Deborah J. Shields
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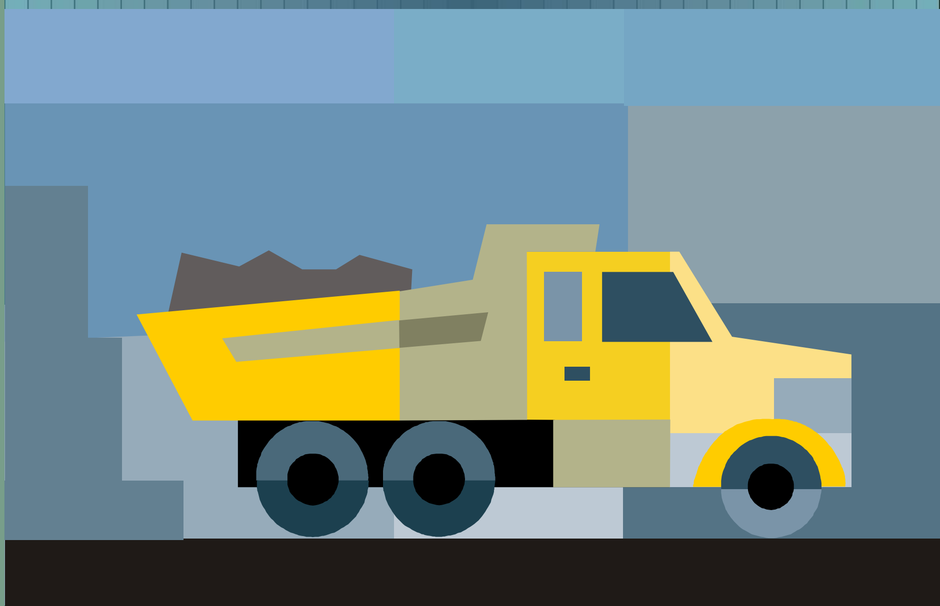
SUSTAINABLE MINERAL RESOURCE MANAGEMENT AND INDICATORS: CASE STUDY SLOVENIA



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GeoZS

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PREFACE

The authors' research in recent years has focused on integration of different stakeholders' goals and objectives into mineral resource policies and management plans. Monitoring and measurement are integral parts of this process. In this monograph mineral resource management, based on principles of sustainable development, is discussed. The principles of sustainable development advocate a balance among interested parties (stakeholders, government, industry) and sectors (economy, environment, and society), democratic processes, and equity within and across generations. A holistic approach is needed in mineral resource management. Particular stress is put on two aspects: the role of stakeholders' values and objectives, and the role of scale. In case study we deal with particular issues of sustainable aggregate resource management and present one of many ways to achieve balanced and fair distribution of costs and benefits from mineral resource development while observing the whole material life cycle including the mine cycle.

It would take too much space to list all those who participated in or supported the work described in monograph, but several individuals must be mentioned. First our thanks to Bill Langer, aggregate resource geologist with the US Geological Survey for sharing his in-depth work in a field of aggregates. Second, we wish to acknowledge Ivan Strgar, mineral resource expert with the Geological Survey of Slovenia, for precise and persistent mineral resource data gathering in last more than 20 years in Slovenia. This data made the case study possible. We owe a debt of thanks to following institutions: USDA Forest Service, Geological Survey of Slovenia, Ministry for Environment, Spatial Planning and Energy of Republic of Slovenia and Ministry for Education, Science and Sports of Republic of Slovenia for the support and funding of the research presented in this monograph.

This monograph is dedicated to all that advocate and believe in sustainable mineral resource management.

Deborah J. Shields, Slavko V. Šolar

ABSTRACT

In the second half of the twentieth century, societies began to realize that new approaches to development were needed. Human activities were having impacts that exceeded the Earth's carrying capacity on global, and in many places on regional and local, scales. This was particularly true with regard to environmental pollution and the consequences of natural resource consumption. Minerals are resources that are both essential for modern existence and future development, and whose extraction and use can cause negative social and environmental impacts. Societies cannot be expected to forego the stream of benefits coming from the use of mineral resource products, and by extension from mining. Therefore, it is crucial to encourage both the mitigation of cumulative negative impacts, which were in most cases the consequences of past practices, and the implementation of new, better practices.

Recognizing that past activities are no longer acceptable, a new development framework has emerged. The framework, called sustainable development, has four overarching goals: economic prosperity, environmental health, social equity for the present generation, and equal opportunities for future generations. In the past decade, the goals of sustainable development have been embraced by most countries in the world, and are now being applied to decision making at global, local, and individual scales, including those decisions related to mining. The foundations for sustainable mineral resource management were laid through a review of sustainable development concepts, their links to mineral resources, national mineral policies and management programs. The likelihood of improved choices from among possible development options is increased when those decisions are informed by knowledge and science. Scientific and technical expertise can be applied to monitoring socio-economic and biophysical processes and, in so doing, provide information and data to every stage of the policy cycle, including to sustainability policies.

The following are presented: (a) a process for the creation of the national mineral resource management program; (b) the content categories for the national mineral resource management program; (c) an indicator organization framework and its contents; and (d) an indicator of sustainable supply of aggregates. We also report the steps taken to create the sustainability-based, draft national mineral resource management program for Slovenia: (a) a democratic, multi-stakeholder public participation process; (b) an adequate and reliable reporting of information on the past trends and the current state of the Slovenian mining with regard to mineral potential, exploitability, market situation, environmental issues, and social acceptability; and (c) fulfilling legal requirements. The purpose of the proposed indicators is to monitor the effects of the resource program, once it has been adopted, and to improve decision-making.

We conclude that the process of program creation is as important as the program itself because of the importance of public acceptance. This is true also for the choice of indicators. In the case study on creating an indicator, an information pyramid is presented that demonstrates how concentrating, i.e., aggregating, data makes complex and comprehensive information understandable. Data on reserves, resources, and production of mineral resources are captured within a simple, flexible database system and reported as a single indicator. The data manipulation tools provide opportunities for an inquiry of individual data as well as analysis of indicator information on different spatial and temporal scales.

Key words: *Mineral resource management, Sustainable development, Policy, Indicators of sustainable development, Aggregates, Slovenia*

1 INTRODUCTION

During the latter half of the twentieth century, public concern about environmental degradation increased. People began to understand more clearly that human societies exist within and are ultimately dependent upon the services provided by the Earth's physical, chemical and biological systems. Inevitably, human actions change these systems. The current spatial extent of anthropogenic impacts, combined with their increasing intensity, has endangered the structure and functioning of our environmental and socio-economic systems, and in some cases actually degraded them (Lubchenco, 1998; World's Academies of Science, 2000).

We have also come to understand that the environmental, economic, and social issues we face display attributes of high uncertainty, urgency, complexity, and connectivity. According to Funtowicz and Ravetz (2001, p. 1), "Nothing can be managed in a convenient isolation; issues are mutually implicated; problems extend across many scale levels of space and time; and uncertainties and value-loadings of all sorts and all degrees of severity affect data and theories alike." If their assertions are correct, then narrow, partial equilibrium approaches to problem analysis will not provide adequate understanding of systems dynamics. New perspectives and approaches will be needed.

The sustainable development (SD) paradigm has several characteristics that make it an attractive alternative for problem analysis, and an area where indicators can be useful. First, it is based on a comprehensive and inclusive, i.e., post-modern, view of systems as open, dynamic, and integrated. The interconnectedness of social, economic and environmental systems is explicitly recognized. Economic growth and technological advancement are deemed to be essential, but should be achieved in an environmentally sensitive and distributionally fair manner (Cordes, 2000).

Second, the overarching goals of sustainability, i.e., economic prosperity, environmental health, social equity, and equal opportunities for future generations, are simple and flexible enough to allow for multiple interpretations and are applicable in a variety of circumstances. Different segments of the population often hold differing, though equally legitimate, viewpoints about the relative importance of alternative sustainability goals, as well as the proper solutions to complex sustainability problems. Allowing for multiple definitions of sustainability has made wider acceptance of the paradigm possible.

Third, the sustainability concept is not science. It is an ethical precept (Norton, 1992; Asheim et al., 2001), and stated desires for simultaneous equity, prosperity, and environmental protection represent moral positions. Morals, combined with preferences and ideals lead to values (Beckley et al., 1999) and there is wide agreement as to the importance of values in guiding public policies and actions (Dunlap & Scarce, 1991; Kempton et al., 1995; Satterfield & Gregory, 1998; Robson et al., 2000).

Finally, SD is a policy concept in and of itself (Davis, 1998), and in addition makes demands on other policies (Dovers, 1997). In the report Our Common Future, The World Commission on Environment and Development (WCED, 1987) presented sustainable development as a policy direction that could address the common challenges they had identified. The scale to which the authors referred was very broad. They noted (ibid., p. 46) that, "ecological interactions do not respect the boundaries of individual ownership and political jurisdiction." Operationalizing sustainable development principles, however, takes place within geopolitical boundaries, as policies are promulgated, codified in law, and implemented. Because of the interconnectedness among systems noted above, policy consistency across sectors is essential.

A lack of harmonization within the legal framework will make the realization of national sustainability goals difficult (van der Straaten, 1998; Shields & Šolar, 2001).

It requires that economic, environmental and social issues be integrated in decision making and that the long term effects on resources and capital, and the capacity for future creation of benefits, be considered. Decision-making itself should be broad, participatory, and also interdisciplinary.

The need to transition to a sustainable development path has been agreed to by the world's nations, first at the Earth Summit held in Rio de Janeiro in 1992 (UNDP, 1992), and again in 2002 at the World Summit on Sustainable Development held in Johannesburg (UN, 2003). There is no one, correct view of what sustainability means or how its principles should be implemented. In the next section we briefly review several alternative perspectives and identify the most well-known approaches to describing sustainability.

2 SUSTAINABLE DEVELOPMENT

The term sustainable development (SD) was introduced in 1980 by the International Union for the Conservation of Nature and described as ensuring human well-being while respecting the Earth's environmental limits and capacities. SD is a concept of needs, an idea of limitations, a future oriented paradigm, and a dynamic process of change. It was popularized in "Our Common Future," the report of the World Commission on Environment and Development (WCED, 1987), chaired by Gro Harlem Brundtland, then Prime Minister of Norway.

The Brundtland definition of sustainable development exhorts us to meet the needs of the present generation without compromising the ability of future generations to meet their own needs (WCED, 1987). This general statement leads to a variety of different, and in some cases even conflicting, understandings of sustainable development, each reflecting a different political or philosophical perspective. This lack of agreement, not withstanding, certain basic principles (Text box 1) underlie virtually all definitions of SD.

Alternative perspectives on sustainability place differing degrees of emphasis on the foregoing principles. Eco-centrism and techno-centrism present one such dichotomy. Eco-centrism argues that humankind is just one part of the larger, global ecosystem and therefore humans must consider and respect the Earth's biological and physical constraints. The environment is placed at a different, more significant level than either the economy or social well-being because it is the source of both of these human necessities (Dawe & Ryan, 2003). From the eco-centric perspective, the Brundtland definition focuses too much on material well-being; the development aspect is over-emphasized relative to the sustainability aspect. However, eco-centric approaches are sometimes criticized as inadequately sensitive to human needs.

The alternative, techno-centric perspective has greater faith in the ability of humans to address and to control environmental and social problems with technological solutions and free market mechanisms than does the eco-centric view. Neoclassical economic growth theory is often at the core of techno-centric models, which tend to acknowledge the importance of environmental protection and intergenerational equity, but emphasize the usefulness of conventional economic efficiency criteria (Solow, 1993). One aspect of many such models is maximization of the present value (pv) of generational welfare, subject to a set of social, market, and environmental constraints (Toman et al., 1995). Techno-centric models are criticized as having unrealistic expectations about the ability of technology to solve our problems. They are further criticized on the grounds that free trade and a reliance on markets assumes that self-interested choice will lead to societal well-being, which may not be the case (Rammel & van den Bergh, 2003), and that a pv optimal path is not necessarily synonymous with a sustainability path (Islam et al., 2003).

One way to clarify the differences between these opposing perspectives is to think in terms of capital, or the related terms endowments and wealth (Costanza & Daly, 1992; Toman, 1994). The types of capital are: natural capital (traditional natural resources), human-made capital (physical, produced assets and the built environment), human capital (the health and well being of individuals), and social capital (the complex of social relations, norms and institutions). Sustainability can be described in terms of capital maintenance and augmentation, i.e., by the degree to which alternative types of capital are deemed substitutable for one another (Pearce & Atkinson, 1993; Faucheux et al., 1997).

From one perspective, SD is the process by which societies transform economic, environmental, and social capital in ways that yield constant or increasing opportunities for satisfying human needs and wants generation after generation. This is termed weak sustainability. The net amount of capital is preserved, but not necessarily each of the four kinds of capital. Different types of capital, accruing in different time periods, are viewed as substitutable. The techno-centric approach is based on weak sustainability.

Text box 1. Sustainability Principles

General Sustainability Principles

1. Sustainability should seek the appropriate integration of political, social, economic, biophysical, and ecological factors.
2. The spatial and temporal scale of management and regulation should be compatible with the ecological and socio-economic scales of activities in question and their impacts.
3. Adaptive management, relying on an iterative process of timely and transparent feedback from socio-economic, resource and ecological monitoring, is essential for sustainability.

Social Sustainability Principles

4. Progress towards sustainability should generate direct economic value as well as non-economic values which may be intrinsic, recreational, or aesthetic.
5. Decisions and actions must be equitable and just both intra- and inter-generationally.
6. Members of the public, particularly local communities, should be empowered to participate fully in decisions that will affect their lives and the lives of their descendents.
7. Information relevant to decision making should be made available to all those who may be impacted so that their can participate effectively.
8. Governance, both governmental and corporate, must be honest, open, and fair.
9. Polluters should be responsible for funding environmental remediation, reclamation and after care.
10. Commodity prices should reflect the full cost of their provision.
11. Individuals should take responsibility for the environmental and social impacts of their personal consumption and behavioral choice.

Environmental Sustainability Principles

12. Sustainability depends on conserving ecosystem structure and function in order to maintain ecosystem services needed for both humans and the ecosystems that provide them.
13. Ecological sustainability depends on maintaining biological diversity and the populations of target species above their thresholds for long-term viability.
14. Users of natural resources must recognize that there are limits and boundaries of natural resource use beyond which ecosystem behavior might change in unanticipated ways.
15. Decisions on environmental protection should not be delayed, even in the absence of full information, if doing so will seriously endanger the structure and function of ecosystems.

Alternatively, SD can be viewed as development that leaves at least the same amounts and types of capital (natural, man-made, human, and social) to future generations as that to which current generations have access. This is termed strong sustainability. The amount of each type of capital must be preserved independently through time. Capital of different types can be complements, but not substitutes, for each other, and discounting between time periods is not allowed. The eco-centric approach advocates strong sustainability.

Models that embody a strong sustainability perspective include the ecological footprint (Wackernagel & Rees, 1996), the pressure-state-(impact)-response model developed by the Organization for Economic Cooperation and Development and the United Nations (OECD, 1994), and the sustainability barometer developed by International Union for the Conservation of Nature (Prescott-Allen, 1999). Two examples of approaches with a weak sustainability orientation are the genuine savings model developed by the World Bank (Hamilton & Clemens, 1999) and Munasinghe's sustainomics (2002).

2.1 MINERAL RESOURCES AND SUSTAINABLE DEVELOPMENT

Natural resources are an important part of any country's sustainability considerations. Discussions about the role of natural resources in sustainability tend to focus on the need to sustain ecosystems and maintain biodiversity. For example, sustainable forest management requires that the capacity of forests to maintain their health, productivity, diversity, and overall integrity be protected, in the long run, in the context of human activity (USDA FS, 2004). The fundamental goal is sustaining the ecosystem.

Minerals too are essential to a sustainable future. Use of these resources is fundamental to human well being as they are essential to virtually every sector of the economy, are the basis for the human-built environment, and provide desired services (Shields, 1998). However, these resources also have intrinsic characteristics that make them not only useful, but also problematic.

First, they, or their constituent elements or compounds, may be durable. Because of this tendency to persist, and in some cases bioaccumulate, the costs, as well as the benefits, of mineral use can extend across generations. Second, mineral deposits are frequently unique (in their occurrence and nature) or they are of lesser or higher quality in terms of grade or volume. As a result, the sitting of mineral operations depends upon the location and character of deposits not wholly on the preferences of the general public. Mines may be proposed or exist in areas where extraction is not a preferred land use, e.g., adjacent to or beneath an existing community or in an environmentally sensitive area. Third, only those extraction and beneficiation methods appropriate to the characteristics of the deposit can be employed, and in some cases those methods may entail relatively greater short- or long-term environmental risk.

Because these realities have not always been well managed, there are cases where there extraction, use and disposal of mineral resources have negatively impacted societies and the environment (IIED, 2002). Low environmental protection standards and low implementation capacity have led to several preventable environmental accidents, e.g., Anzalcollar in Spain and Baia Mare in Romania. There are also problems with inadequate health and safety protection, as demonstrated by the number of underground mining accidents with casualties, and with fair benefit distribution to all stakeholders and to local communities in particular.

In addition, although mineral-rich developing countries have often depended on resource exploitation to achieve their development goals, there are numerous examples of mineral-driven economies that have experienced less growth than mineral-deficient economies. There are many causes for the outcome, one of which is a tendency for the extractive sector to dominate the entire economy (Auty & Mikesell, 1998). Some governments have either ignored or been unaware of the fact that income growth is necessary for human development, but not sufficient (Srinivasan, 1994). Broader social issues related to well-being must be addressed as well. And the foregoing are not the only issues of concern. Others include (IIED, 2002):

- Viability of the minerals industry,
- Control, use, and management of land,
- Minerals and economic development,
- Local communities and mines,
- Mining, minerals, and the environment,
- An integrated approach to using minerals,
- Access to information,
- Artisanal and small-scale mining, and
- Sector governance: roles, responsibilities, and instruments for change.

Awareness of global interdependence, especially with regard to resource scarcity and anthropogenic impacts on Earth's carrying capacity, has led to a more complex and comprehensive view of human activity. We have a dynamic tension between demand for minerals and demand for control or mitigation of the negative impacts of energy and mineral development, use and disposal. There is a recognized need for development with its attendant mineral resource use counterbalanced by a general consensus that such use, in terms of both types and amounts, cannot continue in present fashion. SD has emerged as a framework within which the appropriate combination of consumption and preservation can be sought.

It is counter-intuitive to speak of minerals as being sustainable in the same way as ecosystems, given that individual deposits are finite in size and quantity. Nonetheless, there are several streams of thought on how minerals fit in sustainable development. One perspective focuses on mineral development as a source of wealth creation and by extension its value as tool for the eradication of poverty. This is an example of weak sustainability due to the inevitable transformations of natural capital that results from mineral extraction and use (Shields & Šolar, 2000). The transition from natural [mineral] capital to human-made, and further to human and social capital, can be described as moving from primary means to ultimate ends, i.e., well being (Meadows, 1998).

Pure weak sustainability is untenable. There are life-support, aesthetic, and spiritual services provided by nature for which there are no substitutes. Pure strong sustainability is equally rigid and inappropriate. It would ban all extraction because doing so would reduce the fund of natural capital available for future generations (who would in turn be precluded from extraction). Sensible sustainability falls somewhere between these two extremes and can offer an intermediate path to "more" sustainable behaviors. It is also adaptable to circumstances, allowing for a more eco-centric approach in some areas balanced by a more techno-centric approach in others.

A second stream of thought regarding minerals and sustainability focuses on the environmental and social consequences of mineral development, use and disposal, and argues that a reduction in the per capita use of materials will be essential to the achievement of a sustainable future. This is consistent with policies that promote various paths to dematerialization, including increased reuse, recycling, and remanufacture, and also economic incentives for reduced consumption and economic penalties for use of virgin materials.

In the past decade there have been many conferences, projects, reports, actions, etc. at which the various aspects of first defining and then implementing SD principles in the mineral sector were addressed. These have included the Mining Minerals and Sustainable Development Project (IIED, 2002), the World Bank Extractive Industry Review, and the Global Reporting Initiative. Mining was also discussed at WSSD.

Paragraph 46 of the WSSD Plan of Implementation deals with minerals and mining. The text recognizes that minerals are important to the economic and social development of many countries and that they are essential for modern living, giving the wording a traditional development theory tone. However, the text goes further, calling for enhancement of the contribution of minerals to sustainable development through actions at all levels to: (a) support efforts to address environmental, economic, health and social impacts and benefits …, (b) enhance the participation of stakeholders, … and, (c) foster sustainable mining practices …

Sustainable development principles will need to be applied to minerals management if the goals of Paragraph 46 are to be achieved and unfair distributions of the costs and benefits from mineral resource extraction and use corrected. Each stakeholder will have a role, including government, which is one of the major stakeholders in society. Ascher & Healy (1990) demonstrated that SD can be enhanced or retarded by public institutions. Lack of adequate governance, ineffective bureaucracies, and misguided policies limit nations' ability to develop.

In the remainder of this section we first describe policy as a way to institutionalize public values and objectives. We then demonstrate the relationship among public values and objectives, providing a more comprehensive definition of the word value. We then show how indicators can be used to track the achievement of objectives. In the subsequent section we then return to the idea of sustainable minerals policy and discuss on how governments can design, implement, and track policies and management plans to sustainably manage mineral resources from the strategic to operational levels. We introduce the concept of Sustainable Mineral Resource Management and present a Slovenian example of its application that uses indicators of sustainability. We end with conclusions about the challenges of implementing SMRM.

3 VALUES, OBJECTIVES AND INDICATORS

A policy is a plan of action for dealing with a specific issue in a manner that is consistent with the existing political system and social value set. In democratic societies, policies reflect and embody the public's goals and objectives, and so represent a connecting of desired ends with practical means (Fenna, 1998). Numerous authors have studied what has come to be known as the classical policy cycle (see for example: Howlett & Ramesh, 1995; Okhuijsen & Hove, 1995; Ministry of Housing, Spatial Planning and the Environment, 1997; Bridgman & Davis, 1998; Colebatch, 1998). Some versions have fewer steps, some have more, but all are based on the assumption that policy is created in an orderly, sequential fashion. An issue is defined, alternative solutions are proposed, analyzed, tested, and refined, and eventually a solution is codified in law and then implemented by the government (Stone, 1988).

The classical policy cycle shown in Figure 1 comprises 6 stages: (1) identification of objectives and interests, (2) definition of policy, (3) codification of policy in laws and acts, (4) establishment of a regulatory framework, (5) monitoring, and (6) review and adaptation (Šolar & Shields, 2000).

The policy process illustrated here is an internally rational and linear sequence of events. As such, it works best in situations where there is a single decision maker who is facing a clear, definable, bounded problem, and who can select and implement an effective policy instrument. Unfortunately, this is not a particularly accurate description of the world around us. The reality is that policy making is often a complex and messy business (Carnegie Commission, 1991) because there is seldom a single decision to be made by a single decision maker. Instead, there are multiple interconnected issues influencing each other and affecting multiple stakeholders.

The stages in the policy cycle may get compressed, or skipped, or occur in a different order. Sometimes laws precede policy; on other occasions the review and adaptation stage is omitted entirely. As a result, the process is inevitably influenced by lobbying, negotiation, and compromise. This is particularly problematic in cases where objectives have changed or where the issues faced are multi-faceted and not amenable to simple solutions. Regardless of the order in which the policy cycle takes place, it is the public's objectives and interests that are driving the process and these objectives are contextual expressions of values. In the next four subsections we review basic value theory, then use the Hierarchical Model of Sustainable Resource Management to discuss the role of values in the selection of objectives, explain the role of indicators and consider the issue of scale in some depth.

