster its expansion - and here there would be a convergence due to *sizing demand* and the marked attraction mechanisms, or because it makes substantial contribution to its alteration, resulting in a convergence spurred by science. These expectations were met in the case of Amazonia. Graph 1 gives the result of a comparison of the structure for scientific and technical output with the structure for the value of farming and ranching output of different periods. This thus compares the importance assigned by agricultural S&T - measured by the relative share of accumulated scientific and technical output - to 16 of the most important and 16 of the least important agricultural products in Pará state, which is the largest agricultural economy in the region and the site for almost all farming and ranching research carried out by the SNPA. The 16 most important products in the mid 1990s already account for over 80% of the agricultural GDP which is continuing to grow. With regard to them, the S&T performance fell short and its growth was out of proportion - as it dedicated little less than 60% to these crops of the start of the period and little more than 50% twenty years later, of its output focused on agriculture (covering ranching and basic research). For the 16 least important products whose economic participation dropped steeply to almost zero during the twenty years under consideration, research assigned almost half of its efforts in a persistent and slightly increasing manner. These trends became more marked as the ranking became more polarized, which can be clearly noted in the

series covering the ten and five most and least important crops leading to the conclusion that allocation of research efforts for agriculture has wandered away from the production structure due to two movements, both associated with the more general fact that, although in very few cases appreciable sustainable gains have been guaranteed a productivity for the crops and activities researched: a) because for most of the products which really grew in economic importance, research projects were either not carried out or were insufficient, which could mean from one viewpoint that effective agricultural development requires institutional research as a fundamental element; on the other hand, it could mean that the institutional research has remained impervious to the demands of this development - and because, to the contrary, (b) the products to which more attention has been devoted, have either fallen in importance over time or have been unable to consolidate relevant economic positions. In both cases, the determining factors (associated either with political and institutional guidelines deriving from strategies imposed by the central or local government, or due to the assessments of the researchers themselves and their institutional practices) of research efforts has not led to an output following trends in reality and logically do not address the needs and possibilities of the economic and social structures.

2.5. The local basis for S&T in Amazonia

S&T ventures in Amazonia have been very remote from the needs of the social reality in the region, due either to the predominantly universalistic character of the institutional environment shaping certain organizations. or as a result of the ease with which those operating within finalistic institutional environment give in to strategic demands guided by requirements other than the specific needs of the region. Additionally, such ventures are implemented with a poor level of complementarity, with their institutions, research projects and researchers linked by extremely little levels of communication, connectivity and synergy, with repercussions on productivity as well.

But it could be said that the institutions behind the situation are not exclusively regional in their format: the National Research Institute (CNPq), the Agricultural Research Company (EMBRAPA), the Research Funding Agency (FINEP), etc, operate through mechanisms and criteria that are nationwide in scope. Why do they result in an alienation of production in terms of surroundings social reality, and fragmentation and odd factors in levels that are comparatively higher in other parts of Brazil?

The response lies in the types of mediation with local society - expressed in civil society and the state - implemented between specific needs and the *modus operandi* of the actual mechanisms in the S&T field at the global and national levels. There are mediations which are built up in the field of S&T and mediations which take place in the area of exchange between the field of S&T and the field of society and power. Local society could produce direct and indirect intervention in the field of S&T

with a view to linking this field with practical realities. Direct intervention takes place by setting up S&T institutions appropriate to local needs through both the implementation of their own criteria of *meritocratic judgment* as well as by ensuring the visibility of local S&T priorities; or by *tecnocratic criteria* or setting up channels for *ongoing dialogue* between the producers of scientific and technological assets on the one hand with the national and global fields of S&T, and on the other, with the potential customers and users of their output. Other types of direct intervention include the political capacity to affirm S&T as a basic social need. In turn, indirect interferences include expansion of the internal capacity in the S&T field to identify the needs and ability to formulate demands by both the formal levels of local power as well as various social segments, groups and classes.

The *direct mediation* of local society is discussed through two indicators: local expenditures on S&T (which measure local efforts to intervene in S&T ventures *in the region* and their social needs) and the relative position of its more obvious social subjects with regard to S&T. In order to clarify indirect mediations, it will be necessary to discuss the capacity of the *social sciences* to help define the best way to shape S&T ventures appropriately and the new demands springing up in the wake of sustainable development. This last point demands separate analysis and thus will be just vaguely addressed at this moment.

The proportion of local government expenditures and its structural meaning. We have already given here the data covering local government expenditures on S&T. What implication does this have on the programs that we have just analyzed, the lack of links among S&T ventures, and the external alienation of their results?

This question paves the way for others: what type of role is played by local resources - basically coming from the state government - in the real situation of S&T in Brazil? Which S&T activities are financed by each sphere of government and companies? Is there a “division of work” between them meaning allocation and activities “preferred” by the sources? In order to answer these questions, we analyzed expenditures on S&T by *research and development* (R&D) items in 1994, by origin of resources - federal government, state governments, or coming from public or private companies. There is a clear-cut differentiation in the distribution of resources by activities, according to the spheres where they originate. The highest expenditures of the various *federal government* institutions is in training new scientists at the pos graduate level, and training human resources in other countries (43.5% on average of the total outlays for 1990/1994). Second comes *basic research* with 26.3% followed immediately by *applied research* with 25.6%. Finally, with 4.6% comes *experimental development*. State governments invest heavily in applied research (practically 83% of the total, with regions such South-East and Center-West Brazil assigning over 95% of their R&D expenditures in

this activity), followed by basic research (13%). Only 2.8% of state funds are allocated to training research staff and 1.4% to experimental development. It is the companies which are effectively interested in this last activity, investing 52.4% of their R&D outlays in this field. They are also interested, although at the secondary level, in applied research where they invest 35.5%, and finally in basic research at 12.2%.

