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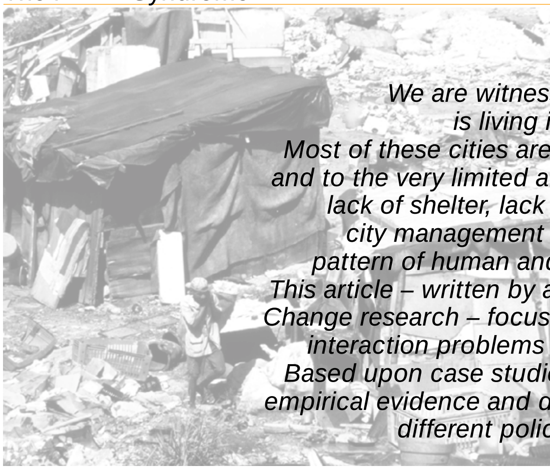

We are witnessing a secular global shift: more and more of the world's population is living in cities, some of which are huge megacities of unprecedented size. Most of these cities are located in the developing world. Due to the velocity of their growth and to the very limited action and planning capacities, many of them face serious problems: lack of shelter, lack of infrastructure (such as water supply and sanitation), financial and city management deficits often combine and reinforce each other, leading to a typical pattern of human and environmental problems, addressed here as the FAVELA Syndrome. This article – written by a transdisciplinary team of authors engaged in Global Environmental Change research – focuses from a systems analysis point of view upon these human-nature-interaction problems generated by rapid urbanisation processes in the developing world. Based upon case studies and global data sets the authors base their syndrome analysis on empirical evidence and draw some conclusions for "curing" the FAVELA Syndrome in terms of different policy-types, taking explicitly into account the limitations of the portfolio of local (and global) policies. *Abstract & Keywords ➪ p. 159*

Global Analysis and Distribution of Unbalanced Urbanization Processes: The FAVELA Syndrome

Jürgen Kropp*, Matthias K.B. Lüdeke and Fritz Reusswig

1. Global Change in Urban Regions

Today, global society is facing a qualitatively new type of environmental problems. These problems and their impacts on humankind itself and/or on the natural environment are no longer locally nested. They have transformed the surface of our planet in an unprecedented way in recent years [1, 2]. Major driving forces of global environmental change are, for example, technical and economic development, fossil fuel use, population growth and urbanization processes. The growing awareness that the Earth System is constituted of components that are strongly coupled with one another and that risky developments can affect social systems as well as different environmental spheres has paved the way for a number of new research programmes, e.g., the International Geosphere-Biosphere Programme or the Intergovernmental Panel on Climate Change [3, 4].

However, it is a formidable task to elicit more knowledge on the complexity of the dynamic interrelationships governing Global Change. This can only be solved adequately by the application of new and unconventional research strategies and tools, and has led to the introduction of a novel methodology for analysis and description: the so-called *syndrome concept,* first proposed by the German Advisory Council on Global Change [5]. This concept, formulated in analogy to medicine, defines syndromes of Global Change as archetypical patterns of problematic civilization-nature interactions. These syndromes can be interpreted as clinical pictures of non-sustainability and therefore characterize endangering and risky developments of the closely interlinked system Earth [6].

Especially in large, overcrowded and rapidly growing human settlements a specific pattern can be observed. This is mainly characterized by a high degree of poverty, important informal sector activities, rapid urbanization, and at the same time a lack of urban infrastructure including both technical and political planning capacities. This pattern is named the FAVELA Syndrome and is assumed to be a typical cause-effect complex which occurs at different places in the world. This is not the only syndrome of Global Change (see Table 1), but it will be elaborated here as a vicarious example. In contradistinction to other common approaches the syndrome concept uses quite a different method to analyse and model this type of pathogenic urbanism. Firstly a network of relationships is defined, which describes qualitatively the various interlinked processes. This network is by definition a transdisciplinary description of the critical process and uses a highly aggregated "vocabulary". Secondly a complex indicator is developed which allows the intensity of the occurrence of the FAVELA Syndrome to be determined in a regionally explicit way.

In the following sections, a brief overview of the syndrome concept is given (for a detailed description of the concept, see references [6, 7]. For the discussion of other syndromes, see references [8, 9]). Then the methodology of syndrome diagnosis is presented, followed by a more detailed qualitative description of the FAVELA Syndrome and its measurement intensity. Finally the results are presented and a discussion section concludes this paper.

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2. The Syndrome Concept

To understand the concept used for analysis of Global Change processes a few notions have to be explained first. The basic units for the description of the earth system with respect to problematic developments (syndromes) are the *symptoms* of Global Change, including the following: *tropospheric pollution, loss of species diversity, knowledge and technology transfer, urbanization*, etc. They define the most relevant aspects of the global dynamics which are closely related to the man-nature interface. Currently the concept operates with about 80 symptoms, which have to be considered as symbols for highly aggregated entities (regarding the information theoretical background of this technique, see e.g. reference [10]). These symptoms, taken from different spheres (e.g. atmosphere, biosphere, economy etc.), focus on qualitative and quantitative changes of the earth system, and usually take into account both their states and their rates of change, e.g. rural poverty together with its change in time. However, for many of these entities quantitative data are not available and only qualitative information can be used. Additionally, between these symptoms there exist a huge number of potential interrelations which are neither conceivable as a whole nor are all active at the same time and location. Therefore from a system theoretical point of view it is necessary to decompose this global network of interrelations into smaller functional units. This separation is based on the assumptions (a) that complex Global Change phenomena cannot be resolved into isolated changes occurring within single spheres and (b) that the complex network of symptoms and interactions from different spheres is reducible in analogy to typical problems or maladaptions occurring within the metabolism of human and natural systems. The list of these patterns, entitled *syndromes*, is presented in Table 1.

2.1. Measurement of a Syndrome

In order to measure the occurrence of a single syndrome, its dynamics is first defined by the specific network of interrelations. This network is based on intuition and expert knowledge and represents only the interlinkages between those symptoms which have been identified to be relevant for the syndrome. However, the question arises whether the proposed network is actually active to a globally relevant extent, and therefore a syndrome of currently ongoing Global Change. A syndrome is active in a specific region, if ist most important trends and mechanisms occur simultaneously [6]. The degree of this activity is called the *intensity of a syndrome*.

Obviously, syndromes are trans-sectoral phenomena, which can only be examined by including the evaluations of experts from many different disciplines. In order to operationalize this, the incompleteness, inhomogeneity and uncertainty of data and knowledge from various experts have to be taken into account. The role of the syndrome analyst is to compile the expert knowledge and reconstruct it according to a formalized framework which exactly fits the requirements of an expert system [11].