3.1 VALUE THEORY

Sustainability is sometimes controversial. This happens because sustainability is not science per se, although it uses science to achieve societal goals. Rather it is a value statement and human values are not fixed and independent of social, economic, and ecological context. Sustainability requires judgment about the state of the world. Inherent therein is our valuation of the tangibles we wish to persist in space and over time (USDA FS, Inventorying and Monitoring Institute, 2003). Thus, sustainability is about choices regarding what to sustain, how, when, where, and for whom. The debate about sustainability reflects differences of opinion about the appropriate answers to these questions and conclusions vary among countries because of differences in culture, values, and circumstances. Differences

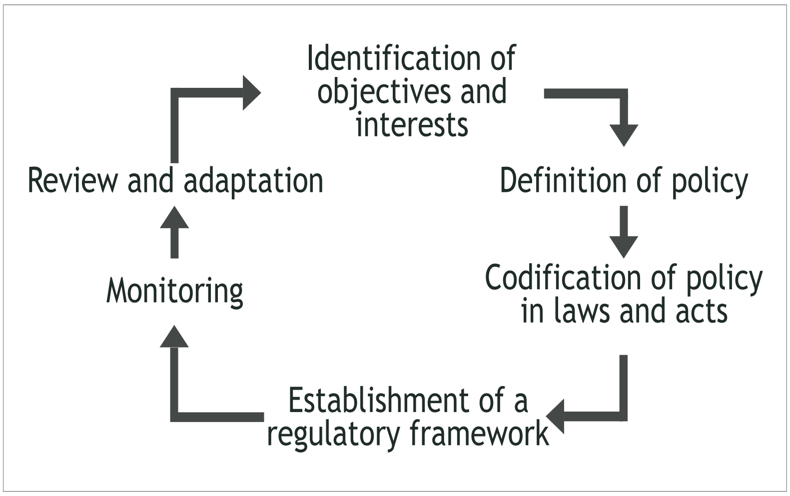


Figure 1 The Place of Objectives in the Policy Cycle

in culture and values are also reflected in the opposing definitions of sustainable development previously presented and explain why the Mining Minerals and Sustainable Development project inventoried over 350 definitions during the course of their work (IIED, 2002).

The values of interest here are held values, which comprise the morals, beliefs, conduct, qualities and states that individuals and groups consider desirable (Brown, 1984), and contextual held values, which represent the application of upper level values to concrete situations (Vaske & Donnelly, 1999). Assigned values are derived from contextual held values and refer to the relative worth or importance (monetary or otherwise) attributed to an object, state or behavior.

Held values, termed underlying values or values proper by Rescher (1969), represent ideals. A value set can be divided into two categories: terminal and instrumental. Terminal values are the generalized end states one seeks in life, whereas instrumental values relate to the means through which one seeks to attain those ends (ibid). According to Rokeach (1973) these values can be further subdivided. The set of terminal values comprises personal values (happiness, freedom) and social values (equality, sense of community). Instrumental values may be moral values (honesty, kindness) or competence values (logic, rationality).

Values exist within social systems, including a society's institutions, communities, and familial units, and these social factors affect the nature of terminal and instrumental held values (Beckley et al., 1999). The relative importance a person places on social as opposed to personal terminal values is a function of where that individual falls along the self-society orientation continuum (Brown, 1984; Opotow, 1993; Karp, 1996). The social context also influences how individuals order their values, i.e., give precedence or emphasis to certain values over others (Boulding & Lundstedt, 1988). The result of the foregoing is that, while individual value sets often overlap, they are seldom completely identical.

The subset of values held in common by a segment of the population is termed a social value set. There is wide agreement that such sets are important guides for and influences on public policies and actions (Dunlap & Scarce, 1991; Kempton et al., 1995; Satterfield & Gregory, 1998; Robson et al., 2000). One way that values drive policy is through the choice of policy objectives, given that most public policies are devised with an objective in mind. As will be discussed in more detail later in the next section, objectives are context-specific applications of contextual held values.

3.2 THE HIERARCHICAL MODEL OF SUSTAINABLE RESOURCE MANAGEMENT

A person's value set and actions are summary expressions framing the beginning and end of a substantive thought process (Satterfield & Gregory, 1998). The actions themselves will inevitably have both intended and unintended consequences, and this path from terminal held values expressed as desired ends to actual change can be modeled as a hierarchical system. Hierarchies are complex systems, composed of partially ordered sets with an asymmetrical relationship among the vertical elements (Sugihara, 1983). The relationship is asymmetrical in that control or influence tends to move from top to bottom, while feedback is more informational than control oriented.

The model of sustainable resource management developed by Shields & Mitchell (1997) is such a hierarchical systems model. It reflects two basic assumptions: (1) people's objectives are a reflection of a contextual application of their held value sets, and (2) management goals make sense only within the context of the human social system (Figure 2). Consistent with that view, terminal and instrumental held values are placed at the top of the hierarchy. Those values influence, and are influenced by the cultural, social, institutional, and economic framework within which that individual lives, and through that process become an ordered value set. Placed in context and mediated by experience and circumstance, they become the set of contextual held values that is assumed to be the primary factor influencing an individual's selection and ordering of objectives.

An objective is a statement of what one desires to achieve and is characterized by having a context (in this instance, natural resources), an object (an action alternative) and a direction of preference (Keeney, 1992). Information on objectives can be organized into a fundamental objectives hierarchy. A traditional fundamental objectives hierarchy is a tree-like representation of an individual's or group's objectives (Caldwell, 1990; Keeney & Raiffa, 1976). Overarching strategic objectives reside at the highest level. Each strategic objective is then subdivided into ever-lower level objectives that provide increasing amounts of detail, thereby clarifying the meaning of the higher level, more general, objectives. These are called fundamental end-state objectives. Often this type of objectives hierarchy is linked to a means-end network that shows the relationships between objectives as ends states and the actions (means) needed to achieve those objectives (fundamental means-objectives).

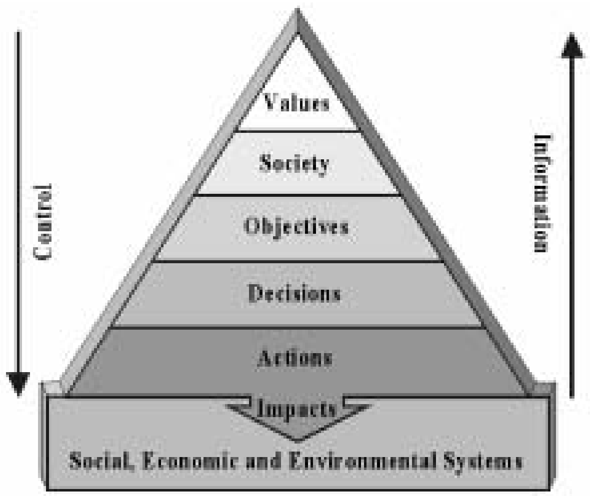


Figure 2 Control and Information flow – Hierarchical Model of Sustainable Resource Management

We assume that, in theory at least, decisions are made and actions taken with the intent of achieving stated objectives. Actions have impacts on social, economic, and environmental systems that can be identified and measured. The purpose of the indicators is to provide information to society about the state of the world and the consequences of fulfilling professed objectives. That flow of information is represented in the hierarchical model by the upward pointing information arrow.

3.3 INDICATORS OF SUSTAINABILITY

Agenda 21 (Chapter 40.4) called for the development of indicators of sustainable development (SDI) that could provide a basis for stages of the policy cycle, including decision making at all levels. These indicators reside at the base of a sustainability concept hierarchy that is similar in construct to the objectives hierarchy. At the top is the goal of sustainability, the strategic objective. This is a broad, over-arching, vision statement that provides the rationale for policies, practice, and initiatives related to sustainable development. Next come principles, which are fundamental truths or laws that form the basis of reasoning or action. Principles are general but can also have spatial, temporal and other limitations in order to make the definition more operational.

Principles are in turn supported by criteria. Criteria describe what it means to be sustainable; they describe the characteristics of a sustainable system and so are comparable to fundamental end-state objectives. Criteria serve as basis for evaluation, comparison or assessment. Criteria are sometimes further described by sub criteria stated as actions to be taken, e.g., increase the percentage of the population having access to clean drinking water, in which case they are similar to fundamental means-objectives. Achievement of objectives is judged against relevant indicator(s), which describe, display, or predict the status or trend of some aspect of sustainable development.

Indicators serve three basic functions: simplification, quantification, and communication. They are parameters (properties that are measured or observed), or measures derived from parameters, which provide information about the state of a phenomenon, environment, or area, with a significance extending beyond that directly associated with a parameter value. An index is a set of aggregated or weighted parameters or indicators.

Ideally, an indicator should meet the following criteria: (a) be representative and scientifically valid; (b) be simple and easy to interpret; (c) show trends over time; (d) give early warning about irreversible trends where possible; (e) be sensitive to the changes in the environment or the economy it is meant to describe; (f) be based on readily available data or be available at reasonable cost; (g) be based on data adequately documented and of known quality; (h) be capable of being updated at regular intervals; and (i) have a target level or guideline against which to compare it (DETR, 2000). In addition, special attention should be given to scale issue, because most of misunderstandings are caused by improper scale interpretations. This issue will be addressed in more detail in a later subsection.

As important as the set of indicators is, the process of creating, implementing and monitoring the set of indicators is of foremost importance. Process democracy is one of the most important cornerstones of sustainability. There are many possible processes for defining indicators for various sectors on different scales, recommendations and even requirements for the group defining the indicator set are similar. The conditions are: (a) shared ownership of process, (b) fair decision-making processes, (c) transparency and accountability, (d) adequate participation and representation, (e) a mechanism for future revision, (f) clear grievance procedure, (g) clear structure, and (h) auditability (Scarse & Lidhe, 2001). Last but not least, the same rules that apply when creating the indicators should be enforced when creating documents (policy, management plan, etc.).

3.4 SCALE AND INDICATORS

Hierarchies are relevant to discussions of scale, just as they were to discussions of objectives and sustainability. Every entity or idea is both a part and a whole. It is a part of something larger and, at the same time, it is the sum of its own parts. This is the essence of hierarchies. Every level in the hierarchy relates in two directions, upward to the larger whole into which it is integrated, and downward to the parts of which it consists (Allen & Starr, 1982). An element or entity in the set has a role that is defined by the upper level to which it belongs, i.e., the higher level constrains the context of lower levels. The broad-scale processes that take place at higher levels of the hierarchy constrain the finer-scale phenomena (Allen et al., 1984). Conversely, as fine-scale patterns propagate to larger scales, they can potentially constrain broad-scale patterns (Huston et al., 1988).

There is no single "correct" scale of analysis (Wiens, 1989); however, this does not mean that all scales serve equally well in all cases. Choice of scale should be an explicit function of the policy and management decisions that need to be made (Rykiel, 1998; Tainter, 1999). The information collected and the analyses conducted should be consistent with the scale of the decision context. Moreover, scale must be an explicit function of our knowledge about and understanding of the systems in question rather than being an artifact of anthropogenic perception of phenomenon scale. This is because perception of pattern and process depends upon the scale at which variables are measured. Thus, the scale of investigation can have profound effects on what is found (see for example Weaver, 1995; Edmunds & Bruno, 1996).

Detection of pattern and process depends on the grain and extent of the investigation (O'Neill et al., 1986). Grain refers to the individual units of observation, extent to the overall area being observed. Grain constrains the inferences that can be drawn; below the grain size, there is no way to observe relevant information. Extent constrains the size of the entity we describe, because it is not possible to observe an entire entity unless the universe of observation is large enough to include all its parts.

A sieve provides a useful example. The size of the mesh in a sieve's screen determines the size of the particles that will be retained in the sieve, as well as those that will pass through. Only particles larger than the mesh size can be sampled. It will not be possible collect samples of particles so small they pass through the sieve and in this way the mesh size defines the grain of the experiment. The size of the sieve itself sets a limit on how much material can be passed through the screen within a specified time period. This, combined with number of samples put through the sieve and the sampling design, represents the size of the universe that will be examined, i.e., the extent of the experiment.

We can apply the concept of grain to open pit mines, such as the one in Jersovec, Slovenia, where clayey to silty chert rubble is being extracted. Silty clay is a product of the weathering of carbonate rocks. Chert has very low Al_2O_3 and Fe_2O_3 content; however, the concentrations of these undesirable impurities are much higher in the silty clay portion of the sediment. The aluminum and iron oxides are removed by separating the silt/clay from the chert fragments through wet screening. By using a cut-off screen of 3 mm, the larger particles (chert) (> 3 mm) can be separated from the silt/clay and smaller particles of chert (< 3 mm). Grain size is therefore 3 mm. The extent is defined by the volume of material screened within a specified time period and the area from which the material was taken.

The grain and extent set the limits of resolution for a study. It is not possible to generalize beyond the extent without making the assumption that pattern and process will not change, i.e., that they are scale-independent (Wiens, 1989). In our example, it is not possible to characterize all the ore within the boundaries of a pit based only on sampling in one area. Since system processes frequently differ across scales, scaling-up with existing information can be problematic. It may result in a biased understanding of broader-scale processes, with the process from the smaller scale being given more importance than is actually warranted in the larger system (MacNally & Quinn, 1998). Similarly, the nature of the entire ore body may not be homogeneous. It would be inappropriate to assume, in the absence of additional data, that concentrations of either desirable materials or contaminants will be consistent across the ore body.

Viewed from the resource management perspective, the problem is that practices that are appropriate for and contribute to sustainable resource management at the site level, may not contribute to sustainability when applied to a larger geographic area (Fox, 1992). Multiple local optima do not necessarily result in a global optimum. This is why environmental impact statements typically include information on cumulative effects.

Nor does it follow that the processes at work at broader scale are the same ones driving a system at smaller scales. Hierarchy theory suggests that using fine-scale data to make predictions about large-scale events is more likely to be accurate than is the reverse process (Fox, 1992). This is because the grain of the broad-scale data may be too coarse to detect the pattern and process occurring at finer scales. Thus great care must be taken when predicting from higher to lower levels.

For reasons of cost and tractability, expanding the extent of a study often entails collecting data at a coarser grain, i.e., as the study area is enlarged, fewer measurements are taken. In so doing the observer gains information on the broad-scale pattern, but loses the fine-scale details. This can be a worthwhile tradeoff when the policy issues of concern are broad scale as well. Moreover, just as multivariate statistical methods can be used to summarize large amounts of fine-grain data to reveal broader relationships, moving up in scale can increase the scientist's ability to generalize (Levin, 1992).

Mineral exploration displays this pattern, albeit in reverse. Exploration activities usually begin with studies of very large areas, perhaps as much as several thousand km^2. More detailed exploration activities are only undertaken in those areas with "good results," so that as the extent of exploration target area shrinks gradually from the entire landscape to the mine site area (mineral deposit of a few hectares) the sampling grain becomes finer. However, the extent of the area over which sampling takes place must be at least the size of the ore body if the objective of exploration is to define the ore body's boundaries.

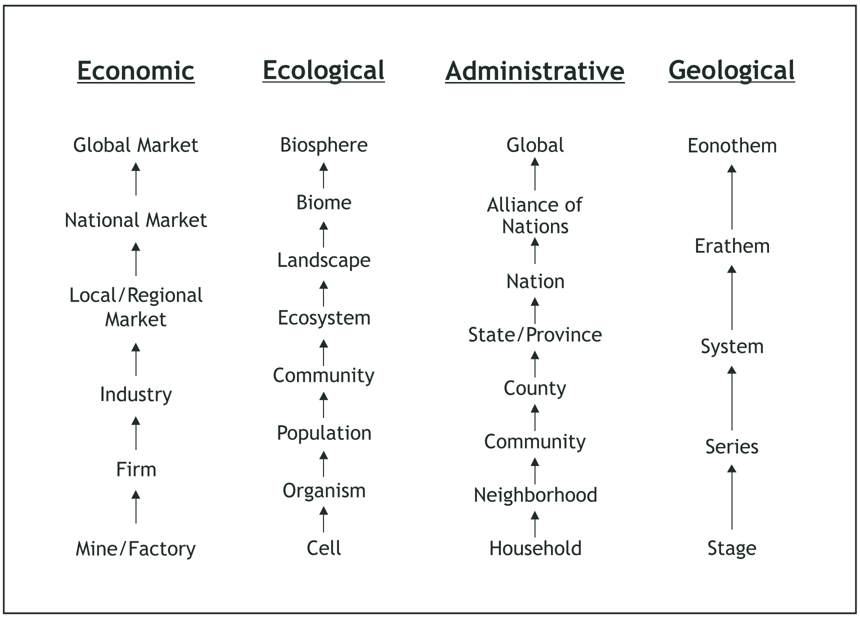


Figure 3 Alternative Scale Hierarchies

Scientists in many fields utilize hierarchies to organize information (Figure 3). Those hierarchies may be either spatial (administrative or economic for example) or temporal (historic, geological). Organizing into hierarchies clarifies information and facilitates the understanding of different aspects of complex systems. The hierarchies chosen for analysis are often interdependent and overlapping. This is because patterns and processes defined within one hierarchy affect the structure and functioning of entities within other hierarchies (Shields & Šolar, 2002) .

Consider for example the inter-relationships among three hierarchies, geological (ore body limits within a geologic formation), administrative (mining property boundaries within politically defined boundaries), and economic (a mine within an industry sector). The extent of the ore body is defined within the geological settings hierarchy; however, the political units that make up the administrative hierarchy will define ownership of and access to the ore body. Mine profitability, which resides within the economic hierarchy, is dependent upon the property rights regime, as well as the nature of the ore body. The existence of the ore body can impact decisions made within the administrative hierarchy about access and ownership, i.e., administrative functioning. And these interactions between two hierarchies (geology and administrative) have implications for the way a process within the economic hierarchy, i.e., mine development, is handled.

The role an entity play depends on the higher level system to which it is assigned, and the higher level system to which it belongs is determined by the phenomenon in question (Allen et al., 1984; Allen & Hoekstra, 1990). This implies that entities can reside in more than one hierarchy, depending upon the phenomenon being investigated.

Returning to our mining example, an ore body can be thought of an as entity. The rock within that ore body could be pure limestone, clay or a combination thereof – limestone (less than 5 % clay), marly limestone, limy marl, marl, clayey marl, marly clay, or clay (less than 5 % limestone). If the phenomenon of interest is the genesis of the rock, then the hierarchy within which the entity resides is geologic. However, the composition of the rock also has implications for (pit) mine design because the ultimate angle of slope stability ranges from a few degrees in clays to a few tens of degrees in limestone. Thus, if the phenomenon of interest is mining or mine design, then the hierarchy within which the entity resides is economic, or perhaps engineering.

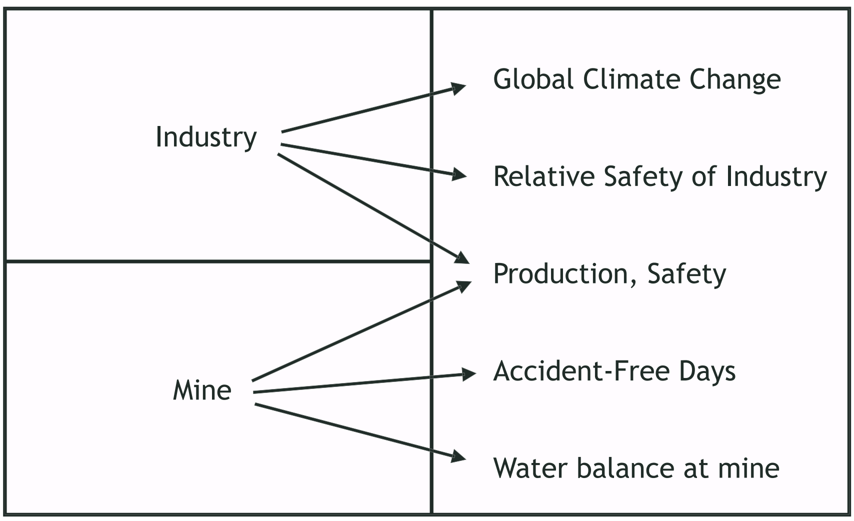


Figure 4 Scales are connected by Mutually Occurring Phenomena

As the foregoing makes it clear, inferring pattern and process at one scale based on information collected at another is fraught with potential difficulties. However, linkages can be made when a single phenomenon is significant at different levels of the same hierarchy (Allen et al., 1984). Some phenomena are applicable across several scales, e.g., global climate change is meaningful at the global and national levels, but not at the mine site level. Similarly, underground water balance is a meaningful concept at the mine site scale, but not at the industry-wide scale. Conversely, phenomena such as production and safety are relevant across many different levels of the hierarchies to which they belong (Figure 4). In cases where cross-scale linkages exist, it may be possible to predict the status of an entity at one scale in a hierarchy based on information about a shared phenomenon from another scale of the hierarchy.

Most entities and phenomena can be described by qualitative or quantitative measurements. That is the purpose of indicators, to provide information about the status of entities or functioning of phenomena. Although entities can be linked across scales by shared phenomena, it does not follow that an indicator of that phenomenon, which is meaningful at one scale, will be equally as informative at a different scale. An indicator can be used to describe a single phenomenon across scales, i.e., aggregated up or disaggregated down, only in those instances when its' meaning does not change as grain and extent are changed.

The relationship among phenomena and indicators can be thought of as a 2 by 2 problem (Figure 5) (Shields & Šolar, 2002). A phenomenon may or may not be playing out at two different scales of a hierarchy. Similarly, an indicator that is applicable at one scale may or may not be applicable at a different scale. An additional complication is that an indicator may be useful at more than one scale, but be indicative of different processes at the different scales. Each of the alternatives will be considered below.

Case I represents the straightforward situation in which both the phenomenon itself and the indicator that describes it are meaningful across two scales. Data on production of mineral resources is among the most convenient and understandable of examples. Production can be reported at many different spatial scales: quarry (company), quarrying area, county, state, country, region, continent and global level. Typically data are collected at the quarry level and then aggregated (summed) for reporting at broader scales. Aggregation of these data (scaling-up) is acceptable in this case because meaning does not change across the scales. Of course, as noted above, scaling-up results in a loss of detail that is available at the disaggregated lower level. There are also instances in which disaggregation is appro-

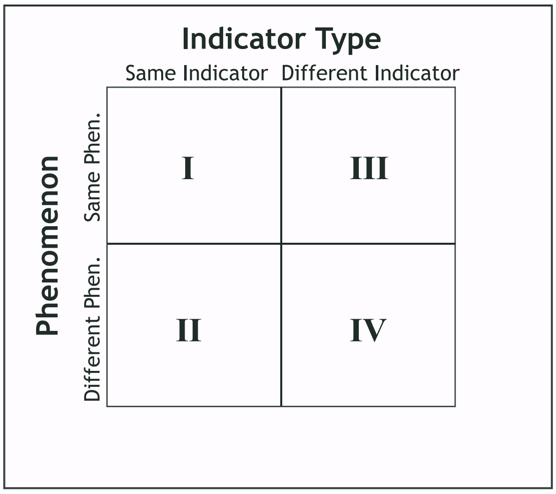


Figure 5 Two by Two Table of Phenomena and Indicators

priate. Production data reported at the industry or firm level can be reported as average productivity per mine or per employee.

Case II represents the situation in which a phenomenon differs from one scale to the next, but the same indicator is descriptive of the phenomena playing out at each scale. This situation is much less common than is Case I, but does sometimes occur. One such situation concerns NO_x emissions. The local scale phenomenon is soil condition. Excess nitrogen makes the soil more fertile than it would normally be, which can lead to changes in ecosystem structure and functioning. Emission of NO_x could be used as a proxy indicator for nitrogen levels in the soil. At the mezzo or global scale, NO_x has been identified as a green house gas, i.e., a contributor to global warming. Thus emissions would act as an indicator of potential global climate change.

Case III represents the situation in which the phenomenon is the same at different scales, but the appropriate indicators differ across the scales. Consider the phenomenon of the spread of exotic, i.e., non-native, plant species. An indicator at the site level might be the presence of vehicles and equipment brought in from "infected" areas. At the landscape scale, an indicator could be fragmentation due to road building or infrared satellite images. Another example relates to the full costs associated with the transport of mineral materials. At the mine site scale, an indicator might be transportation cost per unit of weight, including variable, replacement, and opportunity costs. Whereas at the regional level, an additional indicator reporting the dollar value of impacts on infrastructures (highways, bridges, etc) caused by transport vehicles would be needed.

Finally, Case IV pertains to situations in which the phenomena and related indicators are different across scales of a hierarchy. For example, as noted previously, water balance is an extremely important issue at the mine site scale, and completely irrelevant at the national or global scale; whereas overall water usage by the extractive industry is important at broader geographic scales, particularly in arid regions (Shields & Šolar, 2002).

4 POLICIES IN SUPPORT OF SUSTAINABLE DEVELOPMENT

We noted earlier that policies connect desired ends with the means of achieving those ends. The desired end we are concerned with here is sustainability. The purpose of a sustainability policy is to articulate the principles and goals of sustainable development in a manner that reflects the values and objectives of the citizenry, the social and environmental context, and the limits and responsibilities of public institutions. New policies and policy instruments that respond to complex and broad scale issues of the present will be required. Existing policies reflect the issues and interests of prior eras, and may not be supportive of sustainability goals.

For example, the public policies of the nineteenth and twentieth centuries embodied societal interest in settlement, industrial development, and economic expansion. Pursuit of those growth and development objectives had both positive and negative consequences. The standard of living for most people rose substantially, infant mortality declined and longevity increased. However, serious environmental and social problems were recognized in the latter part of the twentieth century, including pollution and wastes, climate change, biodiversity loss, desertification, population growth, and poverty. The initial response was to develop environmental policies.