Looking now at the relative structure for expenditures by activities, it is easy to see its framework. *Basic research* is financed largely by the federal government which supplies 73.4% of the funding absorbed by this area. State government and companies divide the rest in almost equal proportion. Just under half the funds assigned to applied research (42.5%) come from the state governments. The governments in Southeast Brazil alone account for 35% of these expenditures, practically the same level of responsibility as the federal government. The companies supply only 20.6%. But for *experimental development*, the contribution from the corporate side is decisive: 80.57%, compared to 17.6% for the federal government and 1.8% for state government. And finally, in graduate education and training scientific staff, the government handles this almost alone, allocating no less than 97.8% of the resources. The contribution from the state government is meager here, at 2%, with nothing from the companies.

Table 2. Type of R&D activity financed by origin resources

	Basic Research	Applied research	Experimental Development	Post Graduate Courses and training staff	Total
Federal Gov.	26.27%	25.60%	4.61%	43.51%	100.00%
State Gov. ²	12.93%	82.54%	1.34%	3.19%	100.00%
North	0.03%	34.12%	65.85%	0.00%	100.00%
Northeast	21.80%	64.75%	1.25%	12.20%	100.00%
Southeast	2.52%	95.41%	0.07%	1.99%	100.00%
South	43.99%	47.60%	2.75%	5.65%	100.00%
Center-West	0.00%	97.46%	0.26%	2.28%	100.00%
Companies²	12.17%	35.45%	52.38%	0.00%	100.00%
Overall Total	20.33%	39.42%	14.89%	25.36%	100.00%
Federal Gov.	73.39%	36.89%	17.60%	97.45%	56.80%
State Gov.	12.90%	42.51%	1.83%	2.55%	20.30%
North	0.00%	0.16%	0.82%	0.00%	0.18%
Northeast	0.75%	1.15%	0.06%	0.34%	0.70%
Southeast	1.80%	35.17%	0.07%	1.14%	14.53%
South	10.35%	5.78%	0.88%	1.07%	4.78%
Center-West	0.00%	0.26%	0.00%	0.01%	0.10%
Companies	13.70%	20.59%	80.57%	0.00%	22.90%
Overall Total	100.00%	100.00%	100.00%	100.00%	100.00%
Overall Total	US\$ 371.978	721.047	272.328	464.000	1.829.352
1,000					

Source: CNPq/SUP/COOE and the National Corporate Research and Development Association - ANPEI; CNPq - National expenditures on S&T, 1994. Tables 4.1 and 22; MCT/CNPq - Federal Government expenditures in Science & Technology - 1980-1993. Table 5.

1. Averages for 1990/1994. For 1990/1993 MCT/CNPq - Expenditures... Table 5. For 1994 Expenditures... Table 4.1.

2. Expenditures in 1994.

The rules and their logic in the S&T field in Brazil as a whole become quite clear. The federal institutions play with the rules of the scientific and technological undertake as global field, seeking to maximize the participation of Brazil in building up global scientific knowledge through the legitimate mechanisms adopted (particularly meritocratic judgment at the national level). This is achieved jointly, although concentrated at specific points on the planet, which are accessible through cooperation in basic research and the training of top-level scientific staff. Bursting the social appropriation capacity of the scientific potential acquired at this level of the global economy, as geographers say, is in turn largely the result of local efforts that are objectively directed towards *applied research* - with the national institutions entering this movement at the secondary level. Further more, research achieves the more concrete level of experimentations through the intervention of an agent slanted directly towards the productive sphere (in the case of the data we present, companies, often government-owned). Anyone not following these rules - either due to inability to perceive them or the incapacity to adopt them - (which is equally valid for both state governments and agents) does not qualify for autonomous appropriation - meaning appropriate to their own needs - of the scientific and technological capital produced in the cluster of interactions that constitute the scientific field in Brazil and worldwide.

The perception of S&T by the basic social classes in Amazonia. The initial contacts of regional oligarchies with science had purely symbolic motivation. Setting up the Emilio Goeldi Museum in Pará state - its *debut* in this field and the support of its scientific staff was expensive during the rubber boom viewed as an adornment, a luxury which they could treat themselves to, something like building magnificent opera houses. As such, the scientific venture had no organic links with the fundamental structures of local society.

With the rubber crisis, local government procedures were unable to even think about S&T ventures, either those intended to reduce the deleterious effects on fractions of the elites, or those seeking to strengthen new extractivist activities such as Brazil nuts or even those intended to consolidate farming activities at the present level in areas such as Bragantina.