An important tool which has promoted the progress of expert systems is fuzzy logic [12, 13]. In contrast to classical boolean logic, fuzzy logic makes use of continuous truth values between 0 and 1 which reflect fuzzy evaluations. These continuous truth values either reveal the usage of fuzzy evaluation categories (warm, cloudy, high, etc.) and/or the availability of limited or uncertain knowledge. The underlying idea is to evaluate, on the basis of the available information, different contributions in terms of fuzzy categories, which are then compiled into the form of a logical evaluation tree in order to obtain a single, yet fuzzy, measure of the intensity of a specific syndrome. Using generalized logical connectives (fuzzified AND, OR, NOT) this tree formalizes the criteria of the experts and syndrome analysts on how to combine the different contributions, which are strongly related to the qualitative analysis as symbolized in the syndrome-specific network of interrelations.

3. The FAVELA Syndrome

Currently 1 per cent of the global land surface is occupied by human settlements [14]. A high local population density often results in negative effects

Table 1. Global Change phenomena like soil degradation, climate change or worldwide development disparities can be structured by symptoms and their reinforcement, resulting in so-called syndromes of Global Change. These patterns of non-sustainable development can be grouped according to basic human usage of nature: as a source for production, as a medium for socio-economic development, as a sink for civilizational outputs, see also [7].

	Utilization Syndromes
SAHEL Syndrome	Overuse of marginal land
OVEREXPLOITATION Syndrome	Overexploitation of natural ecosystems
RURAL EXODUS Syndrome	Degradation through abandonment of traditional agricultural practices
DUST BOWL Syndrome	Non-sustainable agro-industrial use of soils and bodies of water
KATANGA Syndrome	Degradadation through depeletion of non-renewable resources
MASS TOURISM Syndrome	Development and destruction of nature for recreational ends
SCORCHED EARTH Syndrome	Environmental destruction through war and military action
	Development Syndromes
ARAL SEA Syndrome	Damage of landscapes as a result of large-scale projects
GREEN REVOLUTION Syndrome	Degradation through transfer and intrduction of inappropriate farming methods
ASIAN TIGER Syndrome	Disregard for environmental standards in the course of rapid economic growth
FAVELA Syndrome	Socio-ecological degradation through uncontrolled urban growth
URBAN SPRAWL Syndrome	Destruction of landscapes through planned expansion of urban infrastructures
DISASTER Syndrome	Singular anthropogenic environmental disasters with long-term impacts
	Sink Syndromes
SMOKESTACK Syndrome	Environmental degradation through large-scale diffusion of long-lived substances
WASTE DUMPING Syndrome	Environmental degradation through controlled and uncontrolled disposal of waste
CONTAMINATED LAND Syndrome	Local contamination of environmental assets at industrial locations

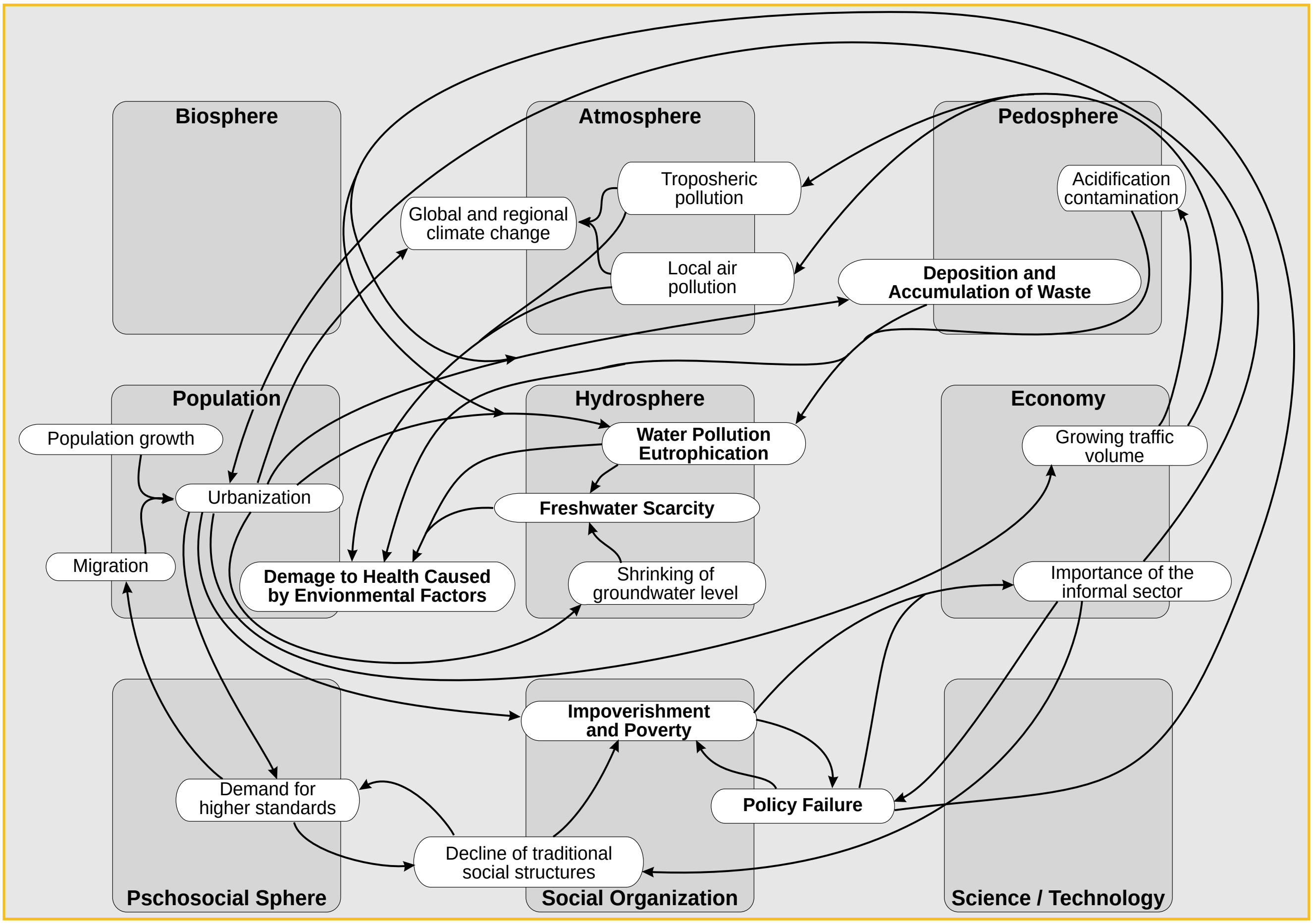


Figure 1. Network of specific interrelations of the FAVELA Syndrome. The symptomes written in capital letters are essential for the critical process and they are designated as the core of the syndrome.