Those policies have in many cases proven to be ill equipped to address the more complex aspects of this new reality (Romm, 2000). They respond to discrete, if important, issues and are applicable only at what Dovers (1995) termed the micro-problem level. In Dovers' typology, micro-problems are spatially and temporally discrete, and exhibit little complexity or uncertainty. Effluent licensing is a micro-problem for which there are now [relatively] effective policy responses in place. Similarly, meso-problems, though more significant, do not pose overwhelming threats to current patterns of production and consumption. They can be addressed with existing policies. One example is trans-boundary pollution.

Sustainability involves macro-problems, which can be defined as multi-faceted, complex, spatially and temporally diffuse, highly interconnected with other issues, and capable of posing serious threats to production and consumption (Dovers, 1997). Because existing policies reflect the problems, objectives, issues, and interests of prior eras, sustainability will require new policies and policy instruments that respond to complex and broad scale issues of the present. Innovative policy approaches that are capable of dealing with uncertainties, encourage coordination and integration across disciplines and sectors, and take a long-term rather than short-term perspective will be needed.

The concepts of policy learning (May, 1992) and adaptive management (Walters & Holling, 1990) will be key components. These are approaches to natural resource policy that embody a simple imperative: policies are experiments that we should learn from (Lee, 1993). Essentially, these authors are contending that the upward flow of information must be enhanced. The policy process also needs to be iterative and adaptive because it is not possible to know a priori if a given policy option is the best choice, or even if it will produce the expected results.

Policy decisions should be informed by science that enhances understanding of systems, provides data on the current performance of systems, and identifies targets for desired levels of performance (Natural Resources Canada, 2001). However, the interface between science and policy is often value-laden (Sagoff, 1988). This is inherently the case for sustainability policy, given that the concept of sustainable development is a value statement. In reality policies, and particularly natural resource policies are created and exist at the intersection

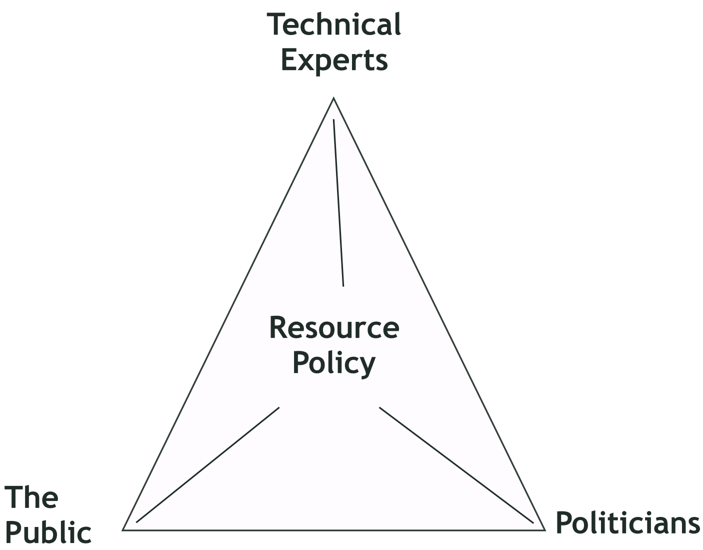


Figure 6 Natural Resources Policy as influenced by Science, Politicians and the Public

of technical experts who provide science input, the public who desire to see their preferences, goals and objectives achieved, and the complex world of politics.

There is clearly a need for a more comprehensive policy process framework that can embrace the disagreement and conflicting goals and values inherent in the creation of natural resources policy. After briefly addressing mineral policies, we present Sustainable Mineral Resource Management as such an interactive model.

4.1 SUSTAINABLE MINERAL POLICIES

Policies reflect the values and objectives of the people involved in their creation. That is as true for mineral policies as it is for environmental, monetary or trade policies. A country's national mineral policy should include: policy scope, sovereignty, economics, quality of life, legislative framework, and regulatory agencies (Otto, 1997). The mineral policy clearly defines types of acceptable mineral activity and types of minerals that can be exploited (Otto, 1997).

One major governmental role in sustainability policy for minerals is to create an enabling economic environment that aligns a country's investments with its underlying comparative advantage, so as to improve the use of scarce capital and human resources (Auty, 2003). They need to (ibid p. 3):

- "Maintain fiscal discipline by broadly matching public expenditure to a healthy diversified tax base;
- Direct public expenditure away from administration, defiance, ad hoc subsidies and white elephant mega-projects towards neglected areas offering high returns, notable those that improve asset distribution such as education, health and social infrastructure;
- Secure property rights without excessive costs, including rights for the informal sector;
- Maintain a competitive exchange rate and remove domestic price distortions; including subsidies that encourage wasteful over-consumption; and
- Promote competitive markets, including efficient financial markets that facilitate entry by domestic and foreign firms and enhance the efficient allocation of investment.

- Provide sufficient information on country's mineral resources; and
- Create, implement and maintain a proper, fair, and enforceable legal and regulatory framework."

More generally, the foundational concepts of sustainable mineral policies are: (a) facilitating the transformation of natural mineral capital into built physical, economic, environmental or social capital of equal or greater value; (b) ensuring that environmental and social impacts of mining are minimized; (c) addressing the trade offs that society needs to make; and (d) taking all relevant scale hierarchies into consideration. It is also essential that a sustainable mineral policy be correlated and consistent with other governmental policies (Shields et al., 2002).

Finally, it should be noted that in the recent decades, some countries have begun to shift to more restrictive extraction policies, when other development opportunities are available. The main reasons for imposing restrictions are: (a) reduced territory potential with regard to minerals, (b) decreased domestic demand by the industry due to economic restructuring, (c) increased supply of minerals from existing operations due to improved technologies and recycling, (d) liberalized importation due to globalization processes, and (e) increased public concern for resource conservation and for negative environmental and social impacts during whole mine cycle (Šolar, 2003). The desire of governments to limit extraction opportunities may diminish in the presence of effective sustainable mineral management policies.

4.2 SUSTAINABLE MINERAL RESOURCE MANAGEMENT

According to most definitions, management deals with the process of planning, organizing, and governing the efforts of co-workers in order to achieve stated goals of an institution. Management therefore about is optimizing the use of human and material resources, together with financial and other contributions, in operationalizing policy goals. Sustainable mineral resource management (SMRM) is thus a process for implementing the sustainability principles expressed in a sustainable minerals policy.

SMRM is based on the premise that decisions should be consistent with the principles of sustainable development. The goal is not to sustain a given deposit or industrial sector, but to sustain the flow of services provided by mineral commodities and to do so in a manner such that, over the commodity's life cycle, the net contribution to society is positive (MMSD NA, 2002). Exploration and exploitation should be managed so that the natural capital embodied in mineral resources is transformed into built physical, economic or social capital of equal or greater value. Environmental impacts of mining should be minimized. Mining should be conducted in a way that is acceptable to the public, so that firms do not lose the social license to mine. Moreover, the provision of resources to society must be accomplished within the context of society's multiple and often conflicting values and objectives. And finally, in recognition of the need for intergenerational equity, the potential for sterilization of resources must be considered when land development decisions are made.

As shown in figure 7, SMRM is an iterative, adaptive process. We start from the premise that people's objectives are value based and context dependent. Therefore the SMRM process begins with the identification of stakeholders, their value sets and related objectives for resource management. Alternative management approaches are developed that reflect those objectives. Social and environmental impacts are predicted for each alternative, technical aspects are considered, and costs estimated. Technically or economically infeasible, or unsustainable, alternatives are revised or rejected. Feasible alternatives that support sustainable outcomes are then presented to the public for debate and negotiation with the goal of choosing an alternative that is acceptable to the public. Once an acceptable management alternative has been identified, it is implemented, monitored, evaluated, and revised as needed. The process of revision once again requires public participation and the cycle is repeated.

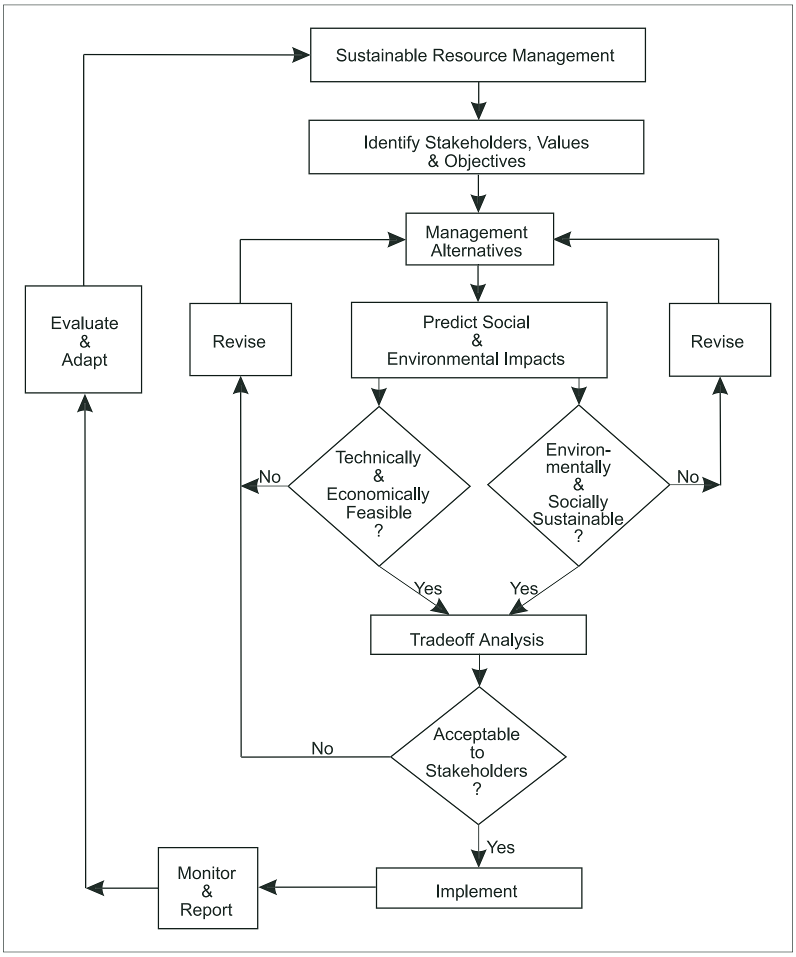


Figure 7 Implementation Process for Sustainable Mineral Resource Management

The issue of monitoring deserves special consideration. The purpose of monitoring is to ascertain if the objectives laid out in the laws and regulations are being achieved. However, existing data and conventional reporting methods may not provide sufficient information (Boyle et al., 2001). Monitoring programs and data reporting requirements are a function of laws and regulations that were promulgated in response to the policies in effect at the time, as well as the level of scientific understanding we had at the time the requirements were laid out, and what was thought to be important enough to measure. There will continue to be a need for data about the degree of regulatory compliance, but information about our progress in achieving the range of sustainability objectives embodied in policy will also be needed.

One purpose of sustainability indicators is to provide these types of information. Indicators and indices package complex mineral information into understandable forms for stakeholders, decision makers and public use. These mineral indicators must be useful as analytical, explanatory, communication, planning and performance assessment tools. Indicators help people understand the complexities associated with mineral resource management policy decisions, such as the interconnectedness of physical and environmental systems and the inevitability of making tradeoffs among conflicting management policy objectives. Thus,

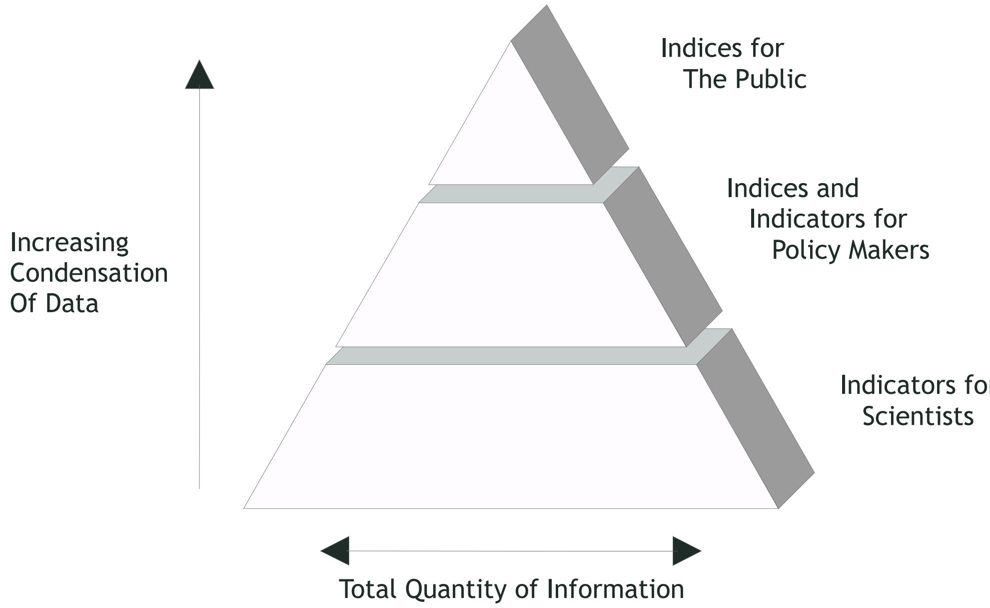


Figure 8 The Relationship between Data Condensation and Audience (after World Resources Institute, 1995, quoted in Emmert et al., 1996)

the information contained in indicators can contribute to public understanding of the state of the world and the potential consequences of fulfilling various objectives.

The question is how best to explain these data and measures to the public, decision makers, policy analysts, and resource managers. For example, policy makers will need to be informed about the full range of impacts associated with each policy if they are to ensure harmony and consistency across sustainability policies. However, policy makers are more often trained in policy schools than in science programs. The import of data or analytical results may not be intuitively obvious to them. If scientists and indicator practitioners want to influence the debate about sustainability policy, laws and regulations, they will need to present information in a way that is meaningful to this lay audience.

More generally, indicators need to be designed so as to provide information relevant to the question at hand and be meaningful to the intended audience. That may lead to data condensation, with the appropriate level of condensation being a function of the audience for the information (Figure 8).

Indicators of sustainability will only be effective if they support social learning by providing users with information they need in a form they can understand and relate. We are not suggesting that different audiences be told different things, but rather that information be couched in language that resonates with the intended audience. In terms of communication, the criterion for using an indicator or index is whether it will tell the ultimate users something they need to know.

The information and communication problem is, however, more complex than selecting the most effective indicator or index. It is also essential that the information contained therein be communicated in the "proper" manner. The rules of communication should be followed: (a) regularity / correctness, (b) justice / equity, (c) sincerity / honesty. Accurate and useful technical information is sometimes rejected for sociological reasons, i.e., because it is inconsistent with the public's value-based understanding of the world (Fairweather, 1993). Science and values are traditionally seen as separate. Prescriptive laws of morality and ethics take an imperative stance on what ought to be: the descriptive laws of science take a declarative stance on what is (Rolston, 1975). But as Levett points out (1998, p. 291), "The struggle to find and use indicators of sustainable development is intimately bound up with the process of deciding what we mean by [the term] and what we shall do about it." Thus, indicators are "intrinsically and unavoidably normative and political," rather than being value free numbers that will be interpreted identically by everyone. Indicators presuppose an ethic, as well as decisions about what is important enough to quantify, what reference point those measurements will be judged against, and ultimately what end state is desirable.

There will be circumstances when it is appropriate to present indicators and indices in the context of peoples' values. Values remain abstract and devoid of their full meaning in the absence of interpretive and cognitive processes, but can be placed in context through narratives and stories (Basso, 1990; Satterfield, 1996). People use stories to explain what matters to them and subsumed in the stories is the practical application of value. Narratives and stories can also be used to communicate scientific information to the public (Kay et al., 1999). Just as an individual's story puts value in the context of a specific situation, a scientist or indicator practitioner can use narrative to communicate indicators and indices in terms of a thing, place or condition that matters to people.

The objectives of a sustainable mineral resource policy and associated management plan, and the form they take, will differ between depending upon the resource in question, and also among regions and countries due to the interplay of differing value sets, goals and objectives (Langer et al., 2003). In the following section we consider the case of Sustainable Aggregate Resource Management (SARM).

4.3 SUSTAINABLE AGGREGATE RESOURCE MANAGEMENT

There has been an inappropriate tendency to focus exclusively on metals when minerals are used as an engine of development. As a result, the potential positive contributions of mineral development are often overlooked in countries with limited endowment of metals. Under- or over-emphasis on the minerals sector can be lessened by addressing mineral development within the context of sustainable development. Each country identifies sustainability goals, with respect to social equity, environmental health, and economic growth, that are appropriate to its circumstances. The contribution of mineral resources to the achievement of those goals will be similarly context dependent.

Natural aggregate is an essential commodity in modern society. Developing nations need stable, adequate and secure supplies of construction materials to build the infrastructure needed to achieve the Millennium Development Goals (Baird & Shetty, 2003). This includes highways, roads, bridges, railroads, airports, seaports, water and waste treatment facilities, and energy generation facilities. Construction materials are also essential to the provision of sustainable housing and the expansion of industrial capacity (CIB & UNEP, 2002). These large-volume materials will need to be provided in a rational integrated manner that maximizes their societal contributions and minimizes environmental impacts.

Natural aggregate is a material composed of rock fragments, which may be used in their natural state or after mechanical processing such as crushing, washing, and sizing (Langer & Tucker, 2003). There are two categories of aggregates, gravel and crushed stone. Gravel generally is considered to be material whose particles are about 2.0 to 63.0 millimeters in diameter. Its edges tend to be rounded. Crushed stone is of the same size range, but is artificially crushed rock, boulders, or large cobbles. Most or all of the surfaces of crushed stone are produced by the act of crushing, and the edges tend to be sharp and angular. Natural aggregate has hundreds of uses, from chicken grit to the granules on roofing shingles (tiles). However, most aggregate is used in cement concrete, asphalt, and for other construction purposes. The average per capita consumption of aggregate generally ranges from 5 to 15 tons per year (Langer & Šolar, 2002).

While aggregate is a non-renewable resource, supplies are nearly inexhaustible on a global scale. They have characteristics that differentiate them from most other mineral commodities:

- a high number of potential extraction sites;
- a high volume to value ratio;
- significantly different set of potential environmental impacts; and
- regional importance combined with a narrow economic transportation radius.

In most cases, aggregate demand is met by local or in-country suppliers. This occurs because most aggregate transportation is carried out on roads and transportation short distances to different locations by road is economically viable. Moreover, constructing and maintaining a dense road network is less expensive than constructing rail or channel networks.

In many countries, aggregates have simplified legal frameworks (local level competence, licensing, taxation, control) compared to other minerals due to their characteristics. In some countries aggregates are the landowner's property even if most of other minerals are state owned.

Aggregates are very often overlooked in minerals sustainability debates due to the fact that they are seldom export products of national importance like metals or energy resources. Aggregates typically do become part of sustainability debate in countries with organized environmental protection groups that have active individual members. These are mostly developed countries where mining is a declining economic activity and most other types of mineral extraction have ended. In developing countries, the negative and positive effects of quarrying are not important issues in the development debate. The negative impacts of aggregate extraction that are passed on as burdens for future generations cannot be compared with the present desire for faster economic development and poverty alleviation. The fact that the costs of remediating negative social and environmental impacts of aggregate quarrying and use will be higher in the future than they are today is neither a priority nor a point of discussion in most developing countries.

Nonetheless, aggregates should be an integral part of any country's overall sustainability plans. Geological settings, and economic and social conditions, are influential factors in determining how aggregates are supplied. But because the manner in which aggregates are supplied affects the ability of developing nations to achieve a sustainable future, it is important that a country's strategic and operational policy guidelines are based on sustainable development principles.

Construction materials and aggregates present a very clear example of the transition from natural to human-made (manufactured / physical) capital. In order to optimize this transition, the positive impacts of quarrying should be maximized and negative ones minimized. On the positive side of the equation, aggregates facilitate everyday life of humankind by providing shelter (housing), easing communication (traffic) and societal infrastructure (for economy, education, health, art and science). Negative impacts are linked mostly to the manner that construction materials are extracted, transported, and disposed of.

Lack of understanding about the links among different types of impacts of quarrying is a source of time consuming disagreements between stakeholder groups, including the general public, industry, environmental, social and expert groups on local and national levels. One of the most effective ways to identify the full range of positive and negative impacts, as well as system interactions, is to examine the entire quarry and product life cycle. Societal, value based, objectives expressed in policies emphasize certain parts of life cycle and bring those issues to the attention of stakeholders. One of the tools that can be used to ensure that mineral resources (aggregates) are provided in a manner that contributes to sustainability over the full life cycle is Sustainable Mineral Resource Management (SARM).

Environmental Aspects - SARM requires developing aggregate resources in an environmentally responsible manner that does not result in long-term environmental harm, even if short-term environmental impacts are unavoidable. Two main environmental categories should be considered in SARM: reducing negative environmental impacts and resource protection / conservation. These goals are very achievable because the aggregate industry has made, and continues to make, great strides in environmental management.

Most destructive environmental impacts of aggregates are on the landscape (visual intrusions), air (noise, dust), water (surface, underground water), soil (erosion, pollution), and on biota (loss of biodiversity). Besides type, the nature of impacts (range, timing, duration, ability to prevent /control) should also be considered (Langer & Arbogast, 2002). There are many regulatory and voluntary tools that can be used to identify, reduce and control negative environmental impacts. These include environmental impact assessment, environmental management systems, environmental accounting, environmental reporting, life cycle analysis, ISO 14000 standards. These tools can be applied both on-site (quarry & processing facility) and to transportation routes.

SARM, however, is not just about protecting the environment from the potential negative impacts of aggregate extraction. Reclaiming aggregate operations or orphaned sites has tremendous potential to improve our quality of life, create additional wealth, increase biodiversity, and restore the environment. In the expanding suburban areas of today, mined-out aggregate pits and quarries are converted into second uses that range from home sites to wildlife refuges, from golf courses to watercourses, and from botanical gardens to natural wetlands. Reclamation should be a major consideration in sustaining the environment and in creating biodiversity (Langer, 2003a).

Mineral resource (aggregate) protection includes: (a) minimal exploitation of primary aggregates with rational production by introducing the recycling and reuse of construction materials as aggregates; (b) exploitation of renewable aggregate and substitute resources; (c) increasing the knowledge about aggregate potential, and (d) preserving the land access to aggregates in designated areas. The first two of these protection measures are intended to reduce the demand for aggregate that is newly mined or from newly developed sites. The latter two address the long-term need for primary materials (Šolar, 2003).

Economic aspects of SARM - There are four main economic aspects to SARM: (a) providing for the material requirements of society; (b) maintaining a viable business environment; (c) encouraging value-added production and employment; and (d) embracing full cost accounting while remaining competitive. The first three of these are the responsibility of government. The fourth is the responsibility of the firm.

All societies utilize a stream of material inputs for manufacturing and construction. In the case of transition and post-conflict economies, there is particular need for construction materials to support development and rebuilding of infrastructure, industrial capacity, and housing. One aspect of SARM involves ensuring that these resources are available to the marketplace. This is sometimes referred to as secure supply. The main elements of secure supply are creation or maintenance of production capacity, identification of sufficient reserves and resources, provision of land access (extraction and exploration sites / areas), and development of the country’s or region’s infrastructure capacity (roads, railroads, power). All the foregoing issues are interlinked and need to be balanced by policy makers and resource managers. Secure supply can also take the form of importation in cases where the full cost of domestic supply would be higher than the full cost of imported materials.

A viable business environment exhibits the following characteristics: (a) a stable and feasible permitting regime; (b) consistent application of rules and regulations; (c) functioning capital markets; (d) reasonable levels of taxation; and (e) well defined property rights. Underemployment and unemployment are serious problems in many parts of the world. Therefore, governments should also consider setting policies that support the availability of a trained workforce and promote employment in the extractive industries. Development of value-added manufacturing is another important issue. Existence of a value-added sector can reduce the need for imported materials while allowing the domestic economy to capture the economic benefits (profits, employment, tax revenues) that would otherwise accrue in another country.

Economic realities drive industry activity. Firms need to remain competitive if they are to stay in business. Nonetheless, firms have a responsibility to accept the full cost of doing business, including costs of preventing or remediating environmental damage. Industry must be willing to accept the fact that in some cases, when all the costs are taken into consideration, a quarry will not be a viable economic enterprise and must be either shut down or not developed. Firms can, however, increase competitiveness by modifying production processes, upgrading product quality, and maintaining a well trained workforce. Production process and product quality can be achieved through voluntary quality control procedures such as adherence to ISO 9000 requirements. Quality is an important market element that can be labeled and traded. Research and development (R&D) is another issue that increases the enterprise's overall performance and has a great impact on increasing the added value. Some of R&D's goals include new products, and using BAT (best available technology) in the field. Finally, maintaining or increasing employment is not only governmental issue, because human resources are one of most important driving forces of every enterprise. Corporate culture, knowledge and skills need to be created, maintained, reviewed and revised (if necessary). Special attention with regard to human resources should be put on health and safety of employees.