During the next stage, by the middle of the century, the political needs of national elites for including Amazonia in their projects, and a series of scares over foreign initiatives in Amazonia explain the formation of S&T apparatus such as the IAN, the new MPEG and the National Research Institute of Amazonia (INPA). They were thus implemented as projects sponsored by national elites as ventures of a defensive nature and, once again, highly symbolic. A type of *big science* whose paradox lay in the fact that it was in no hurry and lacked any immediately identifiable purpose. The genesis of these institutions as S&T ventures was not derived from stresses prompted by local

requirements, that were socially or politically organized¹⁰. No projects or even expectations with regard to such ventures are noted, which would result in institutions with the characteristics of *appliances*, meaning institutionalized forms of action guided unilaterally by other fields and their relationships: by the global-national scientific field, by the global-national economic field or by the global-national power field, a unilateral presence in these fields in the region.

The SPVEA seems to have prepared a S&T project with a local viewpoint - it is not known exactly to what extent it is influenced by regional, political or economic and social forces, or by a national economic situation favoring a standpoint which although technocratic, includes in the broader development projects the modernization of traditional structures. This initiative was undermined by the development project of the dictatorship which condemned structures considered as archaic in its drive towards modernization, either because it did not see them (the ideology of the empty Amazon is an extension of this mechanism) or because it did not consider them capable of changes with the modern characteristics that it idealized.

The project of the dictatorship for this region promised development through massive waves of concatenated effects (linkages) forward and backward due to the *powerful impact* caused by hubs (large masses of investments, concentrated in spatial terms) of development. With regard to industrial activity, this strategy consisted of dismantling “islands of synthropy” (Bunker, 1985) represented by huge orebeds and stands of timber: massive mining and metallurgy complexes and the logging “hubs” such as that of Paragominas are the most tangible material result of this strategy, strongly supported by the tax incentive policy.

With regard to *agrarian issues*, the option for *sweeping impacts* was shaped by two technocratic principles. The first XXX that economic development would be maximized by basing this on a production function shaped by the imbalance in the allocation of factors specific to the region, meaning that it offered abundant land, with labor and capital in short supply¹¹.

Second, that the development and modernization of Brazilian agriculture as a whole would depend on the development of its “extensive margin”: the greater the weight of this total production, the lower the intensification of the use of land and work on the land. This postulate implies that the

¹⁰ Due to the lack of local formulation of the needs which could be fulfilled through scientific activity, the work of Peter Weigel instructs us in the example of INPA (Weigel. 1994:258-304). With regards to the IPEAN (currently the CPATU), the same problem is detected by Felisberto Camargo (1948) who also notes an anti-scientific disposition among local elites who, in his view, prefer emergency solutions to protect extractivist exploitation to the point that “...they would attempt to overthrow all the walls of any work of pure science...” (Camargo. 1948:5).

¹¹ This is the conclusion of the various new-classical approaches to regional agricultural development. The formulation of Haiaymi and Ruttam (1985), presented more recently, seems to us to be the most representative, complete and accepted in this respect

greater the development of agriculture through the inclusion of new lands would result in possibly lower levels of the intensification and technification in terms of old colonization¹².

An attempt was made to blend these principles of neo-classical economic rationality through a *political* strategy which subordinated the former to the latter: the production factor of the private venture which is vital for furthering the development of new agricultural frontiers should foster control over the extensive margin of agriculture and thus encourage the establishment of a capital-intensive production function in the older areas of settlement in Brazil as part of the modernization project carried out therein. Thus, under this strategy, large scale cattle-grazing seemed doubly positive in Amazonia: it could make good use of huge tracts of lands with a minimum number of workers and slow the expansion of traditional agriculture to new lands (the expansion of the agricultural frontier has been an important structural factor in the agricultural and industrial development of Brazil, since the 1920s, as it plays a leading role in the supply of products to the domestic market). This guarantees the market for more intensive production of rice, maize, beans and manioc in older areas. The huge *plantation* could handle part of this task. However, this clearly defines the limit for being labor-intensive. From then on, as a core mechanism for federal intervention in Amazonia, the *tax incentives policy* encouraged extensive *cattle-raising* which firmed from then on as the mechanism for developing agricultural frontier in this region with its own specific characteristics, from the second half of the 1960s on, jointly with a *land policy favoring huge allocations* (Costa, 1989). In a field for unprecedented clashes over access to land and natural resources between companies owning vast tracts of land and ranchers on the one hand, and peasants, people living of the forest by extracting its products and riverside dwellers on the other, in addition to the indigenous communities, often placed in opposition to all the others.

These dynamics imposed conformation on S&T in this region shaped by a double denial. On the one hand, giant cattle-grazing ventures are under way, regardless of the existence of any scientifically validated technology for the region. As shown above, the initial studies on grazing were published early in the latter half of the 1960, when this project was already well under way through "Operation Amazonia". In turn, the confidence shown by the "new" owners of this land in cattle-raising seems to be based on empirical assumptions over local adaptation capacities and the development of crab-grass, (*capim colônião*) which later proved quite unfounded, as clearly shown by Fernandes (1993). Additionally, no consideration was given to what S&T institutions and their scientists had to say on this topic, based on studies already carried out¹³. This policy thus denied at

¹² See comments on this relationship in Mueller and Penna (s.d.) and (1981b).

¹³ In this respect, Weigel (199:315-16) states that there were already scientific opinions in existence at the INPA, at the time this policy was launched, which were soundly based on research results showing that homogeneous crops planted at a large scale in this region were not advisable, particularly grasses.

one and the same time the lack of knowledge and the knowledge of some S&T ventures in this region as it was implemented despite them. The relationship between the field power with the field of organized science in Amazonia under the dictatorship also denied scientific efforts leading to reformulation and imposing their needs. as mentioned above.