(e.g. resource exploitation, air pollution etc.) in and around the cities (cf. reference [15]). Throughout history, cities have been epicentres not only of power, wealth and civilization, but also of social conflicts and epidemics [16]. Only in recent times, due to advances in medical science, sanitary engineering and planning strategies, have most cities in the industrialized world become fully sewered, hygienic, well developed and planned. Even in such cities we can find a broad range of social and ecological problems. But compared to cities affected by the FAVELA Syndrome they show a very different phenomenology caused by different driving forces – that is why we classify the problematic developments in these cities in a distinct syndrome, the so-called URBAN SPRAWL Syndrome (see Table 1). However, in many cities urban population is growing at a very high speed – much faster than during the rapid growth phase of cities in industrialized countries more than a century ago. As a result of present trends at least one third and in some cases more than half of the inhabitants of huge cities live in overcrowded tenements or shanty-towns lacking basic amenities [17, 18]. However, the term FAVELA Syndrome does not only refer to that specific form of settlements, it is also used synonymously for the functional relationship leading to it. This pattern can be derived by generalization of various case studies which are related to this topic [19–24].

3.1. Network of the Syndrome Specific Interrelations

The problematic development pattern representing the FAVELA Syndrome is specified by the syndrome-specific network of interrelations (Figure 1), where the ellipses represent the symptoms and the arrows for enforcing interactions. In short, the FAVELA Syndrome can be defined as a *socio-ecological degradation due to uncontrolled growth* of urban areas (cf. Table 1). The growing population which exists for various reasons in human settlements (in-migration, high internal growth rate) is one of the essential indicators for the existence of the syndrome and contributes mainly to *urbanization* [25]. Especially the globally perceptible trend of rural exodus is a permanent and major driving force of this syndrome. The causes of in-migration are various push-and-pull factors including land degradation, rural poverty, the attraction of urban jobs or health services. Often the new poor urban residents occupy the land on which their home is built illegally (*poverty*). In these areas, essential infrastructure such as drainage systems or water supply is negligible or non-existent [26, 27]. Uncontrolled waste disposal has drastic consequences for the urban water resources (*water pollution and scarcity*) [28], which are directly interlinked with important *health risks* for the urban dwellers [29]. If such a region is affected by a rapid growth rate such a problem complex will stretch the civic administration to the very limit. Local and state authorities are often unable (e.g. due to low tax yields), or unwilling (e.g. due to inappropriate public management structures or corruption) to take preventive or curative action (*policy failure*). The consequences of management deficiencies result in a significant amount of the urban residents having no access to basic amenities, such as drinking water or sanitary services. The socio-economic marginalization of a significant proportion of urban dwellers leads to the increasing importance of the informal sector.

3.2. Intensity of the Favela Syndrome

In order to obtain a global overview of the countries affected by the Favela Syndrome one has to measure the processes characteristic for syndrome development. This means that symptoms and interrelations have to be identified in a single country. Symptoms are usually characterized by their state and rates of change, i.e. their dynamic behaviour caused by, for example, enforcing interactions within the syndrome specific network. However, because of a lack of data it is impossible to measure all symptoms and connections of the specific network. Therefore, one has to determine the *core elements* of the syndrome which are necessary for its occurrence, see Figure 2. According to the qualitative analysis of the syndrome above (i.e. the formalization and generalization of case studies and expert guess), the following symptoms are necessary for the occurrence of the Favela Syndrome:

- urbanization,
- urban poverty,
- policy failure.

Furthermore, the cause-effect chain

- urbanization → environmental degradation by deposition of waste → damage to health is a necessary aspect of the Favela mechanism. In order to measure these aspects of the Favela mechanism, the following indicators are used (the numbers refer to those in Figure 2):

(a) High urban net population growth ①, including net migration and endogenous net growth, is a reasonable indicator for urbanization. Further facets of this process are sufficiently correlated to population growth.
(b) We utilize the total number of urban inhabitants living below a defined limit of income ② which is necessary to meet basic needs, and the relative change in this number ③. Referring to the Favela Syndrome mechanism one would expect both a high proportion of poor people and an increase of its absolute number.
(c) The dashed arrows of the cause-effect chain (Figure 2) can be indicated by a high proportion of the urban population without access to sanitation services ④ and an increase in the absolute number of these people ⑤, as uncontrolled house sewage disposal is a major contributor to health damage, both directly and via microbial water pollution (in the sense of a sufficient condition) [30]. The dotted arrows (Figure 2) can be directly indicated by the high proportion of urban inhabitants without access to safe drinking water ⑥ and an increase in the absolute number of these people ⑦. To maintain the cause-effect chain described above it is sufficient that one of the two infrastructure aspects (safe water supply or sanitation services) is problematic.
(d) To indicate the insufficiency of government measures with respect to rapid urban growth the annual public expenditure for infrastructure improvement per urban resident ⑧ is used. Furthermore we compare the public expenditure for community development with the total public expenditure ⑨ in order to estimate the relevance of the urban development issue for the respective government. A high relevance makes it probable that further measures are initiated by the government which are not indicated by ⑧. Therefore the coincidence of low absolute investment per capita and of a low priority of the urbanization issue is a reasonable measure of policy failure.

Figure 3 shows the logical structure of our qualitative analysis described above using a decision tree. In a first step the numerical data input (circles) has to be evaluated with respect to the logical clauses (rectangles). These logical clauses are then connected by "AND" ($\tilde{\vee}$) and "OR" ($\tilde{\wedge}$) connectives. In the boolean sense the whole analysis would result in the decision whether the clause $\begin{pmatrix}\text{Favela intensity}\\ \text{high}\end{pmatrix}$ is true or not. If one looks, for example, at the problem of defining the exact threshold of net urban population growth for the truth of the clause

$$\begin{pmatrix}\text{urbanization}\\ \text{high}\end{pmatrix}$$

it becomes obvious that the concept of boolean logic is not appropriate for the kind of qualitative knowledge used in this study. Therefore, we rely on the Fuzzy-Logic concept, based on continuous truth values between 0 (false) and 1 (true). In the case of our example we first define a threshold of population growth below which

$$\begin{pmatrix}\text{urbanization}\\ \text{high}\end{pmatrix}$$

is certainly false (2.0 per cent per year, see Table 2) and another one above which it is certainly true (4.5%/a). Between these thresholds the truth value is assumed to increase linearly from 0 to 1. This concept can be expressed by a membership function $\mu_{z_i}(\iota)$ and is called *Fuzzyfication* (Equation 1).