Social aspects - Identifying stakeholders' values, interests, goals and the scale at which they apply is the first step in resolving the complex situations that impact a country's ability to maintain a secure material supply and achieve other policy goals. As an example, there may be abundant sites in a region that have suitable aggregate, but the existence of conflicting land uses, zoning, regulations, or citizen opposition can lead to insufficient or more costly supply. Scale of interest is a consideration in such situations due to fact that benefits and costs accrue to different parties in different regions. A third important issue is intra-generational equity, fairness to those living near or impacted by quarrying. Equity implies a need for transparency and public participation in decision making, as well as access to information within democratic process (Šolar, 2003).

Broader societal aspects can be described in terms of the legal framework, communication and education. The legal framework should protect the interests not only of country or region, but also investors and all other stakeholders. An effective legal framework needs balance between administrative requirements and flexible, time efficient, inexpensive procedures of licensing. Further, a country or region needs to have the institutional capacity to implement and enforce the legislation (monitoring and control components in particular), to develop and maintain resource information infrastructure, to foster research and development, to use funds from mineral rents (taxes) for the benefit of current and future generations, and facilitate cooperation with other sectors.

In addition to the legal framework, voluntary initiatives from different stakeholders (industry, non-governmental organizations) enrich dialogue and facilitate agreements. Voluntary initiatives include communication, education, partnership, and participation. All stakeholders should have access because increased awareness of the costs and benefits of supplying materials to society will lead to more timely agreements about how to (re)distribute costs and benefits of aggregate extraction and use (Šolar, 2003). We can conclude that social aspects facilitate the implementation of sustainability-based resource management that is discussed in next chapter.

Implementation - To ensure that aggregate resources are managed in a sustainable manner, each of the primary stakeholders – government, industry, public, and other non-governmental organizations – must accept certain responsibilities. The government is responsible for developing the policies and climate that provide conditions for success. The industry must work to be recognized as a responsible corporate and environmental member of the community. The public and non-governmental organizations have the responsibility to become informed about natural resource management issues, take personal responsibility for their consumption patterns, and to constructively contribute to a process that addresses not only their own, but a range of objectives and interests. All stakeholders have the responsibility to identify and resolve legitimate concerns, and the government, industry, and the public must cooperate at the regional and local levels in planning for sustainable aggregate extraction (Langer, 2003).

To be effective, SARM must be a pragmatic pursuit, not an ideological exercise. It is an iterative process and government, citizens, and industry should all be involved in the pursuit. The process consists of a number of steps, including issuance of policy statements, elaboration of objectives, establishment of actions, identification of indicators, and monitoring (Langer, 2003c):

- Policy statements issued by governments commonly identify the aggregate industry as a key industry contributing to jobs, wealth, and a high quality of life for their citizens, and commit the government to the protection of critical resources and protection of citizens from the unwanted impacts from aggregate extraction. Industry policy statements commonly identify environmental and societal concerns and commit the company to environmental stewardship and interaction with the community.
- Objectives describe what is to be accomplished and commonly are subsets of the social, economic and environmental components of SARM. Typically objectives will include, but not be limited to: (a) ensuring future supplies of aggregate; (b) reducing the demand for newly mined aggregate; and (c) protecting and restoring the environment (Langer, 2003b).
- Actions are associated with each objective and describe the steps to reach the objective.
- Indicators deserve special mention. They measure progress as well as the effects of efforts to protect and enhance natural and human systems and will be discussed in more detail below.
- Monitoring, feedback, and the regular reconsideration of requirements as events develop to refine the SARM process. The establishment of a joint monitoring process presents an excellent opportunity to forge partnerships with communities and involve citizen groups.

Measurement - Progress toward the policy goals that have been described in detail within a resource management plan need to be measured over time. Measurement can be described in terms of the hierarchical model of principles, criteria, and indicators previously described.

Adaptation - It is useful to think of policy making as a continuous process. Sustainable aggregate management has a place in all these stages. Over time societal goals, governmental policy, laws and acts, public and corporate management plans, regulatory regimes, and data sets can change. SARM should be seen as an adaptive process that responds to changes in social, economic and environmental system and to changing public preferences as well.

There are a range of potential problems associated with adoption, including: (a) unrealistically high expectations, (b) lack of commitment, and (c) inappropriate past practices. Therefore, a very clear roadmap of the management plan, and also a plan to address disappointment, is needed. In order to strengthen stakeholder commitment, all open issues should be discussed in a way that promotes consensus on of the outcomes. Building trust and confidence during the process of creating a management plan can help overcome the distrust that has been created by past bad practices.

4.4 INDICATORS FOR AGGREGATES

The objectives of an SARM plan and the form it takes differ between regions and countries due to the interplay of differing value sets, goals and objectives. The sustainability goals vis à vis natural aggregates for two comparably sized regions of Italy and the United

Kingdom are described below. The goals and objectives are slightly different in each country, which has led in turn to the development of different indicators.

In Italy in the Province of Modena, located in the Emilia Romagna Region in northern Italy, it has been recognized that natural aggregate and clay is necessary to sustain the economic well being of the region (Langer et al., 2003). Modena Province is preparing a Variant of the Intraregional Plan for Extractive Activities (PIAE) that has been in place in the Province since 1993 (Provincia di Modena, 1995, 1996, 2000, 2001). One objective of the Variant of the PIAE is to minimize the impacts from quarrying and guarantee the reclamation of quarries in a manner consistent with the existing landscape. In order to accomplish that objective, the Emilia Romagna Region, in the 1993 PIAE, developed the innovative concept of the polo estrattivo (extractive district). The polo estrattivo is not just one or more quarries, but is the whole of the area characterized by the prevalence of quarrying activities including the intervening and surrounding territory that is subject to quarrying impacts (Langer et al., 2003).

A number of draft sustainability indicators were developed to support the Variant of the PIAE (Langer et al., 2003). Selected indicators for aggregates of the Modena Province are:

1) Increase in number of poli from the old 1993 PIAE to the new Variant of PIAE.
2) Ratio of area within poli converted to extraction versus area outside poli converted to extraction.
3) Volume of aggregate produced per amount of surface area converted to extraction.
4) Percentage of aggregate processing plants that have been moved into pits within a polo.
5) Percentage of abandoned quarries that have been reclaimed.
6) Percentage of perifluvial areas in need of reclamation that have been reclaimed.
7) Percentage of reclaimed quarry area that has been reclaimed as wetland areas.

The Emilia Romagna Regional policy encourages the management of quarry activities through the polo estrattivo (indicator 1, above). Extracting aggregate between adjacent quarries in the poli will result in a more efficient method of quarrying than leaving the land in place (indicator 2). Similarly, in some poli it is possible to deepen the pit without harming the quality or quantity of the ground water, thus extracting more aggregate without disturbing more land surface area (indicator 3). Some aggregate operations locate processing equipment in highly visible locations outside of the pit area or near the riverbed, and the Province is encouraging the relocation of that equipment and the reduction of their numbers through their merging into pits within polo (indicator 4).

Previous aggregate extraction activities have resulted in dereliction and abandonment of quarries, and aggregate might be extracted from some of these abandoned operations as part of the reclamation process (indicator 5). Previous aggregate extraction activities in rivers, floodplains, and other activities in the Province, particularly channel modifications for flood control, have degraded the perifluvial environment. Future quarrying can make a positive contribution to biodiversity and sustainable ecosystems through reclamation of these areas (indicator 6), especially when reclaimed as areas that recreate natural habitat (indicator 7).

In the United Kingdom, natural resource policy, including policies for aggregates, is covered by an overall national development document: "A Better Quality of Life: A Strategy for Sustainable Development for the United Kingdom" (DETR, 1999). In English counties, two levels of plans affect the Mineral Development Plans (Harrison et al., 2002):

- Structure plans that set out general principles and policies for all forms of development, and
- Mineral Local Plans that set out detailed policies governing mineral extraction.

Every county (minor administrative unit) is required by law to develop, implement and review a Mineral Local Plan. The Durham County Mineral Local Plan (County Durham,

2003) states that provision should be made for at least 82 million tones of aggregates per annum, and that part of crushed stone should come from recycling and re-using construction materials. Their stated objectives are to: (a) ensure the efficient use of resources, and (b) minimize the use of non-renewable resources.

Each objective has targets and associated indicators. The target of the first objective is to maintain a landbank necessary to meet supply demands. This target is supported by following indicators:

- The amount of mineral extracted per annum.
- Any changes in the landbank or permissions granted.
- The viability of the existing landbank.
- The level and type of employment activity within sector.
- Changes in the landbank and permissions with Tees Valley.

The second objective has a target to increase the production of secondary and recycled materials and implicitly to decrease production of primary materials. This target is observed by two indicators:

- The amount of materials recycled per annum.
- The level and type of employment activity within the sector.

5 AGGREGATES IN SLOVENIA: AN APPLICATION

Slightly fewer that 2 million people live on the Slovenian territory of about 20.000 km^2. In the last few years the annual growth rate of the economy has been approximately 4 %, the unemployment rate 7 %, inflation around 9 %, and per capita income 10.000 USD. In 1991, the country attained the independence from ex-Yugoslavia, changed the social and economic system, and started the process of integration into the European Union.

Geology controls the location and quality of mineral resources. Lithologically, Slovenia is mostly composed of sedimentary rocks (over 90 %). Carbonate rocks prevail slightly over clastic rocks, with only a small percentage of metamorphic and igneous rocks.

At the turn of the millennium, quarrying (surface mining of industrial minerals and rocks for construction materials, mainly aggregates) and two underground coal mines represent the full extent of the Slovenian mining. The annual production of brown coal is about 0,7 MM tons, and the annual production of lignite is about 3,8 MM tons. There is negligible production of oil in gas and no metal production. Metal mines (mercury, lead and zinc), other coal mines (brown coal) and a uranium mine are in the process of closing.

Slovenia is self-sufficient in aggregates (crushed stone - limestone and dolomite and gravel); however, the country is not self sufficient in aggregates for asphalts due to the limited availability of convenient igneous rocks (Table 1.).

By the turn of the century quarrying was the prevailing form of resource extraction in Slovenia. Identified resources of aggregates in Slovenia are virtually infinite, although not all geological resources are extractable. Mining is allowed only in designated exploitation areas. Quarry permitting is predominantly under mining and spatial planning legislation.

5.1 MINERAL AND MINERALS RELATED POLICIES AND LEGAL FRAMEWORK IN SLOVENIA

Before the attainment of independence, in years before 1991, Slovenia had no officially declared mineral resource extraction policy. What policy guidance existed could be found in related government documents, socialist party statements, or in specific legislation such as that dealing with mineral extraction. This approach to resource policy reflected the socialist orientation of the ex-Yugoslav state. Mineral exploration, development, and exploitation were encouraged in spite of questionable profitability of many operations. And yet, some adjustments to western standards were beginning to occur, both because of increasing state openness and economic dependence upon the market-oriented part of the world.

In the 1980's, because mineral production was no longer viewed as an appropriate development indicator, the conspicuous statement that "development is measured by tons of fuel and non-fuel mineral resources extracted" was removed from national economic policy statements. The implicit, but still unstated, mineral resource extraction policy became more market-oriented than had previously been the case, although a strong state/socialist party influence remained. The result was a kind of semi-market orientation.

During this period the mining law (passed in 1975) was the main policy oriented legislative tool. Expectations with regard to mineral exploration and exploitation activities, the nature of documentation needed, and the extent of state monitoring were all defined within this law. The law itself is complemented by numerous acts, regulations, etc. These lay out the relationship between mining and land use planning, as well as other economic sectors such as agriculture, infrastructure (settlements, roads, electric power lines, military), and

GeoZS

Geological Survey of Slovenia
Dimiceva 14
Ljubljana, SLOVENIA

NON – METALS PRODUCTION IN SLOVENIA

(in metric tones)

		1983	1988	1993	1998	1999	2000	2001	2002	2003
Bentonit				20	447	447	292	278	201	187
Calcite			142.208	105.402	103.000	150.799	197.816	200.000	204.603	119.606
Kaolin		67.290	35.514	20.171						
Chalk		17.942	4.740	2.090	945	1.212	771	651	685	607
Quartz sand		650.295	861.579	374.164	518.755	533.551	503.666	486.554	394.342	449.733
Tuff			109.000		84.101	84.101	112.531	92.928	65.041	84.333
Chert		26.910	30.744	17.477	18.200	15.370	18.000	20.749	13.725	20.824
Ceramic clay		67.490	172.740	152.268	98.588	71.103	90.374	95.404	56.085	79.900
Industrial minerals and rocks		**829.927**	**1.356.525**	**671.592**	**824.036**	**856.583**	**923.450**	**896.564**	**734.682**	**755.190**
Brick clay		607.942	1.034.168	883.420	632.696	722.170	579.944	552.502	591.794	573.584
Building stone	limestone	9.456	34.830	54.321	31.474	35.246	36.399	35.335	32.692	38.942
	tonalite (granodiorite)	27.000	29.344	21.600	54.478	72.149	55.844	39.164	28.237	30.850
	other		9.318	2.465	1.139	810	6.529	27.686	1.820	5.713
Building stone		36.456	73.491	78.386	87.091	108.205	98.771	102.184	62.748	75.506
Raw materials for cement		1.533.912	1.249.387	1.520.954	1.479.644	1.255.179	1.471.571	1.488.942	1.313.047	1.400.423
Construction materials		**2.178.310**	**2.357.046**	**2.482.760**	**2.199.431**	**2.085.554**	**2.150.286**	**2.143.628**	**1.967.589**	**2.049.513**
Crushed stone	limestone	2.549.348	4.714.443	4.620.273	6.748.784	7.370.860	6.241.436	5.420.061	6.053.203	6.623.054
	dolomite	891.376	3.402.742	3.068.666	4.502.498	5.201.508	7.563.748	6.720.545	6.981.502	8.391.079
	other				99.963	65.383	111.636	60.140	14.970	26.207
Crushed stone		3.440.724	8.117.185	7.688.938	11.351.245	12.637.751	13.916.820	12.200.746	13.049.675	15.040.340
Sand and gravel		1.466.141	3.455.355	2.668.860	2.440.115	1.652.065	2.769.590	3.280.968	3.106.679	3.437.911
Construction materials – aggregates		**4.906.865**	**11.572.540**	**10.357.798**	**13.791.360**	**14.289.816**	**16.686.410**	**15.481.714**	**16.156.353**	**18.478.252**
NON - METALS		**7.915.102**	**15.286.111**	**13.512.150**	**16.814.827**	**17.231.953**	**19.760.146**	**18.521.906**	**18.858.624**	**21.282.954**

Table 1. Non-metals production in Slovenia (in metric tons)

natural and cultural heritage. In cases where mining could be expected to negatively impact one or more of these sectors or interests, mineral resources had to be declared "resources of special interest" to be extracted, which necessitated additional permissions. In theory, the law encouraged sensitivity to the environmental impacts of mineral development, but in reality the law lacked an effective enforcement mechanism, so environmental controls on extraction were limited.

Aggregates also fell under the mining law, but were not classified as "resources of special interest" due to their abundance. In contrast to the more regulated situation described above; the extraction permission procedure for aggregates and some other mineral resources (e.g., brick clay) was simplified, with decisions rendered by the local community (municipality). The state had only to be notified.

During the period when the 1975 mining law was valid, mining companies were obligated to submit short and long term development programs to state authorities, even though the state did not have an official mineral resource extraction policy. Companies would develop a mineral resource investment framework as part of their long term plan. These documents were also used as proof of profitability, and their content reflected company policies.

The state's de facto mineral resource policy could also be seen in the basic strategic state document – the Long Term Land Use Plan 1986–2000. In addition to spatial analysis of the current land use pattern (in the late 1980's), development predictions were noted and described. Mineral resource extraction was included and many elements of a mineral policy were expressed, such as the industry's relationship to other economic sectors and potential land use activities.

After the attainment of independence in 1991, transition to a market oriented economic and social system began. In this period of accommodation to European Union legislation, the Slovenian parliament began to debate revision of the mining law and the Long Term Land Use Plan 2000–2020. These two pieces of legislation are expected to comprise the basis of mineral resource extraction policy in next decade.

As a signatory of Agenda 21 and the Helsinki Process Resolutions, Slovenia has formally embraced the sustainable development paradigm. It is important to realize, however, that in period after 1991 the Slovenian mining law from 1975 remained valid. Thus, the essence of the transition period has been the presence of elements from the old (socialist) system, blended with elements of both a newly market-oriented socio-economic system and a sustainable development oriented environmental policy.

The contrast between old and new eras is obvious when goals of the 1975 mining law are contrasted with those of more recent environmental protection legislation. The former encourages mineral development while the latter promotes nature conservation. This dynamic tension is exacerbated by the fact that mining is becoming socially unacceptable in Slovenia. This shift in opinion is partly an expression of resentment over historic instances of land expropriation for mineral extraction. Another source of distrust has been the lack of control of the mining industry. There was a considerable amount of unskilled and illegal surface aggregate mining during the transition period, especially at sites where extraction was easily accomplished (dolomite, gravel areas).

In recent years mineral development in Slovenia has been significantly reduced. To date, however, the aggregate industry has survived, in part because domestic demand is being met with in-country production. In fact, aggregate demand has increased considerably in recent years due to a state highway construction program Although many aggregate quarries remain open, there is growing pressure to restrict extraction. This is occurring for a combination of reasons: (1) public mistrust of the industry and decisions associated therewith; (2) demands for compliance with costly environmental regulations; (3) increases in the cost of land, which has become enormously expensive as people have begun to incorporate the value of mineral resources in the sale price; and (4) the hindrances and extra demands (mostly in monetary terms) being placed on the mining industry by local communities.

During the 1990's, many documents were written and laws adopted by parliament that will have a strong influence on mineral resource policy of Slovenia and therefore on mining activities. One of the most important of these is the Environmental Protection Act (EPA - adopted in 1993). The Environmental Protection Act is an umbrella law which states that natural resources, including minerals and ores, are the property of the Republic of Slovenia and therefore exploitable only with a concession. A concession for a natural resource grants the right to its economic exploitation.

Development of a more precise legal framework for mineral resource concessions within the mining law was left to the Ministry for Economic Affairs. The Ministry subsequently created the Department for Mineral Resources and Mining in 1997, assigning it responsibility for addressing mineral issues for the Government, as well as representing the mining sector. A framework for mineral concessions was outlined in the new mining law, which was adopted end of June, 1999. To date the concessions have not been fully explicated. In this interim period, existing mining permits are still valid.

In recent years the Ministry for Environment, Spatial Planning and Energy prepared several national level spatial planning documents: Spatial Management Policy of the Republic of Slovenia (SMRRS), Spatial Planning Act (SPA), National Spatial Planning Strategy (NSPS), Spatial Planning Code (SPC), and Site Development Plan (SDP). SMRRS is overarching national spatial planning document based on sustainable development principles, which stresses the priority of public interests. It was adopted by the Government at the end of 2001. Mineral resources are included among natural resources and mentioned directly only as an issue / problem of illegal surface mining of aggregates. At the end of 2002, the Spatial Planning Act that follows the policy was passed by National Assembly. The Act defines fundamental spatial planning goals and sets the legal organizational framework. The latter consists of national, regional and local level obligatory documents. On the national level, Spatial Planning Strategy, Spatial Code and Site Development Plan are required. The same documents are also requested on the municipality level. Regional level is defined only by the Regional Conception of Spatial Development.

The National Spatial Planning Strategy (NSPS) has been in place since the 2004 Spatial Planning Code discussion started at middle of 2003. In the NSPS there is a reference to mineral resources. Mineral resources (aggregates in particular) are treated in the following policy guidelines: (a) adequate and secure mineral resource supply, (b) sustainable use of mineral resources, (c) reduction of the environmental and social impacts / costs, and (d) mine reclamation. One of the strategy's proposed actions is to establish a sustainable supply network for aggregates. The network would include a spatial pattern of quarries that is less dense than what is currently in existence, require larger production and reserves per quarry, identify optimal quarry transportation logistics (by train, if possible), and minimize negative social, environmental, and landscape visual impacts.

Mining Sector, which is also a part of the Ministry for Environment, Spatial Planning and Energy, is in charge of the mining sector on governmental level. The Slovenian mining (quarrying) policy is not clearly stated. The main policy guidelines and goals are included within the Mining Act (passed in 1999) and other mining related legislation (environmental, spatial planning, occupational health and safety, nature conservation, etc.), but unfortunately there are inconsistencies across the sector's guidelines and goals. A transparent policy should be presented in the National Mineral Resource Management Programme (NMRMP), required by Mining Act (1999). The NMRMP, currently in draft, should provide the goals, policies and conditions for the coordinated exploration and exploitation of mineral resources in Slovenia, the highest possible degree of their exploitation, as well as the conditions for their rational exploitation. Imperative elements for the elaboration of the NMRMP shall be the degree of environmental protection against mineral development pressures and a conservation policy to protect mineral resources. The NMRMP shall be adopted by the Government on the proposal of the Ministry responsible for mining, and for a period that shall not exceed ten years. Prior to the expiration of the period a report shall be elaborated on the measures taken along with the assessment of the accomplished goals. On the basis of the report the Government may decide to either revise or extend it.

The NMRMP draft's main aim is management that provides mineral resource supply and preserves access to mineral resources for future generations according to sustainable development principles in terms of balance among economic, environmental and social aspects. Furthermore NMRMP defines four major groups of mineral resources and four types of areas of mining interest (exploration, exploitation, potential, and reclamation areas). General programme goals are: sustainable use of mineral resources, mining sector competitiveness, communication and partnership, and harmonization with other sectors' policies. The NMRMP has two parts: the General Plan of Mineral Resource Management (GPMRM) and the Individual Mineral Resource Management Plan (IMRMP). GPMRM forms a technical basis for the elaboration of the spatial components of the national and local planning documents. The IMRMP is to present a technical basis for the elaboration of a detailed (site development) plan.

The two sector's policies described above reflect the basic principles of sustainable development. They are value-based and promote economic prosperity, environmental health, and social equity. Unfortunately, two other aspects of sustainability were not considered: (1) the interconnectedness of human and environmental systems and resulting need for policy consistency across sectors, and (2) the need for broad, participatory, and informed public decision making. Had these latter aspects been taken into account, complementary policies could be devised that makes the achievement of sustainability goals more likely. In order to improve policy consistency close cooperation was established on the expert level and a flow of information of currently drafting documents improves both sectors' documents.

It is important to have overarching vision within consistent policies. By implementing the policy by itself, sectorial decisions may be made on case by case basis, making it more likely that problems will occur. Decisions taken in one sector would usually lead to the partial solution of the problem. This solution is in most cases not part of other sector's problem solutions. In many cases that can lead to new problems. There is a need for solutions in the broader context.

Consider a simple decision by only one sector on a quarry reclamation proposal or another addressing the way a mine should be managed. The outcome will be so-called zero sum game, which means that one side will win and the other lose. This will happen regardless to the amount of input/information.

On the other hand, a decision made by all the sectors involved considers not only narrow case, but is taken within broader context in terms of nationally agreed mineral policy and other policies. This is a guarantee that the decision taken is more likely to be evenhanded, not biased. The latter is usually the case if the decision is only taken within narrow perspective of the one sector alone. But this approach requires decision makers who have strength of character and are willing to advocate for unpopular decisions.

Decisions therefore should not be taken on case to case basis. One of the reasons that mining has so much trouble with the public in many places around the world is that decisions about mining have been made in this manner. The issues are cumulative environmental, social, and local community impacts, as well as the broader (regional, country) consequences of extraction. Governments tend to prefer pragmatic, flexible decision making that many times provides a short-term solution (within the election cycle), but leads to long-term problems. If sustainable mineral resource policy is correctly implemented then the framework for decision-making is set in a way that future problems can be avoided.

Case by case decisions made in the procedure to obtain a mining right have led to an increased number of the quarrying sites. The 1999 Mining Act introduced the mining right at the state level. Previous to the mining act of 1999 quarries were under the jurisdiction either of the state (quarries with larger production) or the municipalities (those with smaller production with limited sales range within local community and neighboring municipalities).

The linkage between the municipality and state mining and other authorities (including spatial planning sector) was poor. There was lack of the information flow, and law and regulation implementation. Quarries with only municipality (spatial / land use and operational) permissions (that were many times issued on incomplete documentation) obtained the mining right for a duration of between 5 and 20 years.