On the other hand, the policies of the dictatorship blocked mechanisms which encouraged companies towards innovation, which guided them by resulting in demands or production of S&T. Both the defensive stance which took innovation as protection or recomposition of normal profit rate as well as the offensive stance seeking innovation as a way to bring in differential profits and consequently competitive asymmetries, became forces that were softened by the removal of risk on the one hand, and the possibility of profits from rents and extraction on the other. The first was obtained through access to various types of income conferred by land ownership, of which subsidized credit was only one, as well as the extensive use of natural resources offered by land and fiscal incentive policies. In fact, these policies made investments in innovation - with rare exceptions - irrational in Amazonia where entrepreneurial rationality took the form of slash and burn agriculture, extensive grazing and uncontrolled logging activities.

In turn, the peasants were constantly assailed in both the new areas (recently cleared) as well as in older settlements, as the political level through the struggle for land and the stifling of representative organizations imposed on them by union policy; at the economic level due to the lack of infrastructure and tight control by mercantile capital in this region. The endogenous capacity to innovate as well as the power to call for innovations was completely blocked for S&T institutions, reflecting the broader block placed by the development policy for the class: access to land and tax incentive funding as well as subsidized credit.

In industry, enclaves had been building up with regard to S&T, where companies supply the region with the techniques it lacks which, in the dominant case of the Manaus Free Zone, do not extend beyond simply assembling components. The outcome of these activities in the formation of S&T ventures is not perceptible. However, little study has been done to assess it.

The mining companies were clearly presenting demand for scientific work during both the 1970s and 1980s, focused largely on prospecting. It is not by chance that it is precisely this area that has the most complete teaching and research facilities in the region: the geo-sciences area at the Pará Federal University. Notwithstanding clear links, this also was needs a separate study.

Thus, during the 1960s and 1970s and almost all the 1980s, with the exception of the mineral exploitation sectors, no impulses are detected coming from the various production sectors, nor the classes and class segments found in the region that could (or would) alter the investment in S&T, with regard either to the private efforts of the various agents - deriving from the level of disposition and

need, the ability to formulate and the respective power to demand - all with regard to government allocations by local states. Additionally, at this stage, no mechanism was available that could make the S&T ventures *in the region* into a system, far less into a S&T field *for the region* with the autonomy required for this. The crisis of the 1980s also affected the budgets of the institutions and initially made this state of affairs even worse. Later on, however, it created the conditions for a shuffling of positions among the players whose formation to representations entered the arena on new economic and political basis. To the extent that, only very recently - from the second half of the 1980s onwards - gradual steady alterations have been noted in both the formulation of demands by the various agents and in the formal willingness of institutions at various government levels to deal with S&T in Amazonia in a different way.

2.6. Reproduction, expansion and size of the S&T Framework in Amazônia

We have been presenting the S&T variables of the region basically from a relative standpoint: as compared either with other regions and the average for Brazil or other variables of the system. An awareness of the true dimensions of the problem of the size of the S&T framework in the region lacks two additional procedures. One is an ongoing comparison of regional variations but in relation to supra-national scales; the other establishes what should be the role of S&T in the region, quantifying its needs. We will not address herein this lack of procedures, whose possibilities for implementation in the region - urgent and necessary - requires separate study.

With regard to the juxtaposition of the size of S&T in the region with global scales, it should be recalled with Shott (1992), that Brazil is a small country in scientific terms which handles only 0.3% of the scientific research carried out worldwide - measured by the number of indexed articles published by Brazilian scientists or those working in Brazilian scientific institutions - and consequently receives only 0.2% of mentions in international literature. No Brazilian scientist is listed among some 3,000 mentioned as “principal contributors” or “significantly influential” in a survey of scientists carried out abroad. This contrasts with the fact that the Brazilian economy and population represent respectively 1.7% and 2.8% of the global economy and population. The weight of the Brazilian economy in these terms is thus approximately eight times greater than that of scientific outputs. A comparison between S&T in Brazil and in the world thus reproduces similar imbalances in terms of both extent and debts, reflecting those shown in the comparison between Amazonia and Brazil. Taking the global S&T average as an ideal benchmark, the negative disproportions are multiplied several times, leading to the assumption of proportional asymmetries in the power of determination of this level over local ventures.

Size, reproduction, expansion. The lack of proportion in the number of PhDs in relation to the size of the economy or the population is, among others, an expression of the difficulties encountered

by this region in retaining its graduates. This incapacity has given rise to constant concern among analysts as it involves a set of factors that have been undermining some noteworthy efforts¹⁴.

Mention should also be made of a current special grant program for regional scientific development ran by the CNPq with a similar effort. On the other hand, considerable effort has been made by institutions to enhance the quality of their staff through training masters and PhDs in Brazil and abroad¹⁵.

However, federal institutions, agricultural research centers staff has shrunk and the growth rate for qualified staff at the Universities has been slow compared to growth in total headcounts (Costa, 1997). The estimate put forward by Ennio Candotti in 1992, when he chaired the Brazilian Society for the Progress of Science - SBPC seems up to date and summarizes this phenomenon well: "... the number of highly qualified researchers hired by research institutions over the past twenty years were estimated at around 1,500. Only a hundred or slightly more of them remain in the region" (Candotti, 1992:240). A throughflow of over 75 arrivals and 75 departures a year among a total of some 300 PhDs in average means an annual turnover of 25%.