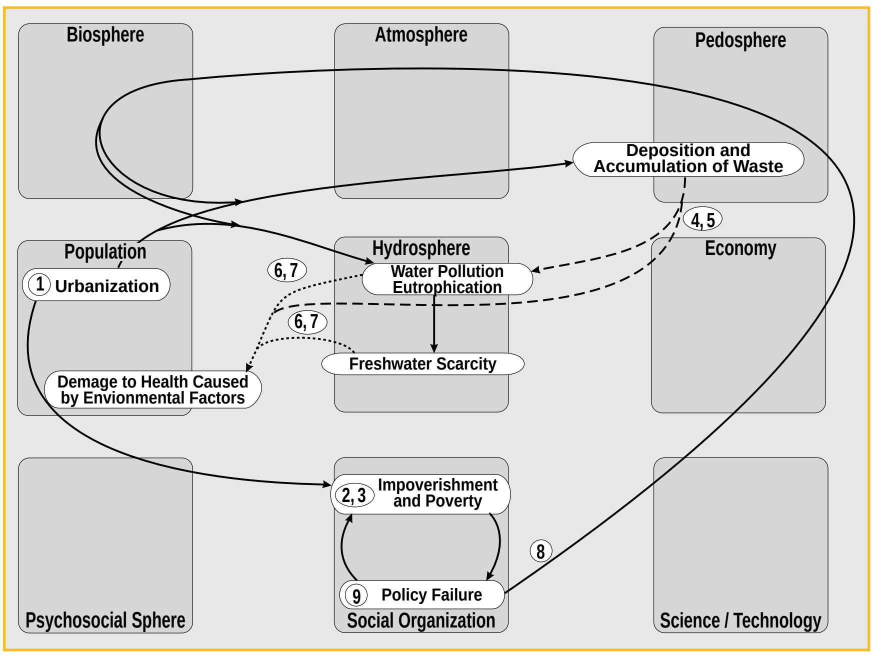


Figure 2. Core elements of the Favela Syndrome. The occurrence of distinct symptoms and relationships is measured by the indicators which are labelled by the numbers – and which are described in detail in section 3.2.

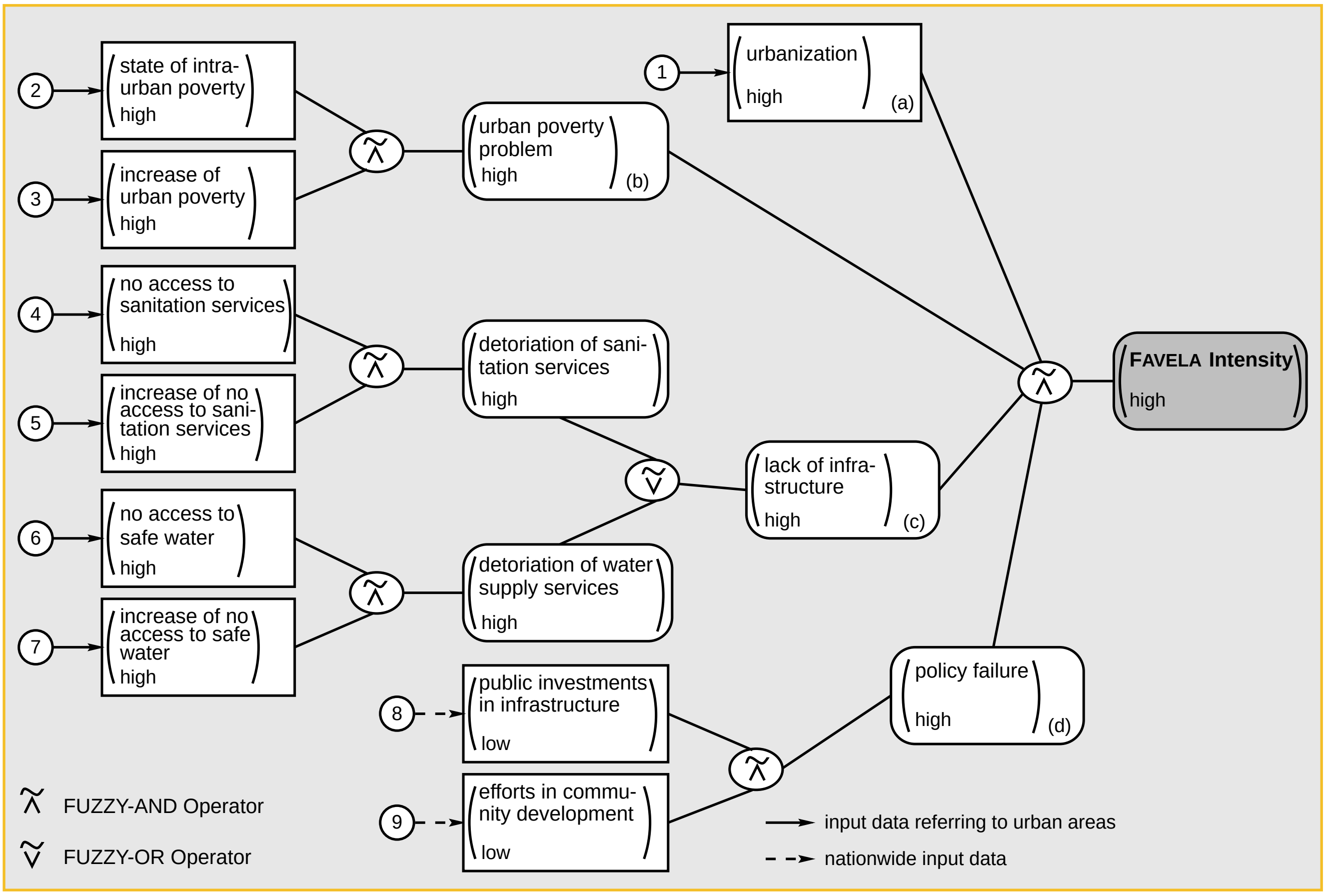


Figure 3. The decision tree for intensity measurement of the FAVELA Syndrome. After fuzzyfication most of the indicators are combined by a FUZZY-AND operator. This is not valid for the measurement of the infrastructure. The measurements for water supply and sanitation services are combined via a FUZZY-OR because the damage to health may be induced by water pollution and scarcity of freshwater or directly by accumulation of waste.

where z_i denotes a logical clause, μ_{z_i} the respective truth value and i the input data. The respective parameters for all indicator-based logical clauses used in the analysis and the threshold values necessary for equation 1 are documented in Table 2. In the next step the expansion of the boolean "AND" and "OR" connectives has to be defined.

Here, we use the so-called "FUZZY-AND" and "FUZZY-OR" operators, which include the parameter γ ($0 \leq \gamma \leq 1$), allowing for choosing continuously between a simple MIN (MAX) operator and the arithmetic mean of the input truth values [13] (Equation 2):
γ values near 1 yield a strictly non-compensatory behaviour of the connectives: in the case of the FUZZY-AND for example, the minimum of the input truth values will determine the result, independent of the other input values, which may be much higher. This parametrization is suboptimal for two reasons:

- obviously there will be errors in the input data: to ensure the robustness of the algorithm a compensatory component should be included;
- the necessity of the coincidence of the conditions (a)–(d) is based on the assumption of strictly monotonic syndrome dynamics, which is a first order approximation (in the "real" syndrome dynamics a symptom may stay constant for a time although the syndrome specific mechanisms are still active).