The other argument to "legalize" all municipality quarries is illegal quarrying that spread widely after economic and social system changes in 1991. There is no existing data on the number of or production from illegal quarries. An overall policy goal is to eliminate illegal quarrying. There are several operational plans for how to deal with the problem, but so far results are not up to public and expert expectations.

Another spatial planning and nature conservation policy goal is the reduction of quarry site numbers and balancing of market demand and supply. Those goals could be achieved with fewer quarry sites and higher per site production. With a rational aggregates supply network, many spatial planning and nature conservation goals could be achieved, among them improved landscape amenity.

Inconsistent policy leads to policy goal confusion. Granting the mining rights to small quarries leads to desired and undesired outcomes. Desired policy goals are: more strict and complete state control over quarrying, and increased pressure on the illegal quarrying. Undesired outcomes are: an increase in the number of small quarries, the production from which could be obtained from larger quarries, and higher environmental and social costs stemming from the larger number of quarries.

5.2 LEGAL BACKGROUND TO AGGREGATE INDICATOR

The Mining Act states that, "The National Mineral Resource Management Programme … shall provide the goals, policies and conditions for the coordinated exploration and exploitation of mineral resources in Slovenia …"; however, an overall mining policy has not yet been articulated. Isolated elements of a policy can be found in the new Mining Act, and in other related acts, resolutions, policies, and regulations, and especially those dealing with spatial planning, nature conservation, and industry. A complete, coherent policy, however, does not exist.

This situation is particularly unfortunate in the case of aggregates. Demand for this commodity exists, and quarrying not only continues, but is the main type of mining presently taking place in Slovenia. At the same time, the Spatial Planning procedures and nature conservation regulations have made permitting of new quarries extremely difficult and time consuming with the result that an informal mining sector has arisen. The latter, combined with inappropriate practices by some aggregate producers, has exacerbated the negative image the public has of the mining sector, making it even more difficult to open new quarries. And finally, because there is no aggregates policy, no effort has been made to plan for the utilization of aggregates produced as a by-product of highway construction, other than as part of the construction itself.

As envisioned in the Mining Act, the National Mineral Resource Management Programme has two parts, a General Mineral Resource Management Plan and Mineral Resource Management Plans for individual commodity resources. The General Plan should include, "description and assessment of the existing reserves and the degree of exploitation of particular mineral resources, a detailed specification of the National Programme's goals and implementation measures as well as the basic premises for the individual mineral resource management plans, taking into consideration the specific features of particular areas and individual mineral resources." The individual plans are operational applications of the General Plan, and should include, "a descriptive and graphic part, and shall contain the description and evaluation of the extent, degree of exploration, and degree of exploitation of a particular mineral resource, as well as the record of reserves and requirements for individual mineral resources in particular areas, and the specification of goals and measures from the National Plan related to individual mineral resources in particular areas."

The General Plan is currently being written; individual commodity plans will follow. The form these documents will take is in part a function of the fact that Slovenia signed the Rio Declaration in 1992 and has since embraced the principles of sustainable development contained therein. Slovenia was also a member of the UN Commission on Sustainable Development for the period of 2001–2003. The over-arching objective of sustainable development is the long-term well-being of human societies. This end is only achievable if we live within the capacities and limits of our environmental support system. Thus, sustainable development requires consideration and integration of economic, social, and environmental concerns. Phrased as principles, these concerns become economic prosperity, environmental health and intra- and inter-generational equity.

An effort has been made to incorporate these basic sustainability principles in the General Plan's two main themes: (1) ensure that a reliable supply of mineral resources is provided to society in a manner that appropriately balances social, economic and environmental concerns, and (2) ensure that future generations have access to the mineral resources they will need.

5.3 STAKEHOLDERS OBJECTIVES IN THE NATIONAL MINERAL RESOURCE MANAGEMENT PROGRAM DRAFT

As noted previously, quarrying is the most prevalent form of resource extraction in Slovenia. Identified resources of aggregates in Slovenia are virtually infinite, although not all geological resources are extractable. Theoretically, mining is allowed only in designated exploitation areas, and is to be conducted under strict environmental oversight. In reality, landscape superintendence has been weak and enforcement of environmental regulations has been lax. At a time when permitting of new quarries is extremely difficult and time consuming, informal miners have faced few legal consequences for their actions. An effective policy on aggregates is needed to correct this contradictory situation.

The first step in utilizing the SMRM approach to develop a Resource Management Plan is to identify stakeholders and their values and objectives regarding quarries and aggregates. Public objectives and preferences range from total rejection to welcoming acceptance depending upon the individual's proximity to a quarry, type of interest (economic, environmental, nature conservation, etc.), and decision making power or influence. Consider for example the objectives of three different stakeholders. These objectives were expressed to the author during various discussions, meetings, and roundtables held between 1998 and 2002. Participants included government, industry, local community, and NGO's (non-governmental organizations).

Industry: Their objective is a stable operating environment, including sufficient sales, production to support sales, and adequate reserves and resources.

Government (Spatial Planning Department): Their objectives include reduction of environmental degradation (to be accomplished through a reduction in the number of quarry sites), regional supply of aggregates, and zoning areas of aggregate resources.

Local Community: Their objectives include minimizing negative effects, including visual intrusions, and ensuring that quarry operations deal with environmental impacts, site closure, and reclamation.

The foregoing objectives can be summarized as:

- Maintain access to adequate reserves and receive permission to mine in acceptable locations;

- Eliminate small, unregulated quarries;
- Disallow super-quarries that cause significant disruption; and
- Close or disallow quarries that are so distant from their markets that commodity transport becomes disruptive to communities.

Having identified objectives, the next step is to develop management alternatives that respond to those objectives and then describe the alternatives using available information. Aggregates can be supplied in numerous different ways. Table 2 shows a hypothetical example of three supply alternatives that have been based on the objectives discussed above. They are described with existing data from Commission on Reserve Evaluation of Ministry for Environment and Spatial Planning. Alternative 1 is a super quarry scenario. Alternative 2 is a scenario of regional quarries. Alternative 3 scenario is a more dispersed system of regional quarries.

	Alternatives		
Data	1	2	3
Maximum number of sites	10	50	150
Maximum annual production / through-put in MM t	5,0	1,0	0,3
Percent of sites with reserves above 1MM t	100	70	50

Table 2 Simple Hypothetical Matrix describing Management Alternatives with Existing Data

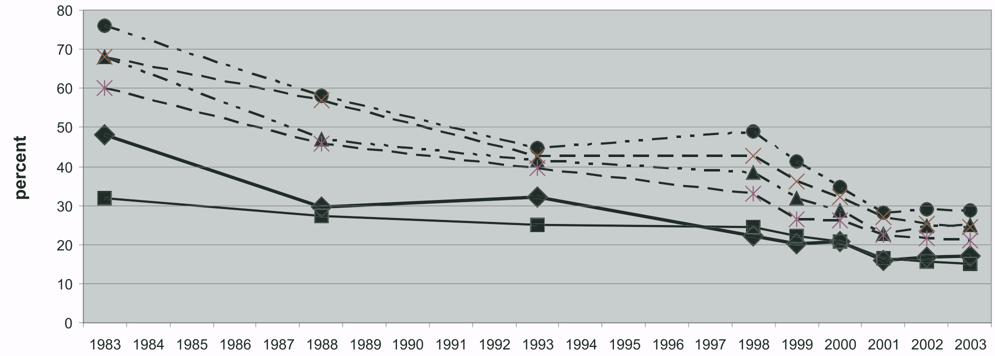
Assuming that all three alternatives are feasible and sustainable, the next stage in the process would be public debate, negotiation and selection of an alternative to be implemented. Final selection requires some level of stakeholder consensus. Public preference among alternatives will be predicated upon each stakeholders' weighting of different objectives, e.g., minimizing the number of quarries versus minimizing transportation impacts. Tradeoffs will inevitably have to take place because it is not possible to optimize everything, everywhere simultaneously.

The desired outcome included in NMRMP draft is for a high percentage of legal quarry sites to have what are termed acceptable production and enough reserves/resources. For Slovenia, a "proper" quarry would have (acceptable) production annually between 50.000 and 500.000 tons, and (enough) reserves for between 10 and 50 years of average production. These levels were chosen so as to address the competing objectives of the stakeholders listed above.

5.4 SUSTAINABLE SUPPLY INDICATOR

In Slovenia, there is so far only one "final" indicator, which resides at the top of a pyramid of primary (raw) and secondary (analyzed) data. It is: "Percentage of "proper" quarry sites by administrative unit, across spatial scales, i.e., from municipality to country." Annual data for this indicator needs to include the number of sites, their production, reserves, and resources of aggregates. These data are transformed into an indicator by combining them with land area (on 1000 km^2, or on administrative, statistical units) and average production per capita as a proxy for demand.

Figure 9 presents the main indicator plus a series of auxiliary indicators. The main indicator incorporates an upper limit on production that has been set in response to the significant negative environmental and social impacts of larger operations. An upper limit on reserves (resources) reflects the fact that for large reserves (resources) stock, larger areas need to be exclusively reserved for extraction. That may increase the possibility for potential land use conflict. The lower limit on production and low reserves/resources was included because small and short term operations are not desired by the public.



	1983	1988	1993	1998	1999	2000	2001	2002	2003
A	**48**	**29,6**	**32,3**	**22,3**	**20,2**	**20,7**	**15,9**	**16,9**	**17**
A (v)	32	27,2	25	24,5	22,3	20,7	16,5	15,7	15,2
B	68	46,9	41,7	38,3	31,9	28,7	22,9	24,7	25,1
B (v)	76	58	44,8	48,9	41,4	34,8	28,2	28,9	28,7
C	60	45,7	39,6	33	26,6	26,2	22,4	21,7	21,1
C (v)	68	56,8	42,7	42,6	36,2	32,3	27,1	25,3	24,6

Legend:
A: Percentage of legal quarry sites that have (acceptable) production annually between 50.000 and 500.000 tons, and (enough) reserves for between 10 and 50 years of average production (based on last 5 years).
A(v): Percentage of legal quarry sites that have (acceptable) production annually between 50.000 and 500.000 tons, and (enough) reserves and resources for between 10 and 50 years of average production (based on last 5 years).
B: Percentage of legal quarry sites that have (acceptable) production annually above 50.000 tons, and (enough) reserves for more than 10 years of average production (based on last 5 years).
B(v): Percentage of legal quarry sites that have (acceptable) production annually above 50.000 tons, and (enough) reserves and resources for more than 10 years of average production (based on last 5 years).
C: Percentage of legal quarry sites that have (acceptable) production annually between 50.000 and 500.000 tons, and (enough) reserves for more than 10 years of average production (based on last 5 years).
C(v): Percentage of legal quarry sites that have (acceptable) production annually between 50.000 and 500.000 tons, and (enough) reserves and resources for more than 10 years of average (based on last 5 years).

Figure 9 Indicators for Aggregates for Years 1983–2003

These limits are arbitrary to some degree, especially upper limits. For that reason, the conditions were altered in the auxiliary indicators. Some of the auxiliary indicators remove the upper limit of production and reserves, or use only reserve estimates. Other auxiliary indicators use both reserves and resources (probable stock of mineral resources). The main indicator is more easily interpreted when contrasted with the auxiliary indicators.

The main and auxiliary indicators are national in scale. The main indicator's trend is negative; the number of improper quarry sites increased in the period 1983–2001. Two major discontinuities occur because data became more accurate in 1998, and then the revised mining act was passed in 1999. From 1999 on, control over operation licenses transferred from local to national control. Starting in 2001, all operations were obligated to pay a mandatory royalty.

In year 2001 the number of sites with insufficient production and reserves (& resources) was higher than that desired by stakeholders and the government, based on stakeholder input and government statements. Conversely, there are only a very few locations having production above the upper limit. This can be seen clearly by examining the auxiliary indicators that do not have an upper limit on either production or reserves (& resources) or use only reserves (& resources). Approximately 5 % of all locations are larger than desired, but over 70 % of locations have insufficient production and reserves (& resources).

Number of Sites 171,

- Annual production 18.500.000 t,
- Reserves: 582 million t,
- Reserves and Resources: 991 million t,
- Per Site
  - Production per site: 108.000 t,
  - Reserves per site: 3,4 million t,
  - Reserves and Resources per site: 5,8 million t.
- Per Capita
  - Number of Inhabitants per Site: 11.675,
  - Production per Capita: 9,26 t,
  - Reserves per Capita : 291 t,
  - Reserves and Resources per capita: 496 t.
- Per Area (1000 km^2)
  - Number of Sites per Area: 8,43,
  - Production per Area : 911.500 t,
  - Reserves per Area : 28,7 million t,
  - Reserves and Resources per area: 49,0 million t.

Table 3 Data for Aggregates for Year 2003

The national level data are also available for each of Slovenia's 12 regions. These regions are grouped into three main regions to create sets of data and indicators for the country, as well as for the three and twelve regions. Comparison at the most disaggregated scale clearly demonstrates those parts of the country in which the value of the indicator is below or above the national value (Appendix).

Additional insight can be gained by considering the frame of extraction activity; overall number of sites, production, reserves and resources and their ratio to population, areas (Table 3). Aggregate data are also divided into groups of crushed stone, and sand and gravel. The crushed stone group is further divided into limestone, dolomite and other rocks. Three and seven production and reserve (and resources) size classes were created. The three main indicator classes are: for production (below 50.000 tons of annual production, between 50.000 and 500.000 tons and above 500.000 tons) and for reserves (resources) (below 10 years, between 10 in 50 years, and above 50 years). The three classes were also broken into seven subclasses. All this information is part of the indicator information pyramid that helps explain the details of the main indicator and also exposes other related information that may be of interest to many stakeholders at the regional and national level.

In appendix regional and temporal distributions of data are available in more detail.

The process of creating the Slovenian NMRPM was as important as the program itself because of the need for public acceptance. This was true also for the choice of indicators. An information pyramid was used to demonstrate how data were concentrated. The aggregation of data made complex and comprehensive information understandable. Data on reserves, resources, and production of mineral resources were captured within a simple, flexible database system and reported as a single indicator. The data manipulation tools will also provide opportunities for an inquiry of individual data as well as analysis of indicator information on different spatial and temporal scales (Šolar, 2003).

Inevitably, many practical problems have to be solved during the process of indicator creation. In the Slovenian case, the indicator selection process had to deal with unrealistically high stakeholder expectations that complete information would be incorporated into a single indicator, when in reality only a limited amount of information was actually incorporated in the selected indicator. That indicator was based on available data that had been collected over a long period of time. During the reporting period, data accuracy was inconsistent; in the 1980's data on location, production and reserves were collected only from what at that time was termed large aggregate sites. Data accuracy is also questionable, due to the fact that many quarry operators were not filling out the annual questionnaires in the same manner. There were particular problems related to reporting on reserves and production in cubic meters. No clear distinction was made between cubic meters of intact mineral resources (in site) and dispersed cubic meters of mineral resources on tracks (of production). As a result, data were calculated into tons under the assumption that all cubic meters were dispersed.

Finally, the question of the adequacy of existing data needs to be addressed. Will existing data provide enough information to enable decision makers and stakeholders to compare and discuss the full range of costs and benefits associated with alternative resource management plans? In the case of Slovenian supply of aggregates, the answer is clearly no. Only a portion of the needed information is available. Consider two examples. First, the scenarios above are based on the assumptions that the maximum through put per facility would be 50 MM t/annum and that 20 MM t/annum represents adequate supply, given that recent production levels have been approximately 17.6 MM t/annum. This assumption may be seriously flawed because it was based strictly upon production data. Historic demand and predictions of future demand were not utilized and the implications of significantly higher or lower demand were not considered. Second, it is impossible to devise management strategies that reflect public objectives without full information on what objectives stakeholders have. The objectives discussed above represent the positions of only 3 stakeholder groups, not the full range of opinion.

6 CONCLUSIONS

Nations have used their mineral endowment as an engine of development throughout history and part of the legacy of doing so remains with us to this day in the form of polluted and un-reclaimed mine sites and altered landscapes. There is also a long history of mineral development that was approved because it was expected to create wealth that could be used to better peoples' lives, but that actually enriched only the mining company and selected elites. As a result, the mining industry is in danger of losing the social license to operate. This does not need to happen.

Societies, both developed and developing, need a stream of material inputs. And developing nations need to generate wealth to alleviate poverty and fund programs that increase the well-being of their citizens. Domestic mineral development can provide both materials and new wealth. Moreover, creation of a value-added sector for minerals can reduce the need for imported materials while allowing the domestic economy to capture the economic benefits (profits, employment, tax revenues) that would otherwise accrue in another country. The question is – how to do so in a manner that most benefits the nation.

We believe that Sustainable Mineral Resource Management offers a structure within which nations can maximize the benefits, and recognize and control the costs of mineral development. For this to occur, developing nations must determine a priori what their development goals are and how mineral resources can and should contribute to the achievement of those goals. They must then carefully track and regulate the behavior of the extractive sector to ensure that their contributions to society are net positive.

That tracking is accomplished with mineral indicators of sustainability. A selected set of mineral indicators should express a need for balance: (a) among stakeholders; (b) between the process of defining indicators and the set of chosen indicators; and (c) among dimensions of sustainability. Mineral indicators of sustainability should be used: (a) as tools for knowledge, information transfer; (b) integral parts of other initiatives and sets of indicators; and (c) as a solid base for decision making.

We report the steps taken to create the sustainability-based, draft Slovenian national mineral resource management program: (a) a democratic, multi-stakeholder public participation process; (b) an adequate and reliable reporting of information on the past trends and the current state of the Slovenian mining with regard to mineral potential, exploitability, market situation, environmental issues, and social acceptability; and (c) fulfilling legal requirements. The purpose of the proposed indicators is to monitor the effects of the resource program, once it has been adopted, and to improve decision-making.

We conclude that the process of program creation was as important as the program itself because of the importance of public acceptance. This was true also for the choice of indicators. In the case study, an information pyramid was presented that demonstrated how concentrating, i.e., aggregating, data makes complex and comprehensive information understandable. Data on reserves, resources, and production of mineral resources were captured within a simple, flexible database system and reported as a single indicator. The data manipulation tools provide opportunities for an inquiry of individual data as well as analysis of indicator information on different spatial and temporal scales.

Data overview and analysis gives a clear picture of the earlier years and the current state of mineral resources in Slovenia, and in particular the situation for aggregates in the years 1983-2003. Mineral resources in Slovenia will play a similar role in the country's future as in the European Union. In the European market economy, mineral resources of higher value will be mostly imported, and the bulk mineral resources, aggregates in particular, domestically extracted. This conclusion suggests that aggregates will remain an important factor in the national economy of Slovenia and contribute to its sustainable development. While the Slovenian aggregate industry does not yet fulfill the public's expectations, it has the potential for doing so with the embrace of resource management and corporate behaviors consistent with sustainability principles.

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APPENDIX

- **PROPOSED SIZE CLASSES FOR QUARRY SITES WITH REGARD TO PRODUCTION**

- **PROPOSED SIZE CLASSES FOR QUARRY SITES WITH REGARD TO RESERVES / RESOURCES**

- **AVERAGE DENSITY OF ROCKS**

- **DIVISION OF SLOVENIA INTO THREE REGIONS AND TWELVE STATISTICAL REGIONS**

- **MAIN INDICATOR AND 1st ORDER INDICATORS WITHIN THREE AND TWELVE STATISTICAL REGIONS BETWEEN 1983 AND 2003**

PROPOSED SIZE CLASSES FOR QUARRY SITES WITH REGARD TO PRODUCTION

Description	*Symbol*	*Classification in tons*	*Classification in cubic meters*
too small	pm	<10.000	<5.000
small	m	10.000-50.000	5.000-30.000
SMALL	**M**	**<50.000**	**<30.000**
medium small	sm	50.000-100.000	30.000-50.000
medium	s	100.000-250.000	50.000-100.000
MEDIUM	**S**	**50.000-500.000**	**30.000-250.000**
medium large	sv	250.000-500.000	100.000-250.000
large	v	500.000-1.000.000	250.000-500.000
LARGE	**V**	**>500.000**	**>250.000**
extra large	pv	>1.000.000	>500.000
SMALL	**M**	**<50.000**	**<30.000**
MEDIUM	**S**	**50.000-500.000**	**30.000-250.000**
LARGE	**V**	**>500.000**	**>250.000**

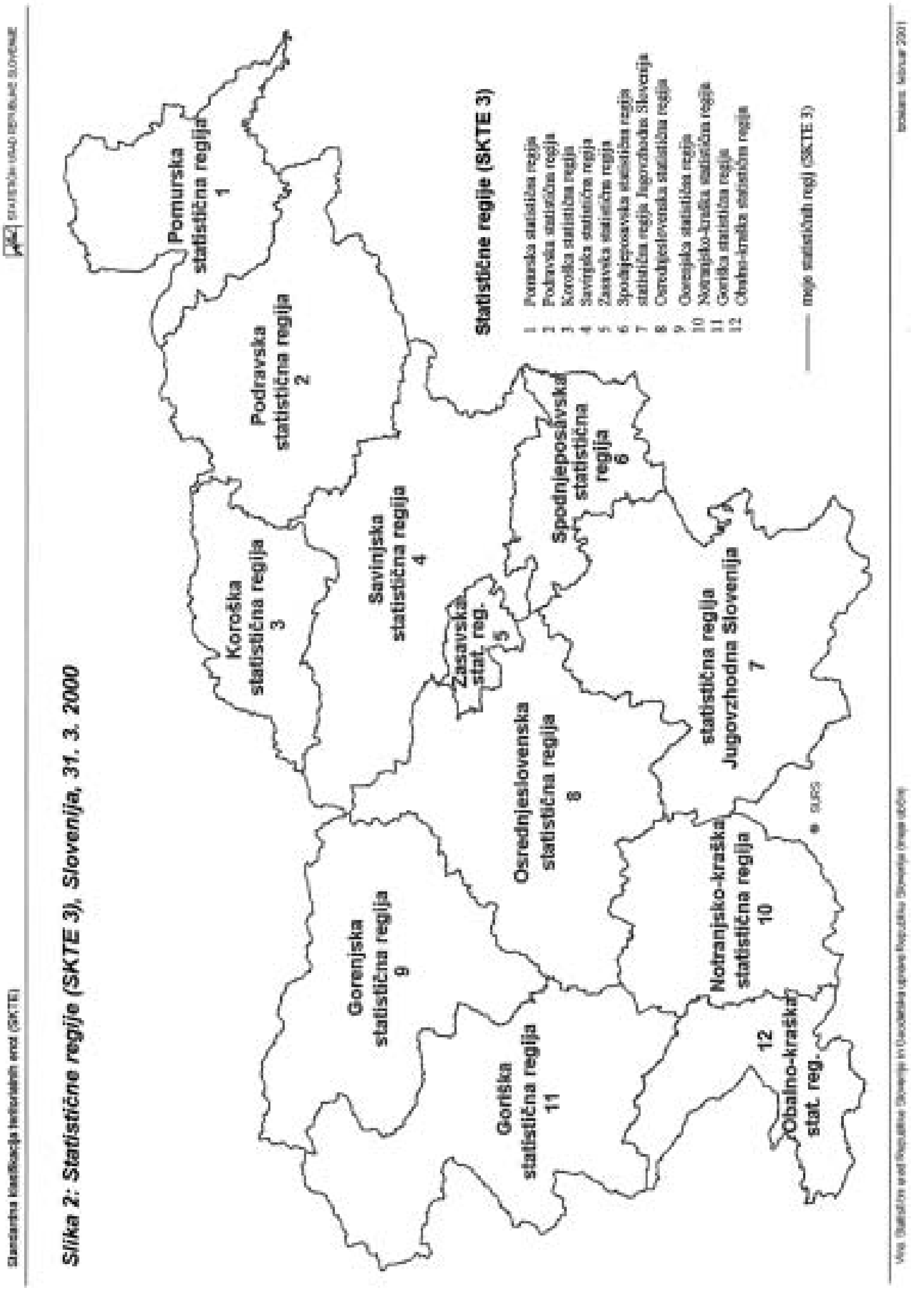
PROPOSED SIZE CLASSES FOR QUARRY SITES WITH REGARD TO RESERVES / RESOURCES[1]

Description	*Symbol*	*Classification with regard to quantity (tons)*	*Classification with regard to years (years)*
too small	pm	<25.000	<5
small	m	25.000-100.000	5-10
SMALL	**M**	**<100.000**	**<10**
medium small	sm	100.000-500.000	10-20
medium	s	500.000-2.500.000	20-30
MEDIUM	**S**	**100.000-10.000.000**	**10-50**
medium large	sv	2.500.000-10.000.000	30-50
large	v	10.000.000-50.000.000	50-100
LARGE	**V**	**>10.000.000**	**>50**
extra large	pv	>50.000.000	>100
SMALL	**M**	**<100.000**	**<10**
MEDIUM	**S**	**100.000-10.000.000**	**10-50**
LARGE	**V**	**>10.000.000**	**>50**