The causes for this high turnover are recurrent¹⁶: low *nominal wages*, aggravated by the high cost of living in the towns of Amazonia which result in *real wages* that are lower still for the researchers in the region, compared to their peers in other parts of the country. This situation is confirmed by study grants that are paid on an irregular basis and the formal impossibility of paying wages in this region that differ from those in the rest of the country. The health-hazard allowance paid by several institutions has not made much difference. Other difficulties include coping with precarious working conditions due to a deficient infrastructure and poorly-equipped laboratories, maintenance problems, etc..

3. Changes underway and prospects for S&T in the region

Ever since the 1980s, significant changes which will shape the future of S&T in the region have been underway. There are 3 sets of alterations which are of outstanding importance:

¹⁴ During the 1980s, under the Humid Tropic Program - HTP, a Subprogram was set up to Settle Researchers in the Amazon Region, backed by funding from FINEP and the FNDCT for special grants to attract and maintain highly qualified S&T human resources in this region. This was a federal government program intended "to coordinate the contribution of science and technology to better knowledge of the conditions of adaptation of human being to the peculiarities of Humid Tropics and the preservation of the ecological balance of the Amazon Region" (Brazil, Laws, Decrees, apud. Benedito e Barros, 1990:33).

¹⁵ Diniz states that at the moment Higher Education Institutions in the region have 566 faculty members in doctorate programs, in Brazil and abroad (Diniz, 1997).

¹⁶ See, among others, Benedito e Barros, 1990:40; Candotti, 1992:241; Diniz, 1996;; Aragón, .

- 1) the re-establishment of democracy in Brazil;
- 2) the complex relationship between ecological crisis and fresh advances by the productive forces of capitalist industrialism;
- 3) the fiscal crisis associated with the crisis of the national and regional development model.

Democracy and new social subjects. The re-establishment of democracy has created a political environment where new subjects are being set up, which can, due to the nature and urgency of the demands impose the stresses needed to shape new configurations in the field of S&T in the region. The innovative factor is that it does not seem too likely that S&T ventures will be able to move much beyond the needs underlying the social reproduction of these new subject over the medium term. Among those who have been gaining political clout and voice are those with a structural position based on unusual innovative dynamics that are not always well understood. These are peasants of various types. I have personally studied these dynamics in agriculture and the empirical demonstrations are irrefutable for crediting them as responsible for the most important changes occurred during the 1980s and which are today tending to firm up in regional farming and ranching activities. These range from the introduction of tropical fruit-growing which is beginning to gain in importance nationwide until the formation of small dairy herds associated with systems where diversity and sustainability are probably high. They also include various attempts to add value to products that are both extractive and agricultural in origin. This segment of society - which should today consist of some 600,000 families, meaning 3 million people throughout the region - is also managing to constitute an asset, in parallel to its economic importance (around 80% of the farming and ranching output of the region), and is becoming a coherent political subject with a marked presence in the institutional reconfiguration process noted in the field of power in the region. An example of this is the reorientation given to the FNO at its insistence, making it into a broad-ranging policy affecting some 50,000 peasant families over the past three years and mobilizing some US\$ 750 million. The clarity achieved by the fact that the principal risk ran by this strategy followed for the use of resources - investment in various permanent systems - is the lack of knowledge which could provide a sounder basis for the technological practices of farmers, which would help transform this segment of regional society into one that places S&T more firmly on its agenda¹⁷.

This was in fact demonstrated during the last “cry of the earth”, an annual event established by this class for putting forward their claims to the institutions of the State and civil society, on which

¹⁷ Curiously, at the recently-founded Council to manage the S&T Fund of Pará State, this segment is not represented (which should be handled by the Farm Workers Federation - FETAGR) probably in the belief that they have nothing to say about the noble issues of S&T. It is certainly felt that agriculture is already sufficiently represented by the Pará Agricultural Foundation - and employer agricultural institution.

¹⁷ In this sense the reflections such as those of Magalhães (1996:177-191) take on added importance.

occasion they showed a willingness to fight politically for this, launching talks which promised to be long and tough with the SNPA institutions. Furthermore, even social players always present, such as forces influencing local correlations are structured around similar needs which in themselves derive from the new context that makes S&T a center of convergence for sweeping social interests, but with local and regional variations; the loggers and forest communities put under stress due to the needs of the ISOs; the cattle ranchers, the shortage of grazing lands, etc.

However, it should be stressed that these forces include the efforts of scientists and academics in the region, who have been managing to build up institutional areas that should not be scorned, outstanding among which are PIUAL, UNAMAZ and CORPAM. These activities form part of a broader phenomenon which lacks any separate research, namely the transformation of scientists into policy makers in the Region.

Ecological crisis and new advances of industrialism. As this century draws to a close, we are living through a unique time of difficult and contradictory relationships going back three centuries between capitalist industrialism (modernity, if one prefers) and nature. This is the outcome of the depletion of the standard in effect until now for social development which, on the practical side, associated the development of productive forces with cultural and biological homogeneity; on the ideological side this stressed the belief in the independence of human kind in relation to the basis of nature as such in keeping with the belief in the adequate resilience of this basis to withstand human actions. The depths and global scope of the ecological crisis has been breaking through ideological barriers and making its manifestations quite clear, setting up a political agenda that is of increasing relevance. On the other hand, scientific and technological advances reflected in biotechnology, genetic engineering and pharmacology have expanded and reformulated the value of the original diversity of the planet. Amazonia and S&T in Amazonia are starting to reflect these new trends although in a controversial manner.