To meet these conditions, a γ value of 0.2 (i.e. a significant compensatory component), was used for all connectives. Beside the uncertainties in the available data there are significant gaps in the data base. The data base for the evaluation of the above conditions (a)–(d) is complete only for 43 of 160 countries. According to the aim of extracting the maximum amount of information from the available data we checked all possible results for the intensity measurement if there are non-existing (and

$$\mu_{z_i}(\iota) = \begin{cases} 0\,, & \iota \leq \iota_1 \\ \dfrac{\iota - \iota_1}{\iota_2 - \iota_1}\,, & \iota_1 < \iota < \iota_2 \\ 1\,, & \iota_2 \leq \iota \leq \iota_3 \\ \dfrac{\iota_4 - \iota}{\iota_4 - \iota_3}\,, & \iota_3 < \iota < \iota_4 \\ 0\,, & \iota \geq \iota_4 \end{cases} \quad \text{with} \quad \iota_1 < \iota_2 < \iota_3 < \iota_4\,, \tag{1}$$

$$\mu(z_1 \tilde{\wedge} z_2 \tilde{\wedge} \ldots \tilde{\wedge} z_N) = \gamma \cdot \min(\mu_{z_1}, \mu_{z_2}, \ldots, \mu_{z_N}) + (1-\gamma) \cdot \frac{1}{N} \sum_{i=1}^{N} \mu_{z_i}$$

$$\mu(z_1 \tilde{\vee} z_2 \tilde{\vee} \ldots \tilde{\vee} z_N) = \gamma \cdot \max(\mu_{z_1}, \mu_{z_2}, \ldots, \mu_{z_N}) + (1-\gamma) \cdot \frac{1}{N} \sum_{i=1}^{N} \mu_{z_i} \tag{2}$$

Table 2. Fuzzyfication of basic indicators. For the interpretation of the threshold values ι_i see equation 1. In our case for a specific fuzzyfication only a part of the whole ramp function is used (either the increasing or the decreasing part). Therefore the irrelevant "edges" which are outside the range of the data are omitted in the table.

Indicator *i*	logical clause z_i	course of $\mu_{z_i}(\iota)$ ι_1	ι_2	ι_3	ι_4
① Growth rate of the urban population [1980–1993, %/a]	(urbanization high)	2.0	4.5	–	–
② Urban poverty [1980–1993] in % of population	(state of intra-urban poverty high)	5.0	35.0	–	–
③ Relative change in urban poverty [1980-1990, %/a]	(increase of urban poverty high)	0.0	1.0	–	–
④ Urban population without access to adequate excreta disposal facilities [1980–1993, %]	(no access to sanitation services high)	–	0.0	80.0	–
⑤ Relative change of urban residents without access to excreat disposal facilities [1980–1993, %/a]	(increase of no access to sanitation services high)	0.0	1.0	–	–
⑥ Urban population without access to safe drinking water [1980–1993, %/a]	(no access to safe water high)	–	0.0	80.0	–
⑦ Relative change in urban dwellers without access to safe drinking water [1980–1993, %/a]	(increase of no access to safe water high)	0.0	1.0	–	–
⑧ Public investments in infrastructure in USD/urban capita [1985]	(public investments in infrastructure low)	–	–	0.0	400.0
⑨ Public expenditure for infrastructure as percentage of total [1985]	(efforts in community development low)	–	–	0.0	30.0

therefore, at worst, arbitrary) input truth values. To do this missing estimates (a)–(d) are replaced by sucessively increasing values (in 0.01 increments and in case of two missing values in all combinations). As a result one obtains a minimum truth value μ_F^{Max} for the Favela measurement indicating the best case and a maximum value μ_F^{Min} labelling the worst case of development. Finally, we indicate the uncertainty of the calculated results by using the difference $U = \Delta\mu_F = \mu_F^{Max} - \mu_F^{Min}$. This measure can become 1 in the case of total uncertainty of the calculated results and 0 in the case of certainty. To illustrate the mechanism of how a complete uncertain input value may produce a limited uncertainty in the result let us assume the simple relation Y = min (X, *unknown*), where X and "*unknown*" are the input variables. For $X = 0.1$ and the unknown value anywhere between 0 and 1, Y can only range from 0 to 0.1 – which represents much less uncertainty than is contained in the unknown value. Unfortunately, this situation changes if X reaches for example the value of 0.9. Therefore, the uncertainty of a result depends both on the form of the algorithm and the values of the known input variables.

3.3. The Data Sets

The available data were evaluated for the time interval 1980–1993. The resulting intensity measurement is therefore valid for the time around 1985 (the numbers refer to those in Figures 2 and 3).

The growth rate of urban population ① is calculated based on data of the urban population from the World Resources Institute database [31]. The estimation of poverty lines is a very difficult topic (see e.g. reference [32]). By means of different sources we have created a database for the percentage of the urban population living in absolute poverty ②. These data are valid for 1980 and 1990 [33, 34]. By multiplication of the percentage ② with the total number of urban residents obtained from the World Resources Institute database [31], the absolute number of urban dwellers living in poverty is determined. Subsequently, the relative change in this number between 1980 and 1993 is calculated ③.

The indicators measuring health care are derived from a database distributed by the World Health Organization [35]. They include the percentage of urban dwellers having access to adequate house sewage disposal facilities ④, and the relative change in the number of urban dwellers without access to sewage disposal facilities ⑤, where the latter is determined using urban population data from the World Resources Institute [31]. Additional indicators are the percentage of urban residents having no access to safe drinking water ⑥ [35] and the relative change in urban residents without access to safe drinking water ⑦ which is calculated in the same way as described for ⑤.

For the measurement of *policy failure* the following data are used: The amount of public expenditure per urban capita invested for community development, slum-clearance activities or housing ⑧. These values are based on data from the World Bank [36] and the World Resources Institute [31]. The last indicator determines the percentage of public expenditure used for community development ⑨ [36].

4. Results

The result of the analysis is a global evaluation of the severeness (*intensity*) of the FAVELA Syndrome (Figure 4a). The time period for which these results are valid is 1980–1993, since during this time period the largest amount of data, especially on poverty and sanitation services for urban areas, are available (for example, see reference [37]) on a nationwide basis. Therefore, the results displayed in Figures 4a and 4b for each country reflect a nationwide average over the cities of the respective country only. This is a serious shortcoming for any research on Global Change problems such as the FAVELA Syndrome which clearly has very different local expressions, as many case studies show. Here exists a need for further research. Nevertheless, even if we had at our disposal global datasets on cities with a better local resolution than at present, we would still need national averages as have been used in our study. Urban problems are by no means de-coupled from other social or environmental problems of a country (e.g. the driving forces for the Favela Syndrome located in the Sahel Syndrome), and political action capacities (e.g. the resources of the national political system) are clearly limited; they need to be focused according to priorities. To measure the relevance of a specific syndrome for a country – in terms of severeness and priority for political decision makers both on a national and on an international level – a national (urban) average has to be made and compared with the intensity of other syndromes that might occur on a country level. As explained in detail in section 3.2, Figure 4a shows as the main result the truth values for the clause *"intensity of the Favela Syndrome is high"* (red for "true", green for "false", respectively). As discussed earlier, this result has different degrees of certainty due to data gaps in different countries. This uncertainty is presented in Figure 4b. The truth value for a particular country was omitted when less than half of the necessary data was available (blue land areas in Figures 4a and 4b).