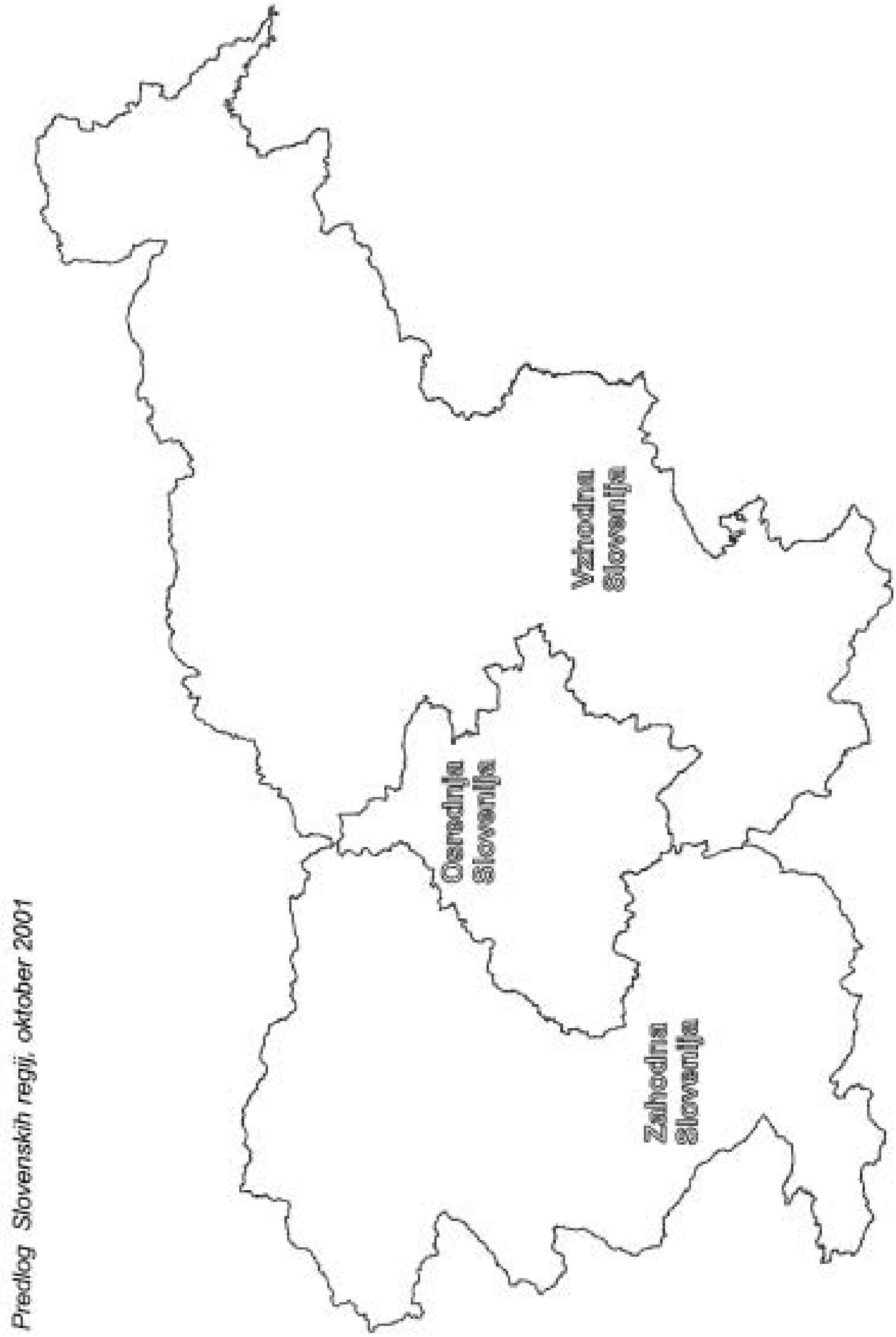
[1] – distinction is made between reserves and resources, resources are uneconomical reserves and potential reserves within exploration and exploitation areas

AVERAGE DENSITY OF ROCKS

Rock	*Density* ***(t/m³)***
clay	2,00
dimension stone	2,70
quartz sand	1,40
crushed stone	
limestone	2,70
dolomite	2,60
igneous and metamorphic rocks	2,90
sand and gravel	1,90
marl	2,60
chalk	2,10
tuff	2,40



Statistical regions (12) of Slovenia, 31.3.2000



Proposed division of Slovenia into three regions, October 2001

Main indicator and 1st order indicators within three and twelve (statistical) regions between 1983 and 2003

Picture P1. Percentage of quarry sites with annual production between 50.000 and 500.000 tons and reserves for 10 to 50 years of average production within 12 statistical regions and its comparison to the main (national) indicator in years 1983–2003

Picture P2. Percentage of quarry sites with annual production between 50.000 and 500.000 tons and reserves for 10 to 50 years of average production within three regions and its comparison to the main (national) indicator in years 1983–2003

Picture P3. Number of inhabitants (x103) per quarry site within 12 statistical regions in years 1983–2003

Picture P4. Number of inhabitants (x103) per quarry site within three regions in years 1983–2003

Picture P5. Number of quarry sites per 1000 km^2 within 12 statistical regions in years 1983–2003

Picture P6. Number of quarry sites per 1000 km^2 within three regions in years 1983–2003

Picture P7. Production of aggregates (in tons) per inhabitant within 12 statistical regions in years 1983–2003

Picture P8. Production of aggregates (in tons) per inhabitant within three regions in years 1983–2003

Picture P9. Production of aggregates (x103 in tons) per 1000 km^2 within 12 statistical regions in years 1983–2003

Picture P10. Production of aggregates (x103 in tons) per 1000 km^2 within three regions in years 1983-2003

Picture P11. Reserves of aggregates (in tons) per inhabitant within 12 statistical regions in years 1983-2003

Picture P12. Reserves of aggregates (in tons) per inhabitant within three regions in years 1983–2003

Picture P13. Reserves of aggregates (x103 in tons) per 1000 km^2 within 12 statistical regions in years 1983–2003

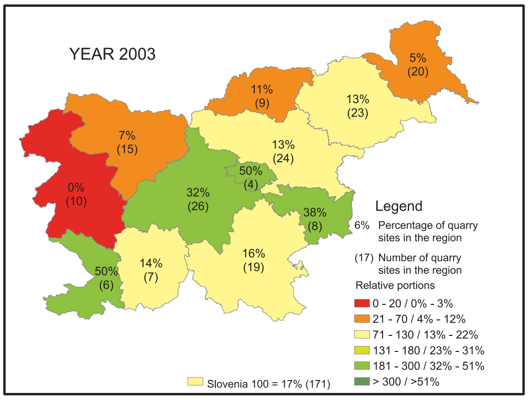
Picture P14. Reserves of aggregates (x103 in tons) per 1000 km^2 within three regions in years 1983–2003

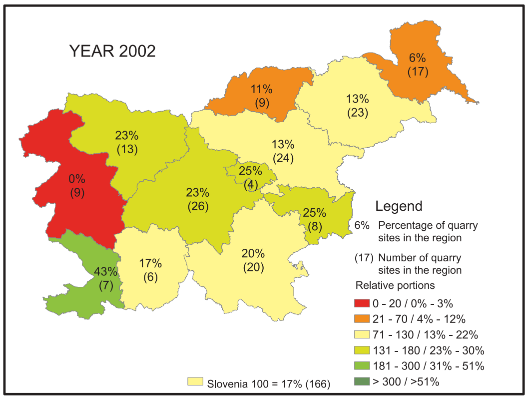
Picture P15. Reserves and resources of aggregates (in tons) per inhabitant within 12 statistical regions in years 1983–2003

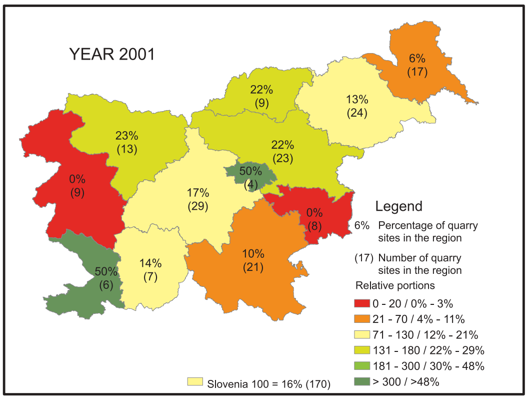
Picture P16. Reserves and resources of aggregates (in tons) per inhabitant within three regions in years 1983–2003

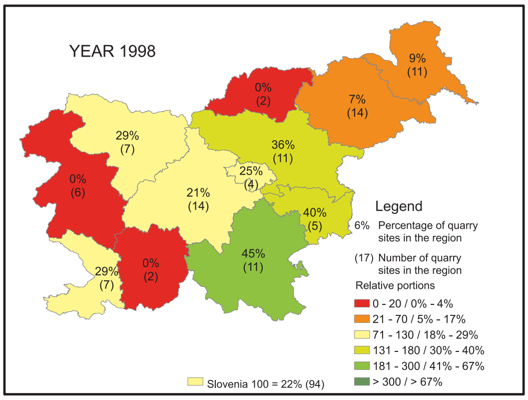
Picture P17. Reserves and resources of aggregates (x103 in tons) per 1000 km^2 within 12 statistical regions in years 1983–2003

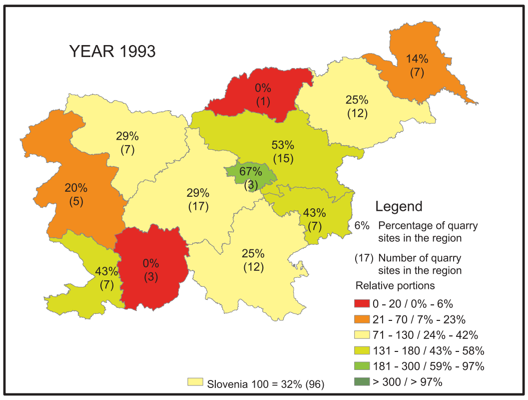
Picture P18. Reserves and resources of aggregates (x103 in tons) per 1000 km^2 within three regions in years 1983–2003

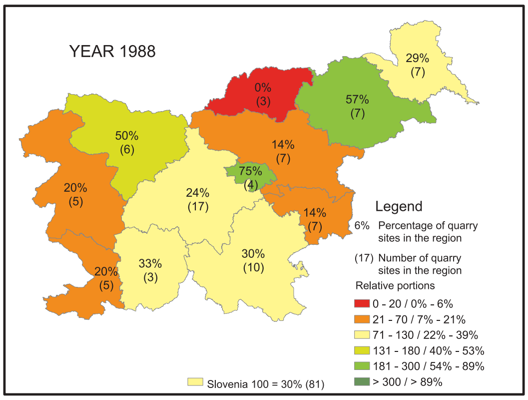


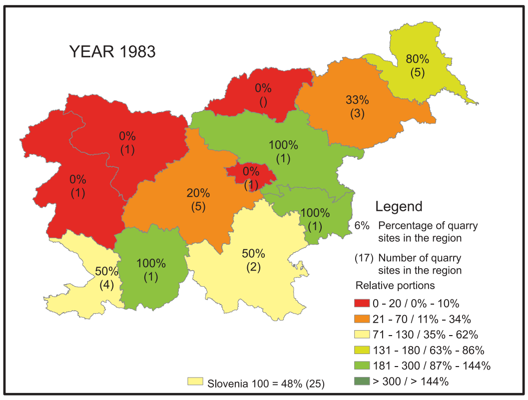




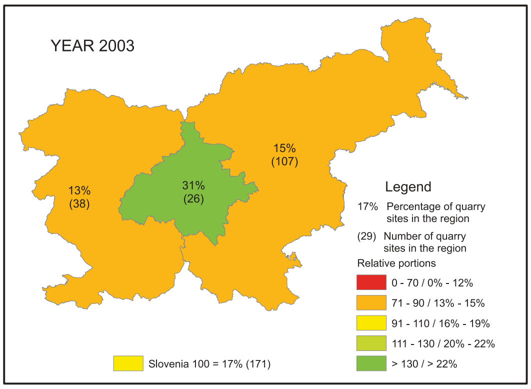


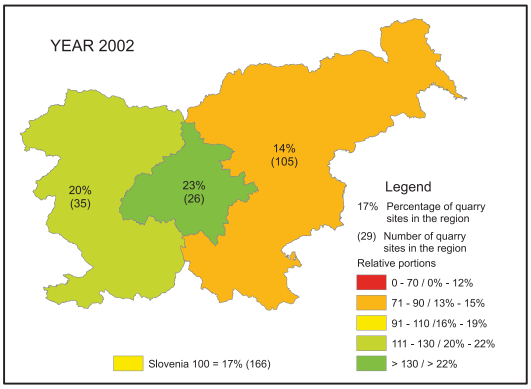


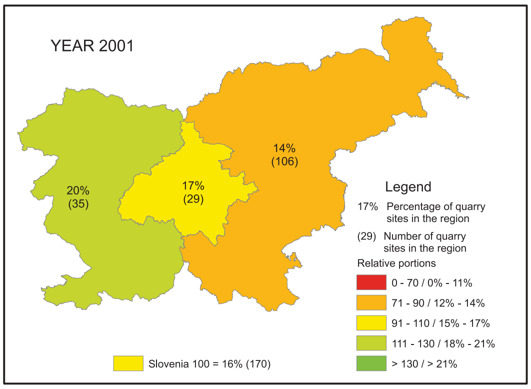


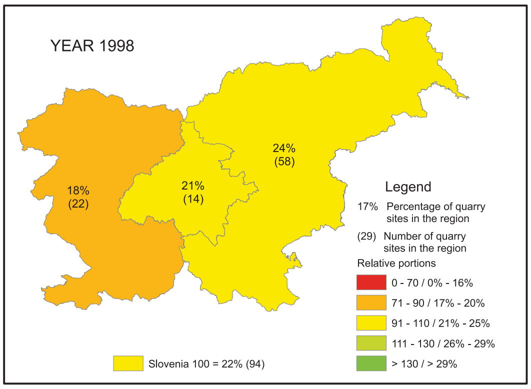


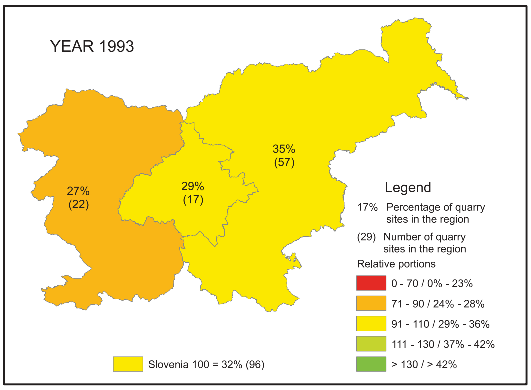
Picture P1. Percentage of quarry sites with annual production between 50.000 and 500.000 tons and reserves for 10 to 50 years of average production within 12 statistical regions and its comparison to the main national indicator in years 1983–2003

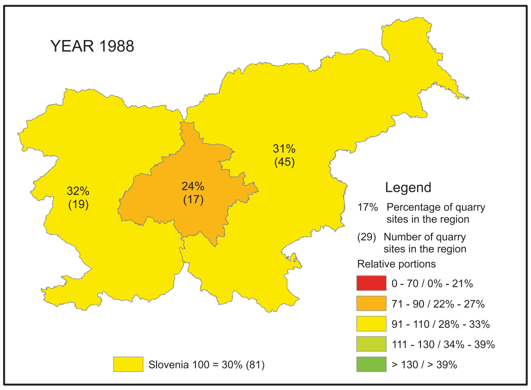


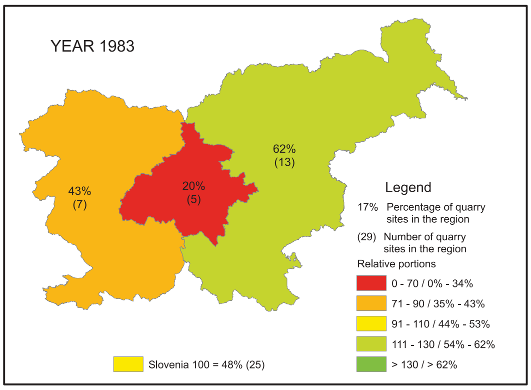




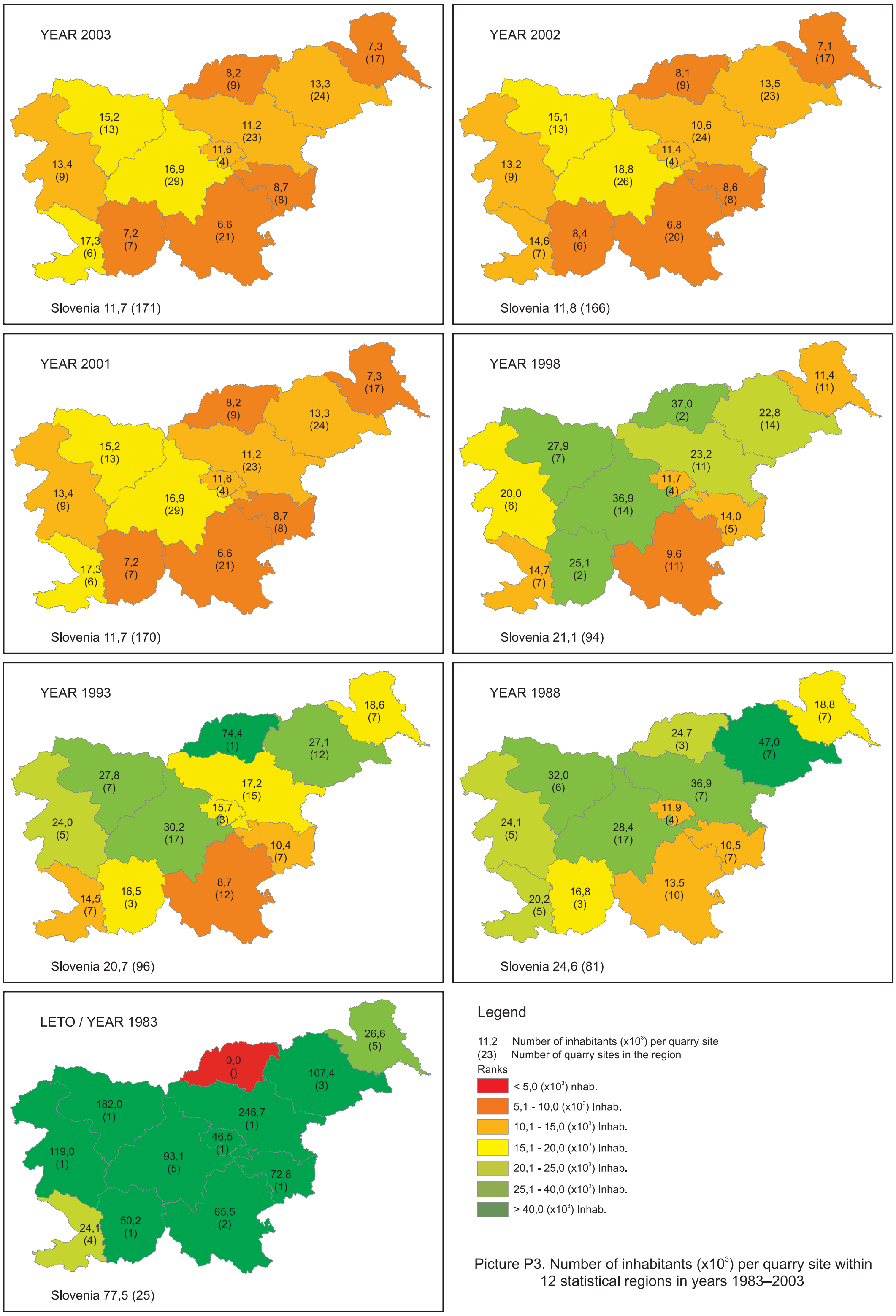




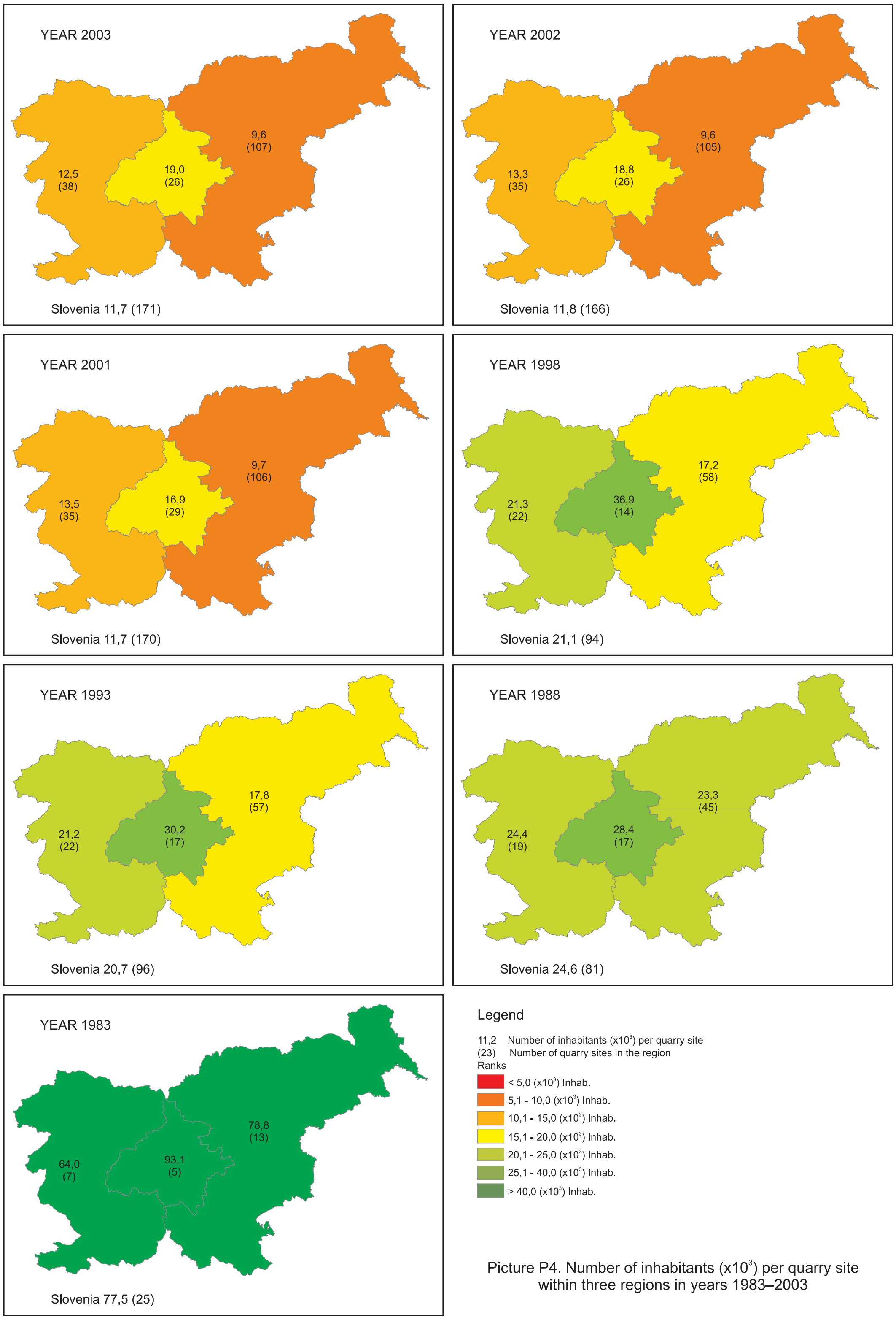




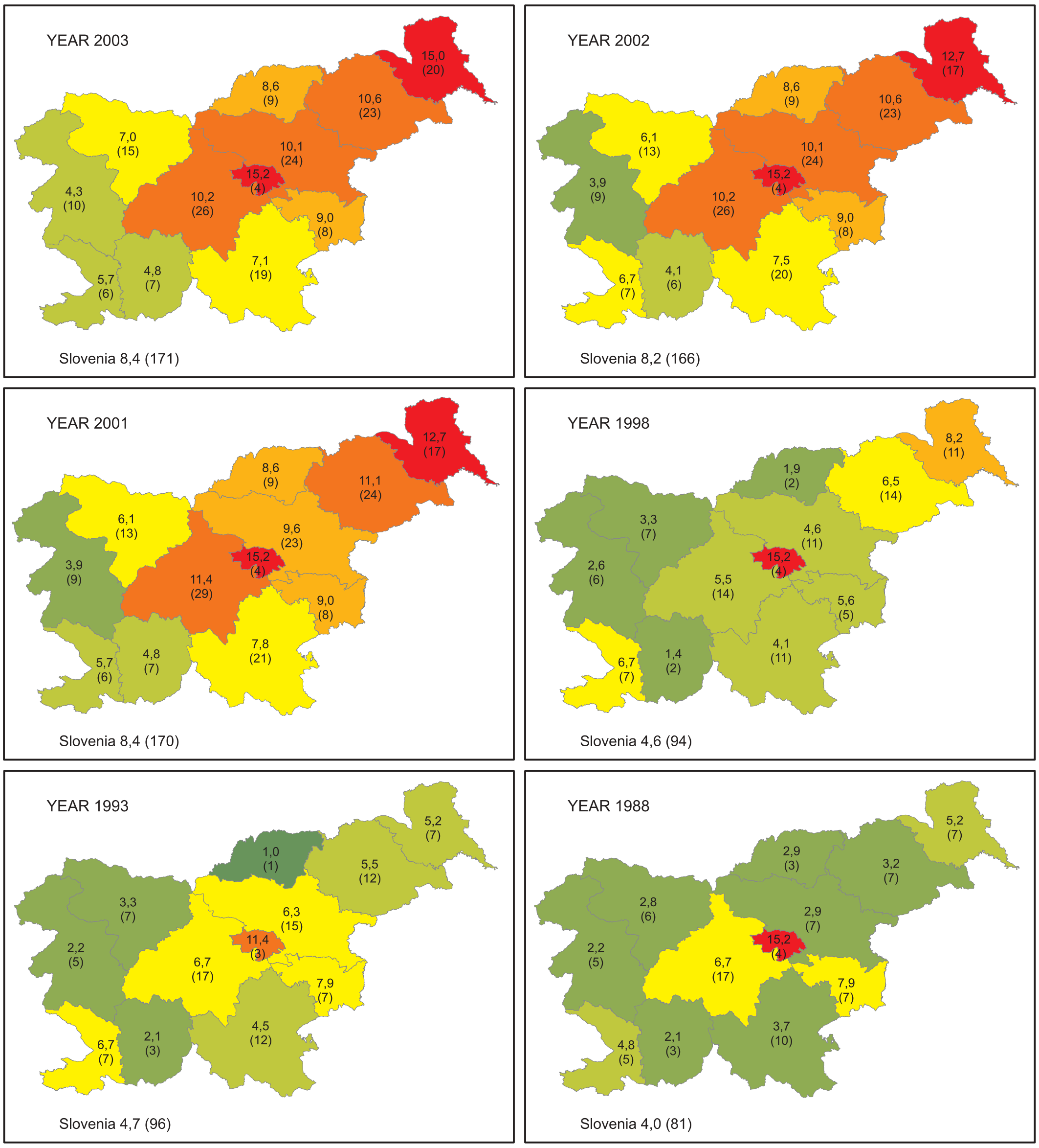
Picture P2. Percentage of quarry sites
with annual production between
50.000 and 500.000 tons
and reserves for 10 to 50 years
of average production within three
regions and its comparison
to the main national indicator in years 1983–2003