Fiscal crisis and institutional factors in S&T. The fiscal crisis and its structural basis, the economic crisis of the development project of the dictatorship has affected the institutional framework for S&T found in Amazonia, altering its basis and foundations across the board. The most elementary type of stress has sprung from the budget crisis of the institutions, particularly those that are more specifically finalistics, with at least two main effects: heightening their eagerness to enter into partnerships with both international institutions and institutions of civil society, well undermining in finalistics institutions the budget basis of centralized technocratic power. This has opened up channels for penetrating the institutional context of S&T in the region by the issue of *sustainable development* as formulated on the basis of the ecological crisis, while at the same time opening the flood-gates to demands from local and extra-local production sectors. The opposition thrown up to scientific

undertakings focused on preservation are not minor nor is the clamor against scientific undertakings focused on the use of natural resources, including those which are well adapted to local and other needs. In turn, establishing the local requirements of S&T is a process marked by conflict, triggered by different concepts of the reproductive needs of its various agents.

New awareness and new science: the notion of sustainable development. As the new international ecological awareness, of which sustainable development is a by-product, is not a movement of ideas that is linear and positively established, ambiguities and contradictions should be more explicit in order to ensure greater strategic clarity for the new times ahead. In fact, the new ecological awareness has at times approached the region as a mere ideology (what I have been calling “ecologism” - Costa, 1992), at times as mediation for new technocracies whose agents - governmental and non-governmental organizations - generally have their own *a priori* objectives contained in notions of sustainability that are decontextualized in historical and social terms, and organized methodologically by perceptions own of the natural sciences¹⁸.

However, the notion of sustainable development lines up a cluster of ideals whose value is unquestionable for shaping new national and regional development strategies. Its basic trilogy, - development that is socially fair, economically efficient and ecologically prudent - organizes the core ideas that will tend to have the power of mobilization over the next few centuries similar to that of the ideals of the Age of Enlightenment - liberty, equality and fraternity - over the past two centuries. In Amazonia, its power to build depends on:

a) the critical capacity (neither compulsive rejection, nor subordinate or mystic acceptance) of the social absorption of its challenges;

b) the social capacity to transform its requirements into reproductive advantages and, by extension in a globalized world, into competitive advantages or the current forms of production in the region.

In both cases, setting up a local S&T field is a basic pre-requisite. Setting up a S&T field in Amazonia would mean endowing at one and the same time the S&T ventures underway in the region with unit, and ensuring the autonomy of this unit through the establishment of its own rules and the local social legitimacy of its output, with the concomitant result of boosting its two-way communication capacity with both the rest of the nation and the world.

¹⁸ In this sense the reflections such as those of Magalhães (1996:177-191) take on added importance.

4. Conclusions and recommendations

There is a new international ecological awareness shaped on the one hand by ecological crisis (entropy) prompted by industrialism, and on the other by new advances in industrialist control over nature. Its political and economic expressions are tending to increase in importance, although in a world where the intensification of the volatility of the elements in the capitalist relationship (labor due to the progress of automation, and capital due to its rising dependence on financing, both of which have been made possible by the scientific and technical revolution ushered in by information technology and new communications technologies) and the extent of its effects (globalization) are necessary references. As being behind its own crisis, as well as being the source of possible solutions (presentation, Santos, 1993 and Zinn, 1994).

The crisis of the projects of industrialism in general include those of peripheral industrialism in particular - like that of Brazil, with increasing social and regional inequalities, high capacity to destroy nature, low level of competitiveness at the international level etc. - , with effects on the appreciation of formal democracy as the foundation of this new space for political negotiation of social conflict as well as the invalidation of deregulation that endows the market with the primacy of economic adjustment. This being the case, associated partly with the polarities and contradictions of the new international environment dividing, to some extent, from new domestic conditions, a willingness appears at the central government level favorable to the *discussion* of sustainable development (see Brazil, 1995). These inclinations tend to emerge in the institutionalized forms of local power in Amazonia, partly as a somewhat passive reflex of what takes place at the central level, and partly as strategic ways of reorganizing the areas for negotiations of local forces in their relationships with Brazil and the world. This prompts in initiatives that were unparalleled in the region until very recently, of which eloquent examples are the establishment of the Council for the Environment, Science and Technology in Roraima, and the Sustainable Development Plan in Amapá alongside the establishment of state boards and bureaus for dealing with the environment and development in practically every state in the region. In all these mobilizations there is a tacit awareness of the decisive role of S&T in what would be a type of sustainable development. In actual fact, the movement of ideas - found in the documents, rules and even names of the institutes, boards and bureaus - delegates sustainable development to S&T¹⁹.

¹⁹ The most complete formulation of the fact that "... the promotion of sustainable development in the Amazon region requires a level of knowledge whose indispensable pre-condition consists of the implementation of a broad-range of studies and research projects and an intensive exchange in the field of S&T to be handled by the scientific and academic institutions in the region... The rational and sustainable use of environmental resources in Amazonia depends on the application of advanced technology developed or adapted to its specific conditions" (Brasil, 1995:18-19)

However, this concerns runs up against the reality that we have briefly described: a fragmented science (either in the broad sense as analysed by Morin, as well as in the restricted sense as we described) with institutions acting as frameworks that fail to communicate among themselves, developing new truly instrumental perspectives of projects (in many cases invisible) and determining from outside the economic and political power for the region. This results in a wide gap between the S&T produced therein and the needs of the fundamental players for their development.