As a further application of the algorithm introduced above, we checked the change of which input factor (i.e. high urbanization, high lack of infrastructure, high urban poverty or policy failure) could lead to a maximal improvement (decrease) in syndrome intensity for a particular country. From the structure of the FUZZY-AND operator which combines the four factors into the intensity measure, it becomes clear that the variable with the lowest value influences the intensity most effectively. In Table 3 we show the distribution of this "sensitive factor" for the countries where complete input data sets exist.

It is thus clear what policy advice our systemic indicator will propose: Improve those factors that ensure a maximum reduction of the Favela Syndrome, i.e. those factors that are already in a relatively good condition. This result from the mathematics of the algorithm becomes plausible if one takes into account that these four factors are related by the syndrome mechanism (see Figure 1). Influencing one of them affects the other factors, e.g. high urbanization increases the infrastructure and poverty problems, lack of infrastructure increases via damage to health the poverty problem which interacts with policy failure via a positive feedback loop etc. Thus, according to our model, a further improvement of the factor with the (relatively) best performance is the most efficient way to decelerate the fatal dynamics of the syndrome.

Of course one could think of other policy options to reach sustainable urban development. One could put forward a strategy that *combines* poverty reduction, infrastructure improvement, the curbing of rapid urbanization processes and a better allocation of public expenditures. This would clearly be the best policy option both in syndrome terms

Table 3. Policy objectives to mitigate the Favela Syndrome mechanism most effectively under limited resources – for detailed interpretation see text. Only countries with the full indicator information are considered. If other factors promise similar success in reducing intensity of the syndrome they are given in brackets.

(1) Combat poverty	(2) Improve infrastructure	(3) Reduce urbanization	(4) Combat policy failure
India (2)	Bangladesh	Chile (2)	Botswana (2)
Indonesia	Cameroon	Arab Republic of Egypt (2)	Brazil
Kenya	Ghana	El Salvador	Colombia (1)
Republic of Korea	Lesotho	Sri Lanka (1)	Dominican Republic (2)
Madagascar	Malawi (1)	Uruguay (1)	Ecuador (2)
Malaysia	Mali (1)		Togo (2)
Mexico	Morocco (1)		
Nicaragua (2)	Nepal		
Pakistan	Peru (3)		
Papua New Guinea	Philippines (1)		
Paraguay	Thailand		
Tanzania	Tunisia (1)		
Venezuela	Zambia		

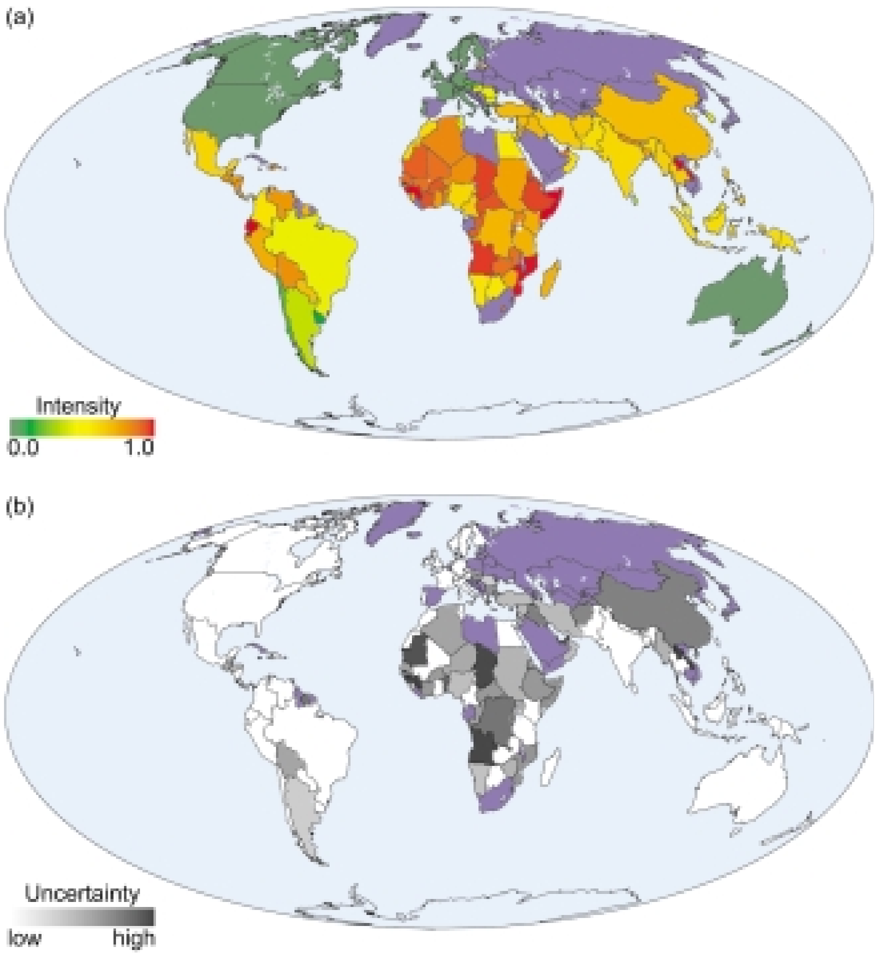


Figure 4. (a) Truth values (1 = true; 0 = false) of the clause $\begin{pmatrix}\text{Favela intensity}\\ \text{high}\end{pmatrix}$.

(b) Degree of uncertainty of the results displayed in Figure 4a. The decrease in certainty is encoded by the transition from white to dark grey (for a detailed description see text, section 4). Blue land areas indicate that less than half of the input data used are available.

and in terms of sustainable development, where economic, ecological and social goals have to be equally met. Nevertheless even sustainable policy options have to take into account the problem of *limited action capacities* and *restricted resources*. What if there is only a very small amount of money, time, or organisational capacitiy available to mitigate the FAVELA Syndrome – for example because there are other problems or syndromes around? In this case our limited optimalisation strategy is a guide to realistic sustainable urban development, taking into account not only actual limitations but also path dependencies of urban and political systems. The relatively good performance of the "minimum" or "sensitive factor" indicates with some probability a more or less marked "success story" of urban management that could be built on from an efficiency point of view.

5. Discussion

As a first result we find that the FAVELA typical pattern of urban system growth cannot be detected in highly industrialized countries of Europe and North America. This is not very surprising, since most of the experts see other types of problems (urban sprawl, high energy use, toxic waste etc.) as being active here.

We now discuss our results by selecting nine countries and confront our findings with various other sources from the literature. The selection criteria were: (a) countries with no uncertainty, (b) three countries from each continent (Latin America, Africa, Asia) for reasons of regional comparability, and (c) countries with different limiting factors (see Table 4).