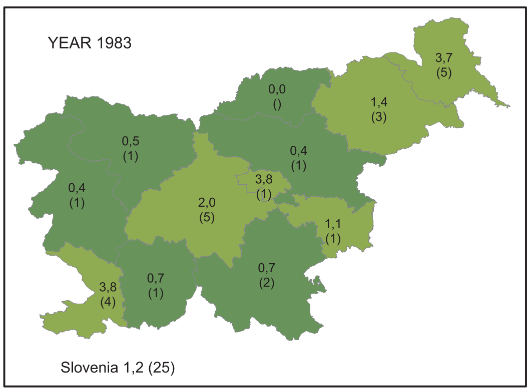


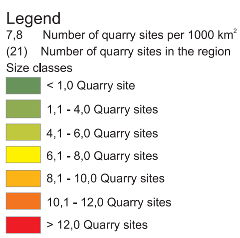
Picture P3. Number of inhabitants ($x10^3$) per quarry site within 12 statistical regions in years 1983–2003



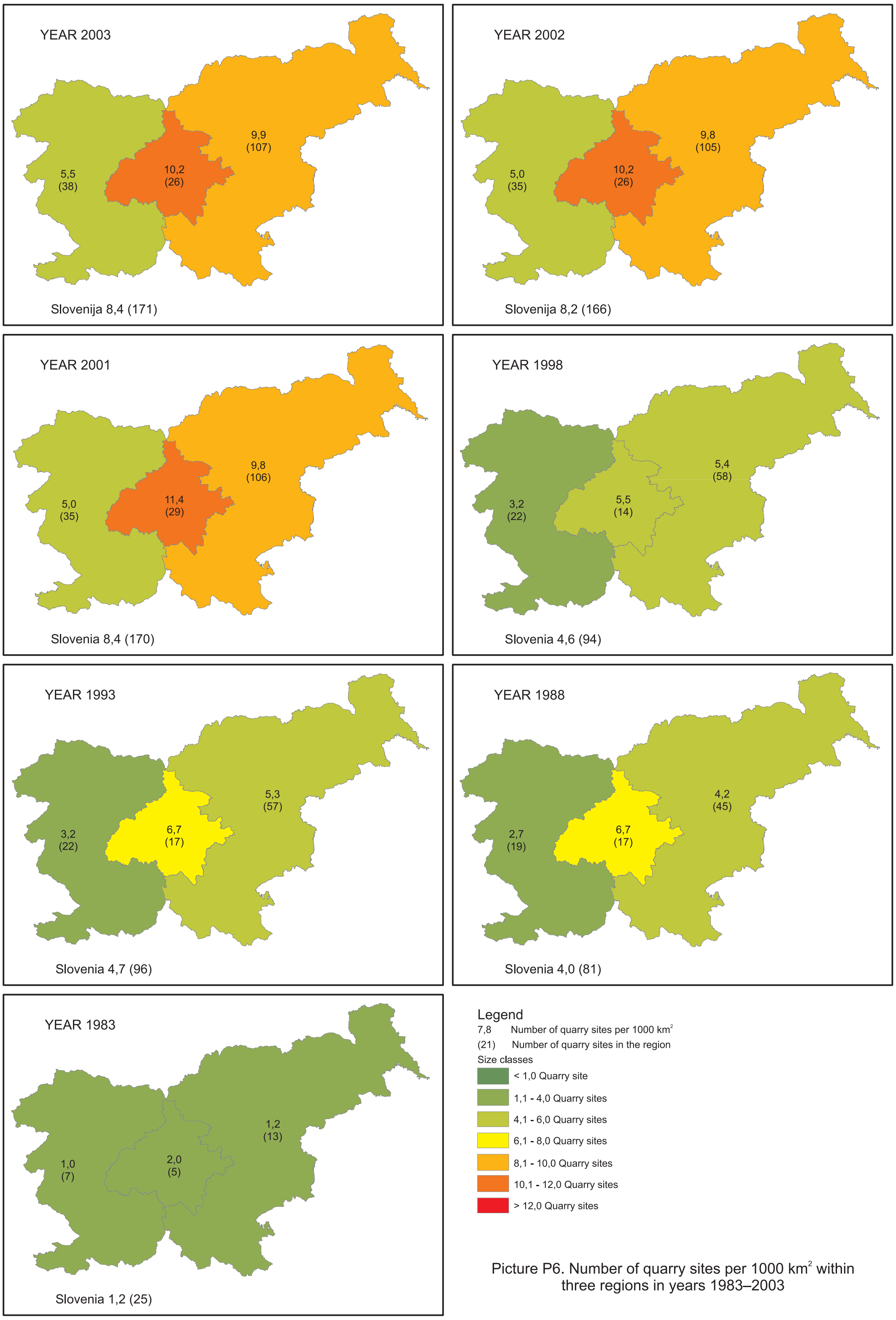
Picture P4. Number of inhabitants ($x10^3$) per quarry site within three regions in years 1983–2003



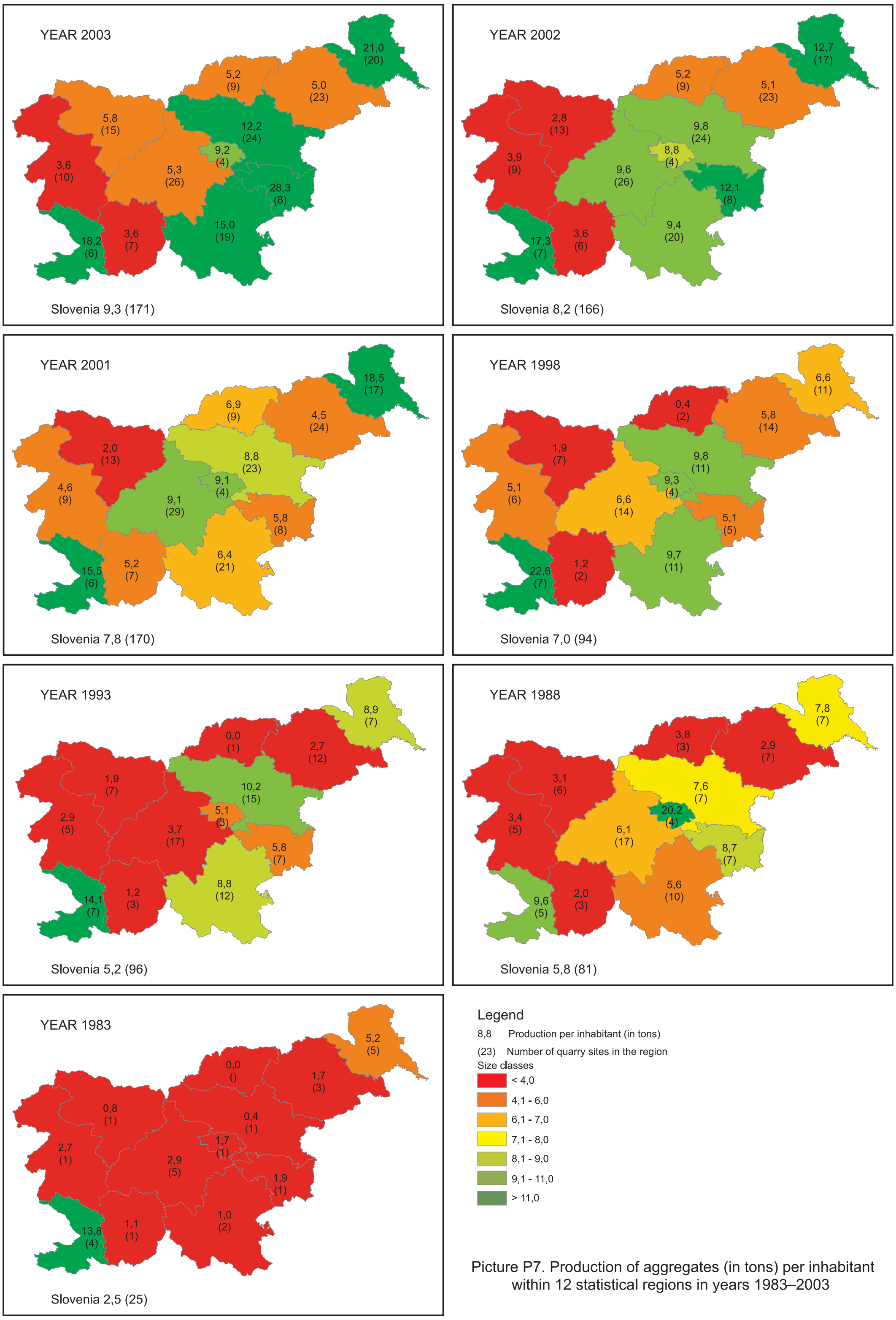




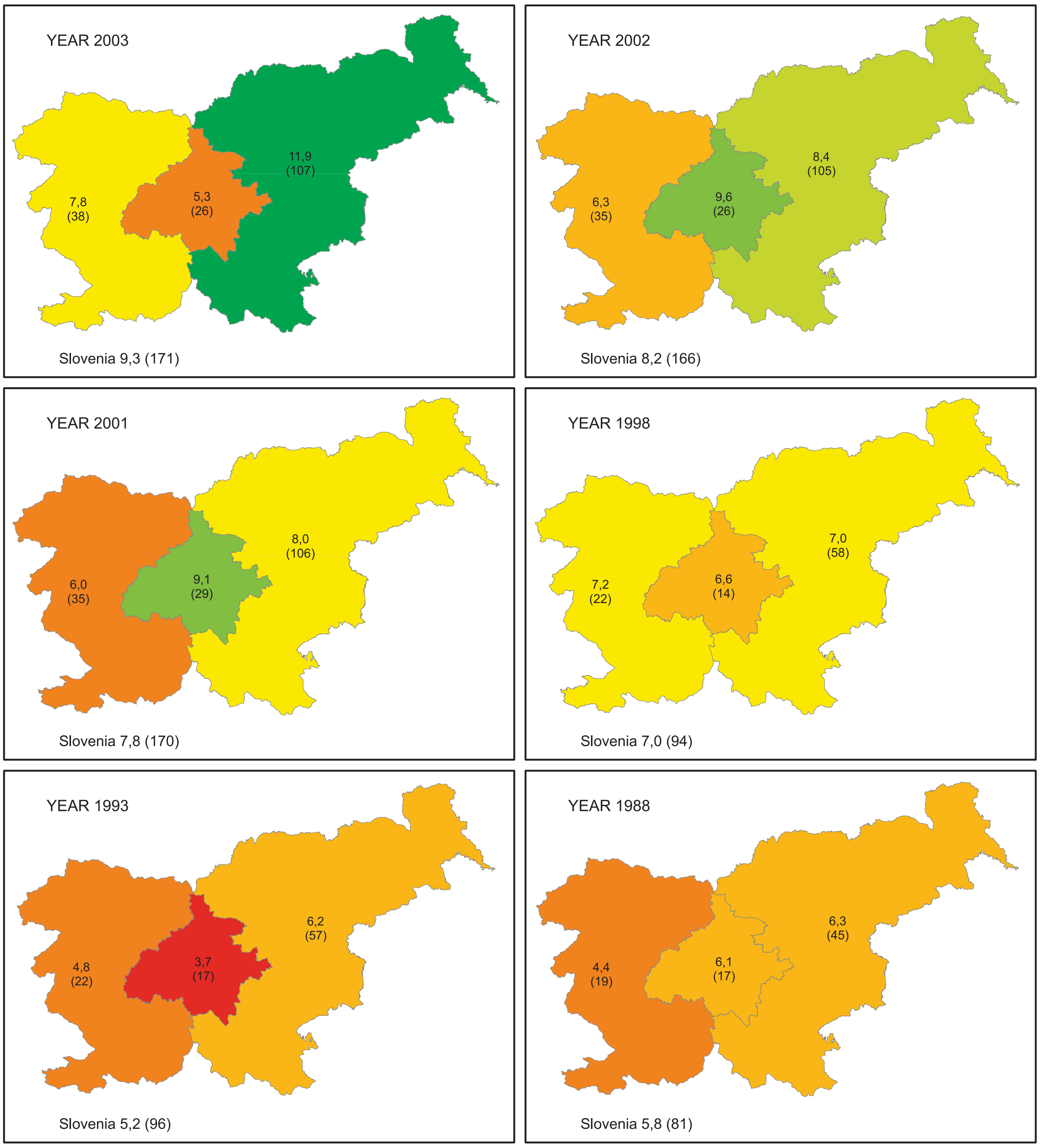
Picture P5. Number of quarry sites per 1000 km^2 within 12 statistical regions in years 1983–2003

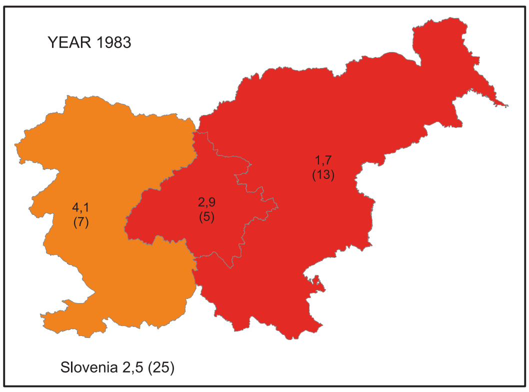


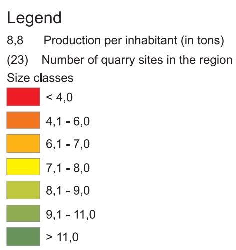
Picture P6. Number of quarry sites per 1000 km^2 within three regions in years 1983–2003



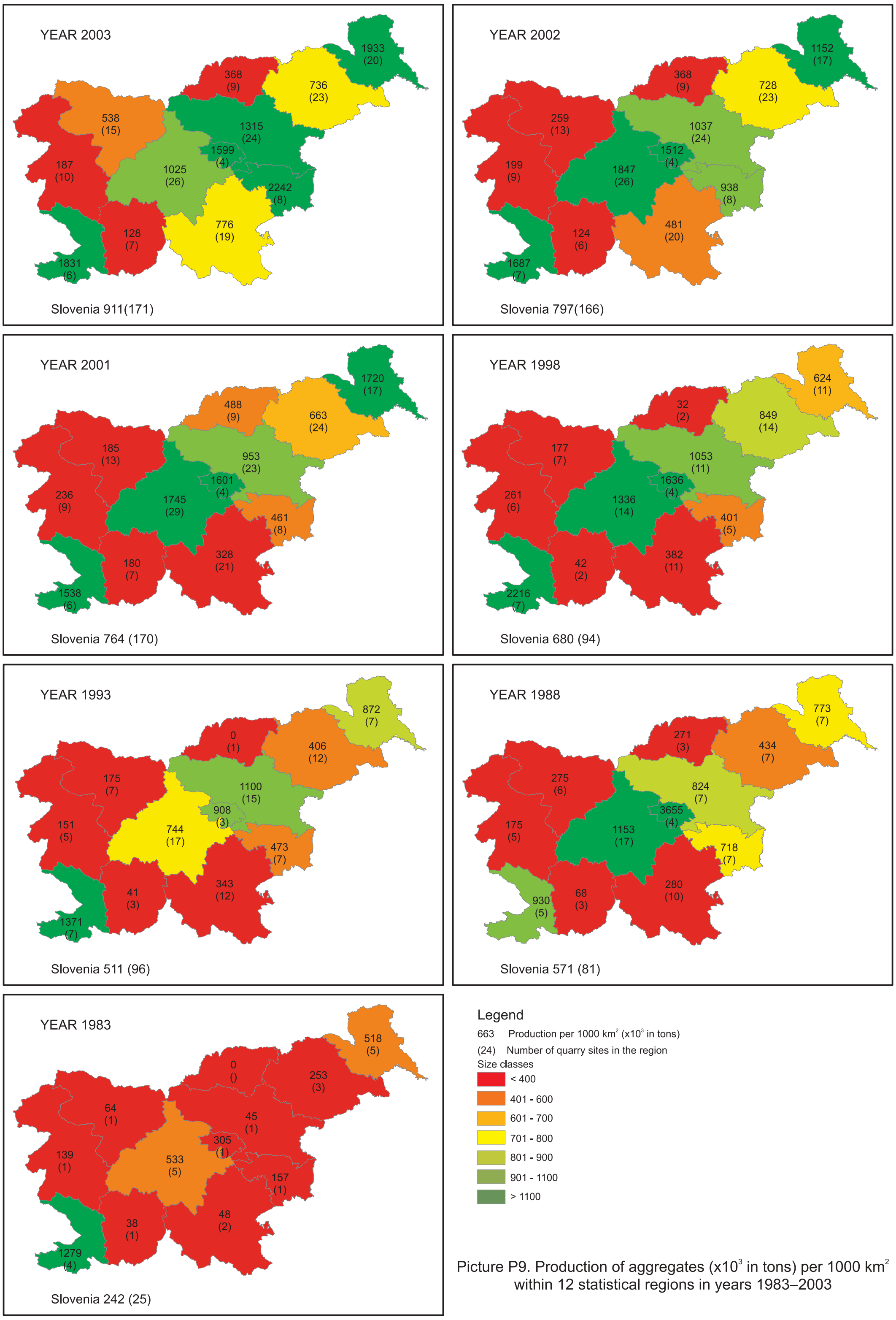
Picture P7. Production of aggregates (in tons) per inhabitant within 12 statistical regions in years 1983–2003



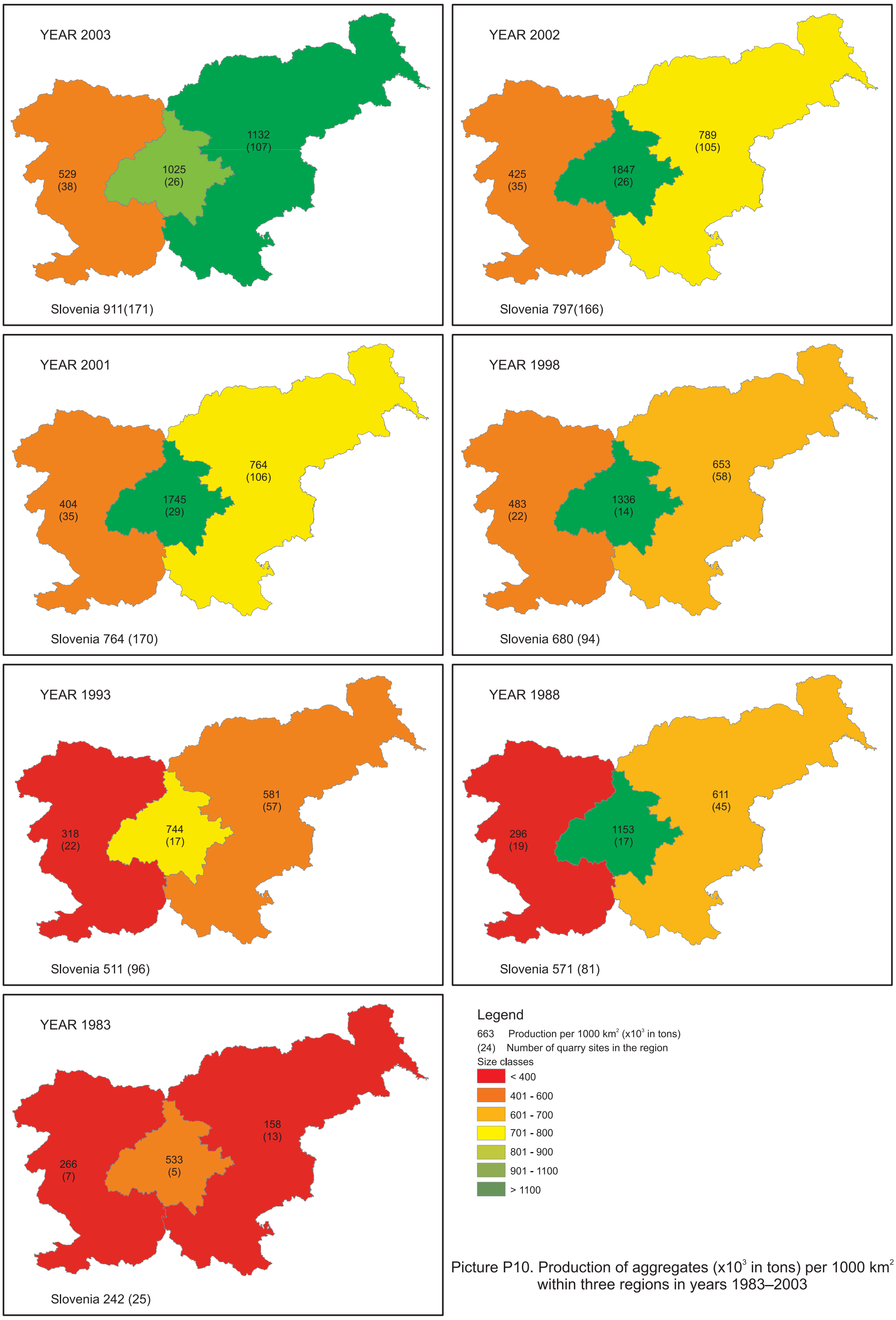




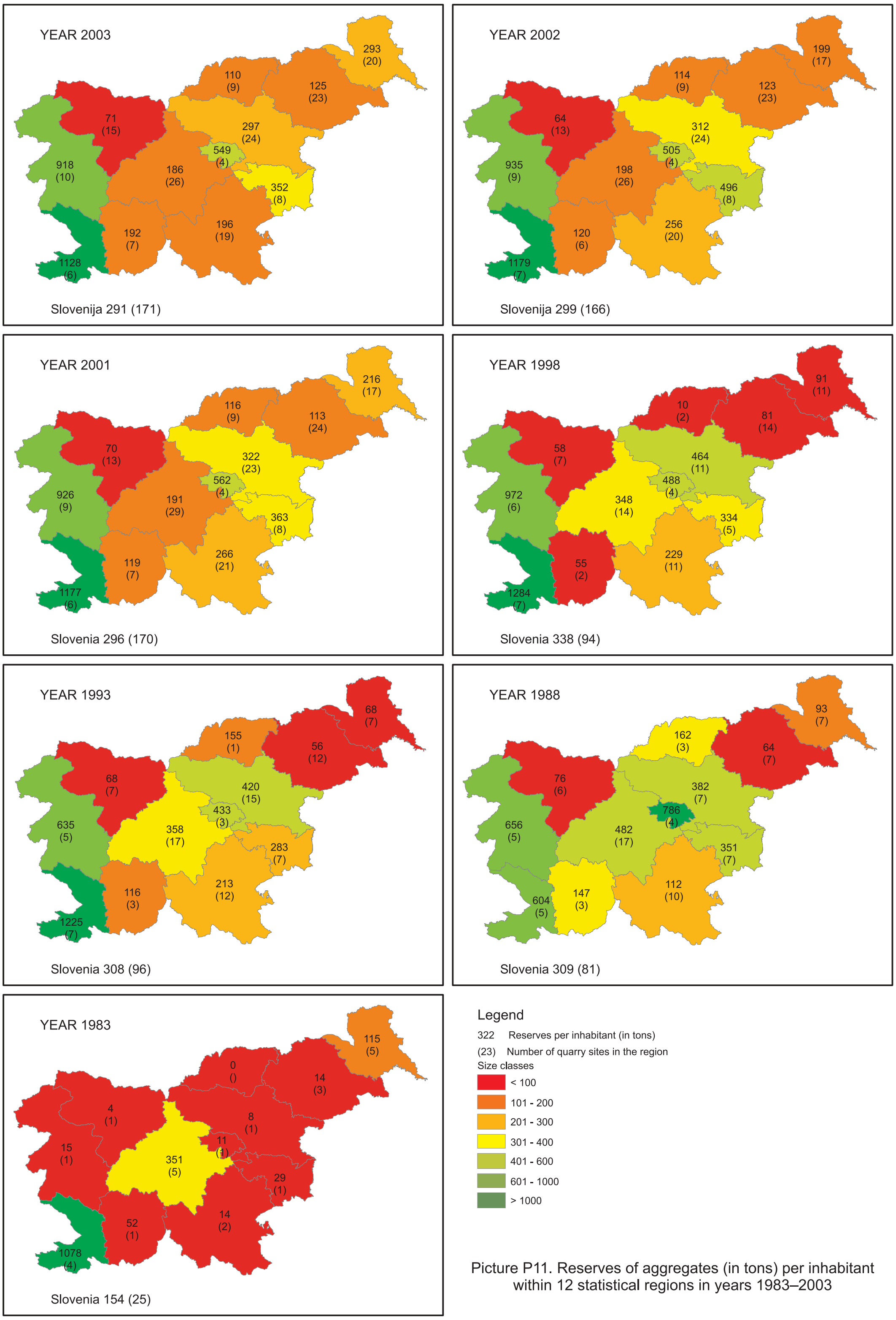
Picture P8. Production of aggregates (in tons) per inhabitant within three regions in years 1983–2003