A strategic guideline for shaping a new type of development - sustainable - on this basis demands the pursuit of five principal objectives, interlinked in the formation of a S&T field in the region:

- 1) construction of its unit;
- 2) construction of its autonomy;
- 3) enhancement of its efficiency;
- 4) sizing its dimensions;
- 5) introduction of the framework ideas of sustainable development as a reference.

Unit of the field. The quest for this objective results in two movements: one that pursues interfaces among the output shaped by universalistics and finalistics institutionalities and the other urging joint efforts between the natural sciences and social sciences.

The S&T institutions of the region and the scientists that work within this system circles around their centers: the accumulation of scientific capital and the mechanism for the circulation and distribution of their elements for meritocratic or technocratic appreciation. The mechanisms which ensure such appreciation are structurally powerful in parallel to the power and legitimacy of the technology that underlies this science. They are powerful because they really constitute the laws which have produced the fundamental tension that guides progress of modern science²⁰. The fact that such progress - critical and for many standpoints, rash - is another issue, although it is of vital importance and of much interest to us.

The universalistic and finalistic institutions are thus structured expressions of the mechanisms for enhancing the value of S&T output. Their antagonisms in the field of global S&T thus do not indicate exclusive solutions but rather constitute a complementarity which at the local level can be expressed by dividing into two poles. This means that the two types of ventures need each other and

²⁰ A current manifestation of this power maybe assessed in discussions over the CNPq decision to strengthen meritocratic mechanisms, eliminating institutional grants when still in existence, even for master and PhD students. This was covered widely in the press. An excellent summary of its arguments can be found in the *Jornal da Ciência*, Year XI, n. 269, June 1997.

S&T process requires them²¹. This being the case, a necessary unit to which I refer should be obtained: a) through programatic principles and thematic organization that transcend the institutions as such, both in order to, first, establish the problems common to S&T and present them to its agents as a thematic framework that can overcome dycotomies (meaning to build up unit) between activities focused on basic research and those involved in applied research, between technological research and scientific research, and between social and economic research and scientific and technological research; to introduce the implications of sustainable development into the guidelines for the orientation of the field and b) through complying with the rules of the institutions found therein: not by denying this through laws and decrees nor due to mere political pressures on the rules of functioning for the field of S&T at both national and global levels²². This suggests objective intervention in the functioning of the meritocratic and technocratic rules which makes them themselves the vectors in the constitution of the unit of the regional field.

The first step is to establish the broad-ranging programatic principles that correspond to strategic options with general and specific implications for the field of S&T. For instance, shaped by regional history and social practice in evidence, it should be established that if longlasting fair development is the aim, diversity takes precedents over homogeineity as the guiding principle of S&T activities; that the principle of regional competitiveness takes precedents in scientific work over private product activitiy; that the biological paradigm prevailed over mechanical and chemical aspects and that the preferential scale for sustainable development is a small venture.

The establishment of *themes* should be the outcome of a drive to interlink these principles with the forms and basis of action for the social and economic structures found in the region, spotlighting the links in the production chain - from infrastructure through production and processing to circulation - each of which with their own S&T needs.

Obtaining this type of basic framework will not be only the outcome of a technical process but rather the dynamics of bringing the natural scientist closer to social world, through theory - where the necessary mediation of social scientists (as the decoders of this universe) convert at a specific moment

²¹ Very recently, Gordon Johnson, the dean of the Wolfson College, Cambridge, once again presented the complementarity - and the practical interest over the long term acknowledged in the type of support by industries - of "blue-sky research" which "... you do not see where it is going, nor do you have any certainty regarding the results and there may be no immediate application" and "... where it is necessary to give the academic the maximum amount of freedom to think and spend, to spend and to think" (Johnson: 1997).

²² For instance: the lobby attempting to alter in favor of the North - as an underprivileged region, the meritocratic mechanisms of S&T functioning at the nationwide level. There is there an implicit allusion here to VICIOSO functioning that is skewed in favor of the Southeast. Personally, I do not believe this is the case. As has already been made clear, the mechanism itself is concentratory. This means that even when acting with full regionalistic transparency (and this is certainly the case), nevertheless the outcome is unfavorable for regions that do not have their own S&T field, as is our case, compared with those which have already built this

into the unit of the field itself - and the practical size through which, once the social players have made their expectations clear with regard to the field of S&T, objective horizons are set for the insertion and legitimacy of scientific undertakings as such²³. These are the general lines of a process for building a S&T project for the region.

The objective interventions in the meritocratic rules imply the local creation of merit value that can be converted into scientific and technological capital (resources for research, etc.) by through the convergence of the project (or work) with the thematic framework discussed in the previous item. There are many tools that must be triggered for this to occur:

The creation and strengthening of regional scientific media (one suggestion would be a thematic-regional cutting; heavy investment in an “Amazon Botany Review” which could cover, if possible, - through encouragement and the quality of this publication - the entire botanical output of the region; as well as an “Amazon Agronomy Review”, “Amazon Economy Review” etc.)

Acknowledgements awards.