At a first glance one might be surprised by our results for Brazil, classifying its FAVELA intensity as only medium- opposite to expectations and associations raised by the name Favela. Urban poverty and urbanization are both quite high, whereas the lack of infrastructure and especially policy failure is lower. We identify the latter factor as a sensitive one and thus a key element in syndrome mitigation policies under conditions of limited resources and the search for most effective solutions. The central government expenditures on housing, amenities, social security and welfare (including water supply, slum clearance, water treatment) were 32 percent of the total expenditure (1980) and 25.5 percent (1991) [36], indicating a relatively low policy failure according to our definition. Brazil launched the PROSANEAR project to serve the urban poor in 1982 who had up to then been widely neglected by water and sanitation projects. The project had only limited success in the 1980s and it was about to fail when World Bank intervened in 1992. The joint effort of the Brazilian government and the World Bank led to remarkable successes in providing for the urban poor (about 1 million people benefited from the program until 1998), mostly due to two key features of the program: (a) it was oriented towards the real needs of the poor households and was carried out in a highly participative manner, (b) it made use of appropriate low-cost technology that could both be run and financed by the poor [38].

In Mexico the syndrome intensity is higher than in Brazil. As urbanization rates in both countries are comparably high, this is mostly due to higher degrees of lacking infrastructure and policy failure. The water supply and sewage system of Mexico City, the largest Mexican city, is highly unsustainable. With a daily supply of more than 300 liters per person the city exceeds per capita consumption figures of most European cities. 25% of the water is lost due to deficient pipe systems. The annual costs for water supply of Mexico city is are about 450 million USD; the revenue obtained from the service is about 42 million, less than 10% of the total cost [39]. Policy failure is mainly due to the strong focus upon growth and a wide neglect of inequality and poverty issues in the 1970s and 1980s – despite a populist, if not revolutionary rhetoric of government officials [40]. Nevertheless some action was taken by the end of the 1980s by targeting the poor with a national program (PRONASOL) to improve their economic opportunities, health and housing situation, including water supply and sewage infrastructure [41]. This effort, together with a slight reduction in poverty at the end of the period covered by our data, kept urban poverty lower than in the Brazilian case. Unfortunately Mexico did not follow the path of poverty reduction in the later 1990s (not covered by our survey), whereas Brazil managed to improve that issue to a remarkable extent [42].

The last country in Latin America, which we will discuss briefly, is El Salvador. Its FAVELA intensity is almost equal to that of Brazil, whereas the crucial factor for further progress under limited conditions is the relatively low degree of urbanization. A very critical factor instead is policy failure. This

Table 4. Truth values for a few exemplary countries and logical clauses.

Country	Brazil	El Salvador	Mexico	Botswana	Kenya	Zambia	India	Malaysia	Thailand
logical clause	truth values								
(urbanization high)	0.76	0.27	0.75	1.00	1.00	1.00	0.70	1.00	1.00
(urban poverty problem high)	0.69	0.42	0.52	0.72	0.50	1.00	0.48	0.11	0.60
(lack of infrastructure high)	0.45	0.36	0.71	0.37	0.75	0.74	0.49	0.49	0.40
(policy failure high)	0.13	0.88	0.58	0.34	0.89	0.92	0.89	0.66	0.83
(FAVELA intensity high)	0.43	0.44	0.62	0.55	0.73	0.88	0.61	0.47	0.65

finding is very fitting in the case of El Salvador, a country that was the scene of a violent civil war from 1979 to 1992, leaving the country in severe crisis and with many dead and displaced persons. In part due to the war, the government cut back expenditures for basic social services (health care and education); they dropped from 5.8% of GDP (1980) to 2.4% (1990). The civil war diverted public resources from infrastructure and the social sector to military expenditures. After 1989, a new government formulated a comprehensive poverty alleviation strategy (safety nets, improved access to basic social services); public social sector expenditures rose again (from 23% of total public expenditures in 1988 to 31% in 1992). However, the impact of this initiative has been limited by major structural constraints [43]. The war has led to flaws not only in all population data, but in our limitational approach as well. The relatively low degree of urban growth in the 1980s is largely due to the huge number of people that left the country as refugees. Both before and after the period covered by our data the urbanization process was more intensive. This example shows that no policy advice could be quasi automatically "deduced" from the syndrome indication proposed here; case and region based knowledge is an indispensible companion of syndrome research.

Turning to Africa, Botswana shows a medium FAVELA intensity, whereas that of Zambia is very high. Both countries saw high urbanization rates during the 1980s and early 1990s, although on a quite moderate absolute level in Botswana. Both countries are economically dependent upon primary resources – diamonds in the case of Botswana, copper in the case of Zambia. The distributive effects of the economic exploitation of these resources are very uneven in both countries, leading to high urban poverty rates, dampened a little more by Botswana's mixed economy structure. Falling copper prices since 1975 and an inappropriate development policy led the Zambian economy and the country's social system into heavy crisis, affecting the rural population first. Rural exodus led to an overloaded urban infrastructure typical for the FAVELA Syndrome. The cutbacks in social policies and in service provisions during that period contributed heavily to the syndrome occurrence in the case of Zambia [44]. In Botswana the policy failure was much less marked, mainly due to infrastructure provisioning, social and

health policies [45]. The recommendation would thus be to further promote this path of policy prudence. In the Zambian case only the improvement in infrastructure seems promising. In the case of Kenya, where the overall incidence of the syndrome is between the Zambian and the Botswanian case, further improvement of the situation of the urban poor seems most promising (rate of urban poor 1992: 30.7%), given very high rates of urbanization and policy failure. In Kenya the latter aspect is much due to the fact that the state has reacted only lately and with unclear concepts to the syndrome. The policy of bulldozing settlements, compulsory evictions and inappropriate alternative settlement schemes prevailed for a very long time [46].