Alteration in the equation for boosting the value of S&T output in the region. We said earlier that the merit value (V_m) of a scientific undertaking research or article was objectively established by an equation of the following type: $V_m = P + D^{-1} + E(u)$, where P would be the paradigmatic framework, D^{-1} the inverse of the distance between the product obtained or in view from the border of the paradigm, and $E(u)$ the hope for the respective use thereof. By requiring that $E(u)$ be “measured” by the level of convergence of the product obtained or in view with the framework discussed above, this would result in intervention in the mechanisms establishing merits. This merit must however be convertible into scientific or technological capital in order to make strategic sense. It must offer guarantee that the continuity of the undertaking through the availability of resources for this purpose, under the same rules.

The framework outlined above should also be the *tecnocratic reference* between the local institutionalized relationship and propositions from elsewhere, at both the national and international level.

These resources should be available either locally or under local control (or resources from elsewhere would be accepted) for partnerships filling in the fields in the reference-framework, etc..

Autonomy in the regional S&T field. Autonomy is taken here to mean the political backing of the field through its legitimacy before the major sectors of society and the expression of this

up. And among them, those who have invested more social efforts in consolidating this field in relative terms are favored to a greater extent

²³ Peter Weigel and Cláudio Fonseca recently developed a methodology which, with adaptations could become a basic guide for obtaining this framework. The rapid knowledge and broad dissemination of this work is recommended (see Weigel and Fonseca, 1997 - original).

legitimacy in the form of local funding for its functioning. This autonomy produces (and derives from) the capacity of local society to retain to its own advantage the results maximized by the meritocratic and technocratic mechanisms of the organization of the S&T undertaking.

In Brazil, the universalists ventures internalize scientific paradigms and the finalistic ventures absorb the technological paradigms dominant at the global level. As the vectors have been conducted by the central powers in the country, they are supplemented by local S&T actions and undertakings which seem to be the principal component in shaping paradigms to the practical requirements of social reproduction. It is as though the S&T system in Brazil would delegate to local levels of power the tasks of adjusting and sizing its results in economic and social terms. This strategic “delegation” is not stated explicitly but is real and structurally consistent, meaning it can produce (and has produced) a long-term development dynamics, not only for S&T. Viewed from regional standpoint, however, its power to heighten the dilemma of scientific merit *versus* social fairness is devastating with marked effects on local standards for concentration of wealth and poverty.

The thematic unification mechanisms suggested above are also seen from another angle, ways of guiding and shaping S&T undertakings to real needs insofar as they constitute the organizers of structurally routed demands. They are thus the tools for building up the autonomy of regional S&T as they will produce their own set of problems from the strictly scientific and technological viewpoint, at the same time corresponding to the needs of the various economic and social structures found throughout the region. However the effectiveness of these guidelines depends on the actual mechanisms for putting them into practice: through financing under local control; through the participation of various social segments interested in the processes of formulating requirements, placing these requirements on the political wish-list and in monitoring and assessing the activities of S&T as such.

Bringing in funding (meaning social substance, deriving from the political will that is channeled and transformed into means) controlled by a strategic center committed to the unification and autonomy of the S&T field in the region depends on two sources: state budgets and public financing for regional development. It is not realistic to assume that the oligarchic elites of the region will make any alteration in the possible flow of funding available today, at their own initiative. It is necessary to mobilize the social segments interested in S&T in order to ensure that local resources - even those covered in state constitutions and state budgets - do not undergo systematic suppression and discontinuity. The following points are of the utmost importance here: necessary means - for the lobbies of civil society that has S&T on their agendas from the standpoint of a notion of sustainability; for this task, the support and close links of NGOs could be of the utmost importance, particularly those testing alternative technologies and analysing traditional wisdom and know-how; support for scientists

in the region in setting up organizations which will make them into collective policy-makers, through civil society that can put pressures on local governments; local scientists and their regional allies should build up alliances for nationwide action that could redirect the flow of federal government funding through regional development in order to favor strongly S&T guided by the principles listed above, to the detriment of supporting the profitability of the private sector, which still constitutes the core of the tax incentives policy (with the implications mentioned above) for the region. I believe that, as this is necessary, the following idea can be defended whereby only private enterprises with sustainable technological basis (judged by criteria from the field of S&T rather than the technocracy of the regional development agencies) should have access to such incentives. State funding for S&T should be provided in the same proportion that is used today to finance private companies: for each unit of state financing, even the three FINAM agencies assigned to S&T, with the commitment to fixed remuneration - for quotaholders, based on state funding, with regard to the rate and duration; financing for regional S&T funds in proportion to private and state concessions of any type.

Sizing the dimensions of regional S&T and its level of efficiency. Based on the above suggestions, an expansion would logically be expected - in the S&T field in the region due to the inflow of fresh funding and its effects on the retention and training of scientific staff, together with enhanced efficiency: due to greater integration and internal cumulativeness as well as boosting its capacity to respond to the demand put forward by various social segments. However, an additional recommendation and comment is appropriate here. Based on the framework of principles and needs recommended above, this could well result in the establishment of a general outline of funding required for a project focused on the unity and autonomy of this field over a time horizon of perhaps a decade. One of the results of this exercise would be to highlight the needs of massive new S&T ventures in the region. This is because obvious areas for research and teaching for any responsible development project in the region are largely absent. I hereby mention two: the region urgently needs a major biological agriculture and agro-ecology center, as well as a major naval engineering research center.

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