Our last cases are located in Asia. Thailand shows a slightly higher intensity of the syndrome than India, whereas Malaysia has performed somewhat better – despite the fact that the urban population growth in all three countries is high, in Thailand even very high. The latter country serves as an almost classical example for urban primacy (more than 60% of the total urban population lives in Bangkok), being the destination for most rural-urban migrants and serving as by far the most important national economic growth-machine. In India we find many more big cities, including four megacities (Mumbai, Calcutta, Delhi, Madras) with 5 to 12 million inhabitants. In both countries, India and Thailand, many urban residents live in shanty towns and in inner city slums. But whereas about 75% of the Bangkok slums have their own access to safe drinking water [23], this holds true for a much smaller proportion of people in Indian cities. Severe and widespread water-borne diseases, concentrated mainly in urban slum areas, are a well-known problem in Mumbai, Delhi or Madras [46, 47]. One might be astonished to see that the urban poverty problem is slightly higher in Thailand than in India, which is home of much more poor people (about 320 million in 1993). Nevertheless India managed to reduce poverty incidence from 45 (1950) to 36 percent (1993–1994). And although this meant an increase in the absolute numbers of poor, given India's population growth, about 76% of the poor in India live in rural areas [48]. As urbanization has accelerated faster than population growth, the absolute number of the urban poor has slightly decreased in the period covered by our data. In the case of Thailand we observe a slight growth in the number of urban poor. In spite of its overall good economic performance during the 1980s, the government launched a series of stabilisation and structural adjustment programmes that lead to a slight increase in the numbers of poor people, whereas the incidence of poverty (percentage of households) still fell by a little. In the following years (not covered by our survey) Thailand performed much better in poverty reduction [49]. The detected policy failures in both countries are comparably high, relating to clientelism, hierarchical and fragmented public authority responsibilities and little coordination in Thailand, inefficiency due to over-bureaucratization and high political priority for defense rather than city development in India. As many firms and private households in Bangkok use private ground water resources – leading to overuse – Thailand's policy failure does not lead to such an extent of water supply problems as is reported from many cities in India [50]. This would suggest a policy that enforces self-help and creativity by supporting poor households with adapted technologies and strong participatory elements, as in the case of Brazil's PROSANEAR project. Bangkok is nevertheless a good example of an ecologically problematic urban development, especially regarding air pollution, industrial waste or traffic jams. But this pattern of urbanization problems, observable as well in Seoul or Shanghai, is connected rather to the Asian Tiger than to the FAVELA Syndrome.

The situation is quite different in the case of Malaysia, where the syndrome intensity is lower than in India and Thailand. In spite of high urbanization rates and a moderate to high degree of policy failure, the performance of infrastructure provision is quite moderate and, most of all, urban poverty development is a big promising factor. After a period of relative stable urban poverty rates during the 1950s and 1960s, Malaysia saw a marked reduction of urban poverty during the 1970s and 1980s. This progress was partly a result of the trickling-down effect of the country's remarkable industrialization process during that time, when the country was part of the so-called "East Asian Miracle" in the 1980s [51], and partly due to government action within the framework of the so-called New Economic Policy, trying to reduce economic disadvantages of the poor, especially the Malayian majority [52]. In Kuala Lumpur, where 14% of the urban population of Malaysia lived in 1975, land demand is a constant problem, especially due to the urban poor that are looking for low-cost housing areas. The number of squatter households has remained relatively stable (40 000) for the 1970–1995 period, although overall city growth was substantial [53]. Further poverty reduction thus would be most effective in mitigating the FAVELA Syndrome.

With regard to the many case studies on urban environmental problems of the FAVELA type one might ask for the value added of a syndromic approach and its measurement proposed in this paper. There are two major shortcomings of case studies: first they lack global coverage, and second they lack comparability. Thus they are of very limited use for a global assessment of the processes of environmental degradation, health crises and unplanned urban growth as focussed on by the FAVELA Syndrome. Even if all major urban regions of the world were covered by case studies that record the performance of all relevant system variables and trace their time behaviour, for methodological reasons, it would still be an unsolved problem to compare and link those studies. Too many disciplines not co-operating in an inter- or even transdisciplinary manner, too many different approaches (bottom up versus top down, participatory, structuralist …) exist. There is no process in sight that would ensure future compatibility in methodological terms. And even if we had covered all urban regions by the same method of case study analysis we still would lack the analysis of possible future pathways based upon systems analysis.

Case studies will remain an important complementary source of information, but cannot substitute systems analysis approaches like the one introduced here. Case studies provide us with a constant stream of in-depth knowledge of problems, regions and actors, they are very useful tools to validate global assessments, and constitute a fruitful stock of evidence for checking policy advice derived from systems analysis. There is a clear lack of analytical and systemic tools that could make much more use of these positive properties of case studies for global assessments and modelling (but cf. [54,55]).

6. Conclusion and Outlook

An in-depth analysis of an archetypical cause-effect pattern of Global Change, named the FAVELA Syndrome, is performed systematically on the basis of intuitive expert knowledge and available data. The most important novel aspect of this approach is the decision to employ a trans-disciplinary pattern. This decision has a number of crucial implications.

First of all, we have to realize that a mature methodology for composing such pattern in a well-defined way is still lacking.

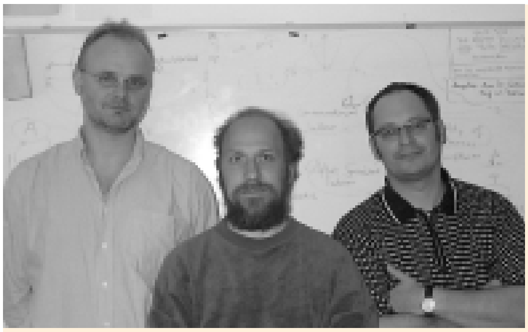
However, a symbol-based analysis of complex phenomena is a common methodology (e.g. in modern expert system technology; see, [56, 57]), and we have to accept that our everyday perception of entangled situtations ist undoubtedly organized into patterns, which are identified, processed and stored in a more or less intuitive manner. For some new and recent research efforts regarding the dynamical development of such pattern, see references [57, 58]. It is the major goal of the approach presented here to make this intuition generally more and more educated in order to provide a better understanding of the vast multitude of interrelated processes involved in Global Change.

The outcome of the analysis of the FAVELA Syndrome is a measurement of the intensity of the unbalanced urban development in certain countries. It can be clearly seen that mainly the African countries are affected by this syndrome, whereas the Asian countries and the countries of South America are affected to a lesser extent.

The evaluation scheme for occurrence of the central symptoms and their interactions as well as the severity (truth value of high intensity) of the FAVELA Syndrome allow, on the basis of available data, for a worldwide and comparative assessment of this specific pattern of problematic urbanization. Our analysis has shown that in most cases a result with a relatively high certainty can be obtained while for 35 countries the truth values obtained are characterized by a medium to low certainty. For the remaining countries the lack of data allows not even an uncertain assessment.

A comparison of these results with various empirical case studies confirms the outcome of our examination. The consistency between the expert knowledge and the obtained truth values supports our understanding of the complex network of interactions. The defined indicator is suitable for a regional assessment of critical urbanization processes. However, the lack of data makes it impossible to estimate this development in a large number of countries. Therefore further collection of data is necessary, especially in the case of an urban poverty assessment. Furthermore it is necessary to obtain more information of regional or even local resolution in order to get a more detailed picture of the spatial distribution of unbalanced urban processes within one country.

Although much more research is needed, we consider the measurement of complex interrelations based on syndrome patterns to be useful for identifying global "hot spots". The concept of the FAVELA Syndrome diagnosis presented here concentrates on a systematic assessment of the current processes of Global Change. However, it is the intricate dynamics of these processes which might bring about the major impacts of Global Change on human society. Therefore, at least weak projections of the main lines of development of globally relevant interactions between civilization and nature are required in order to develop potential steering concepts. The defined syndrome pattern opens a promising road towards management scenarios if the dynamics of such patterns are investigated. Therefore, our future work will mainly focus on this topic.



From left to right:

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