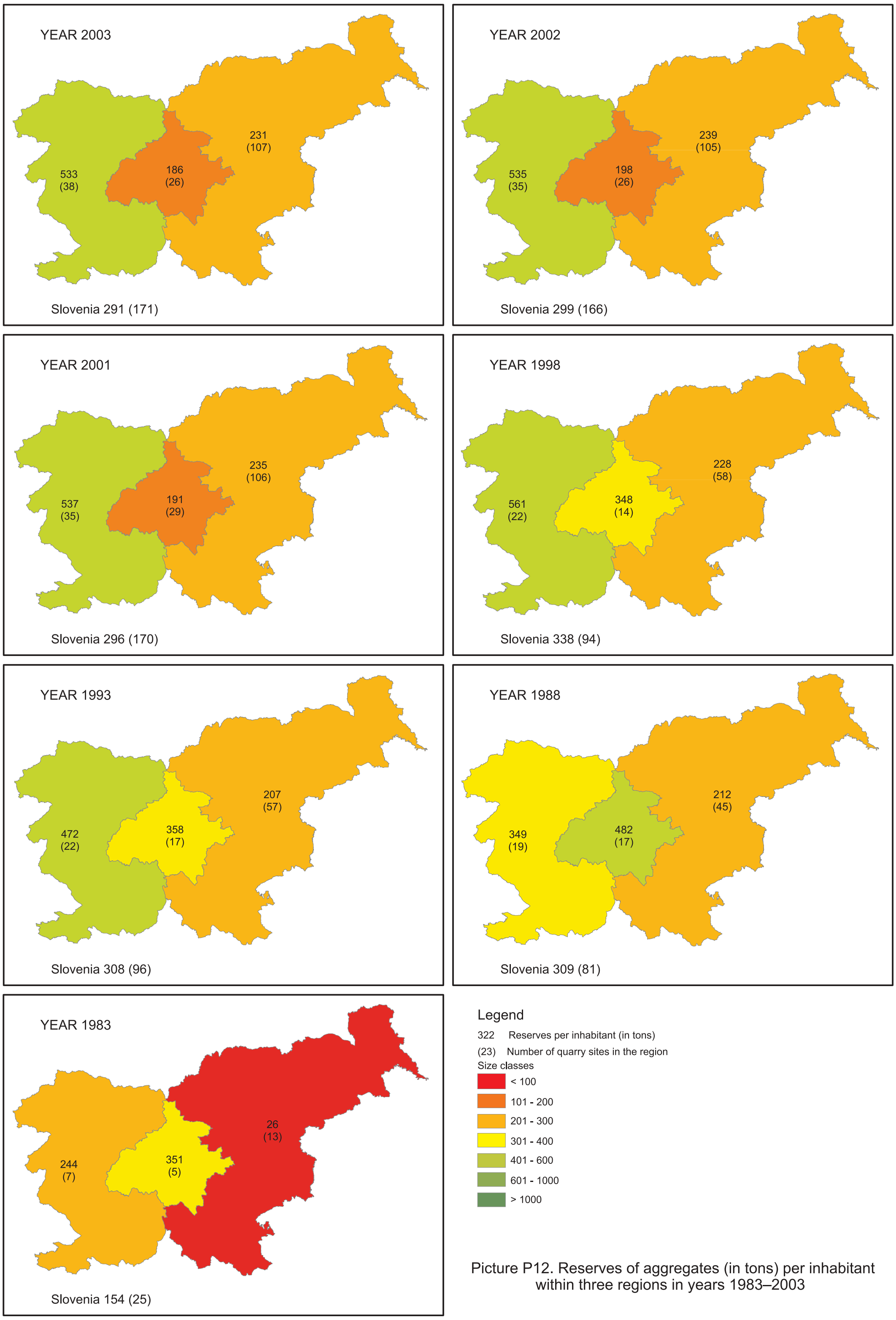
Picture P9. Production of aggregates (x10^3 in tons) per 1000 km^2 within 12 statistical regions in years 1983–2003



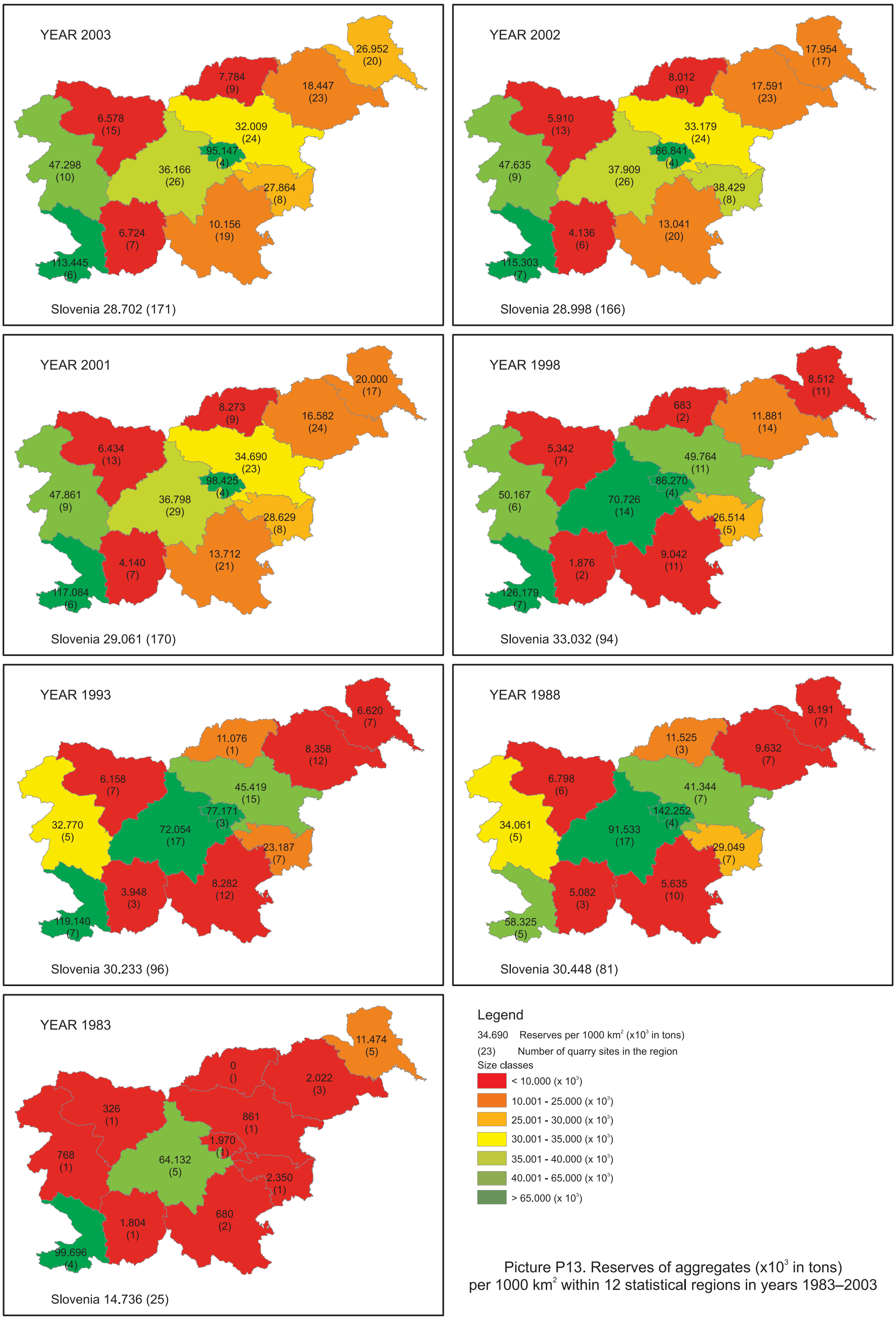
Picture P10. Production of aggregates (x10^3 in tons) per 1000 km^2 within three regions in years 1983–2003



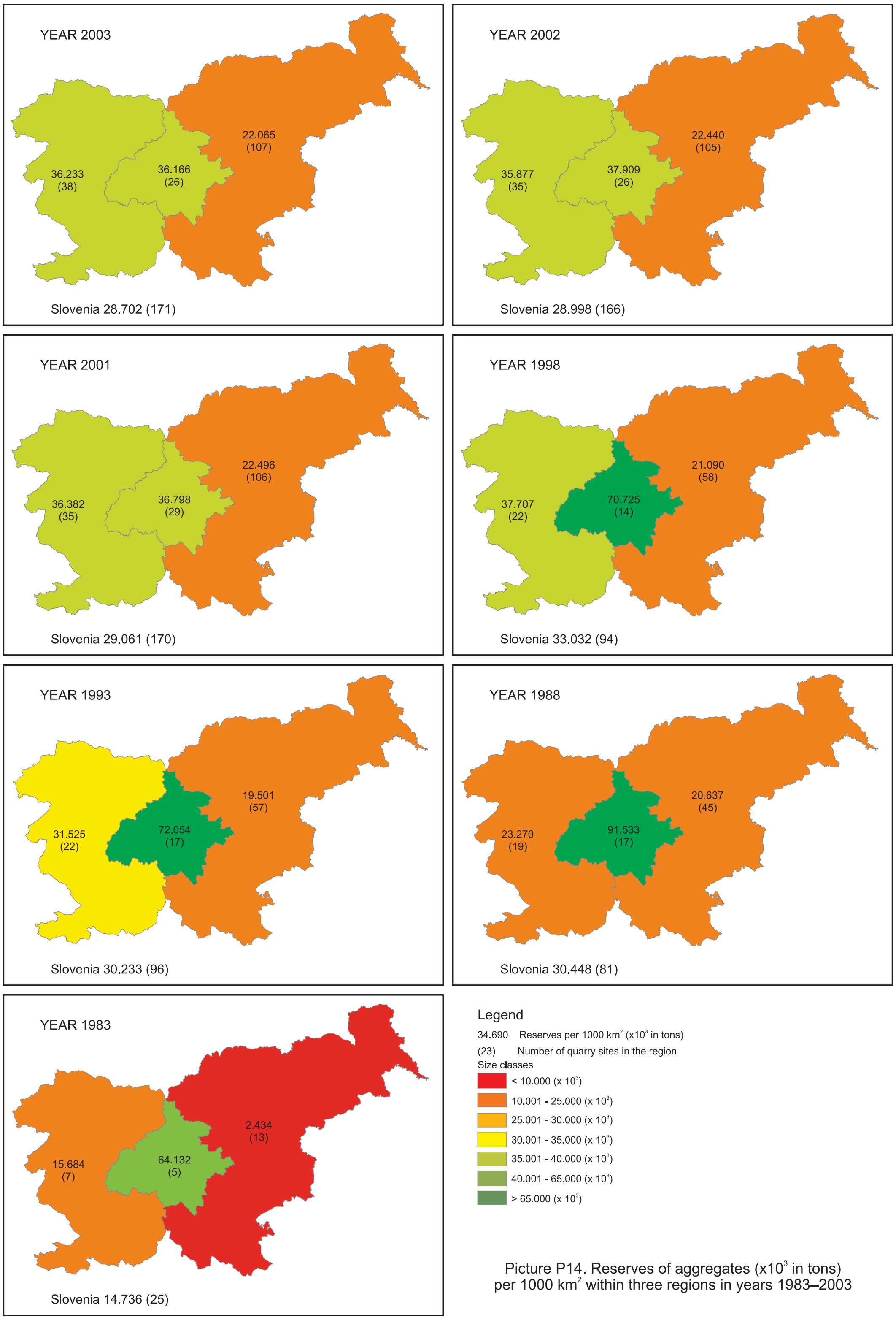
Picture P11. Reserves of aggregates (in tons) per inhabitant within 12 statistical regions in years 1983–2003



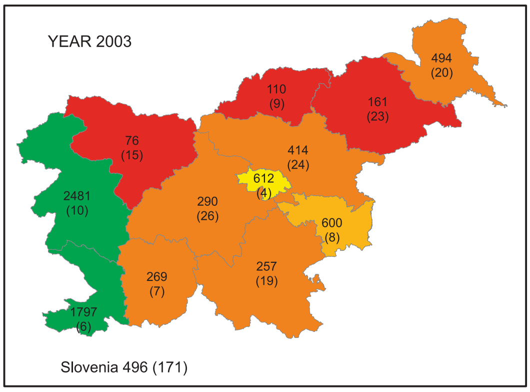
Picture P12. Reserves of aggregates (in tons) per inhabitant within three regions in years 1983–2003

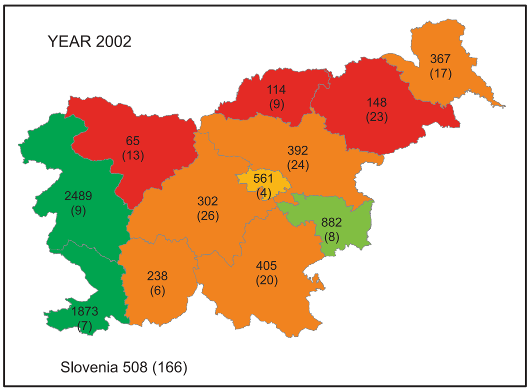


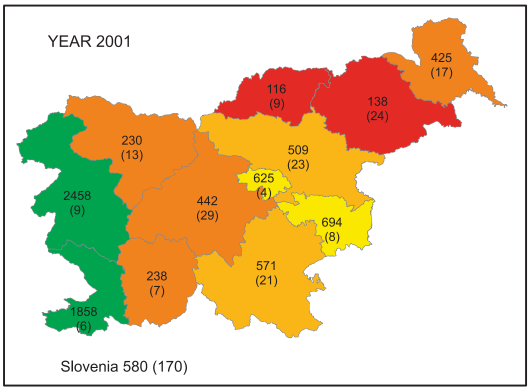
Picture P13. Reserves of aggregates (x10^3 in tons) per 1000 km^2 within 12 statistical regions in years 1983–2003

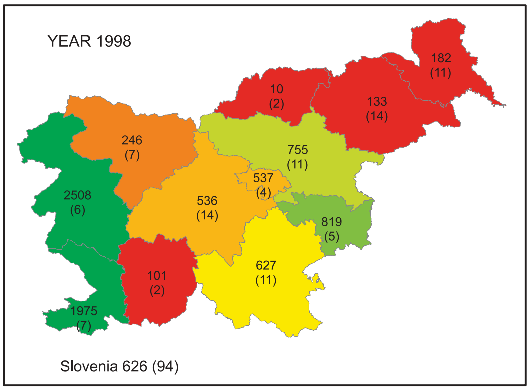


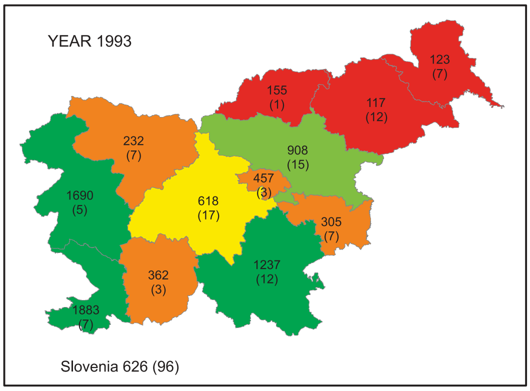
Picture P14. Reserves of aggregates (x10^3 in tons) per 1000 km^2 within three regions in years 1983–2003

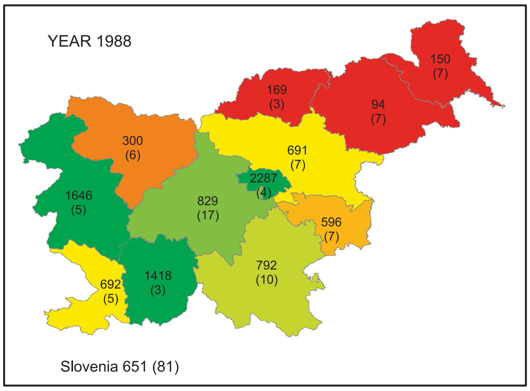


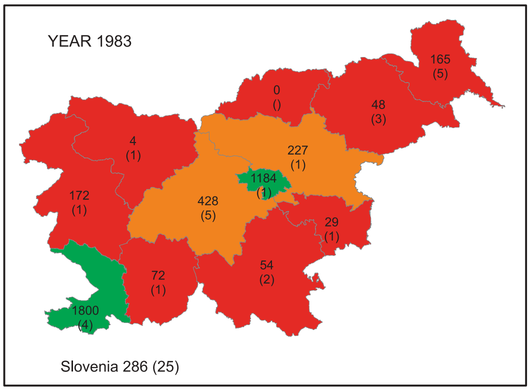








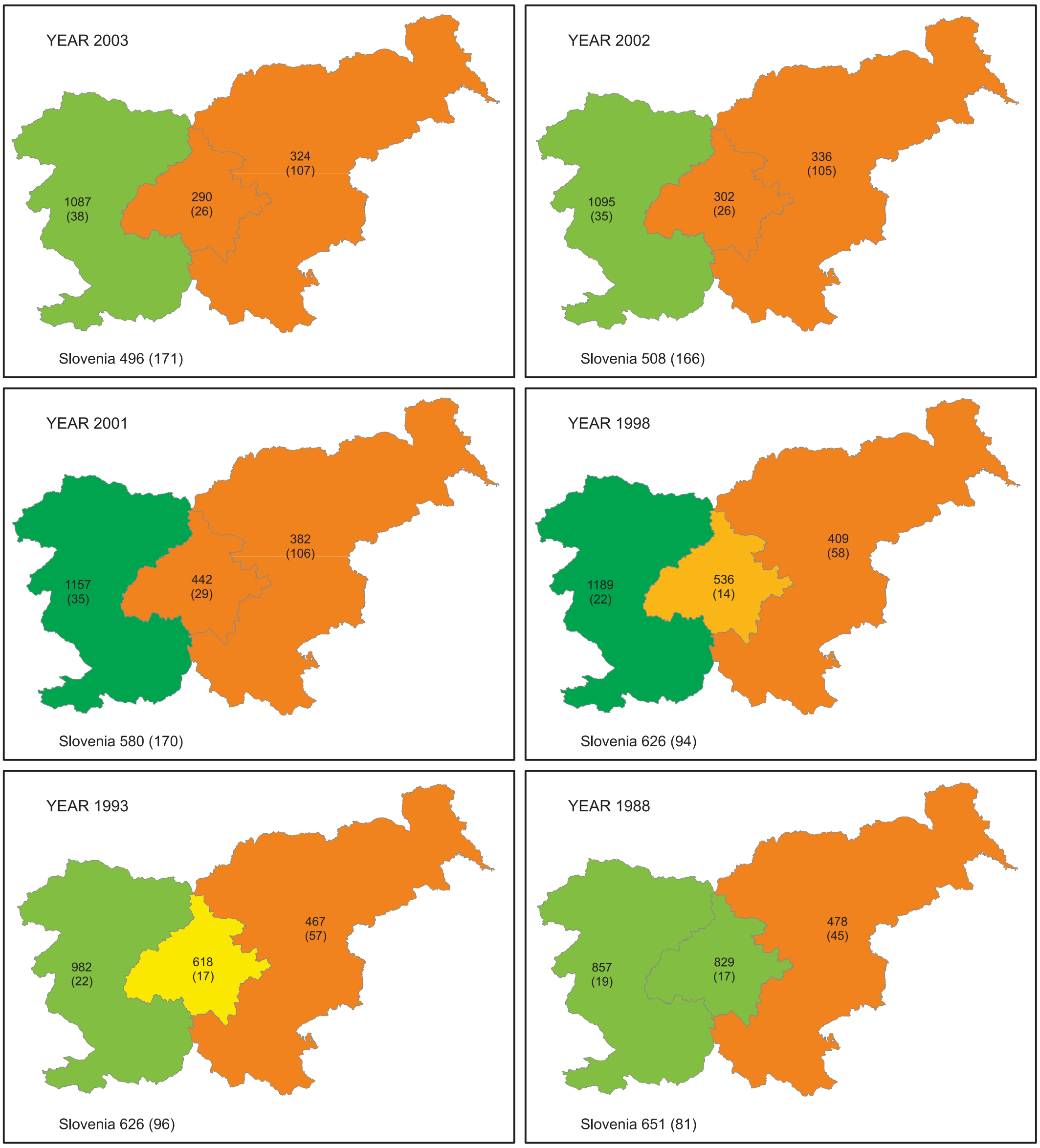


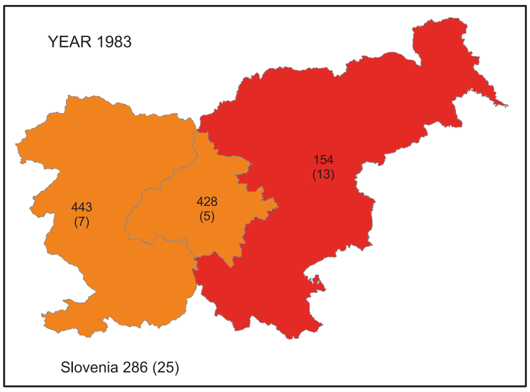


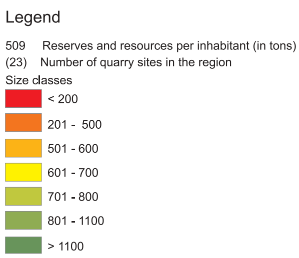
Legend

509 Reserves and resources per inhabitant (in tons)
(23) Number of quarry sites in the region
Size classes
< 200
201 - 500
501 - 600
601 - 700
701 - 800
801 - 1100
> 1100

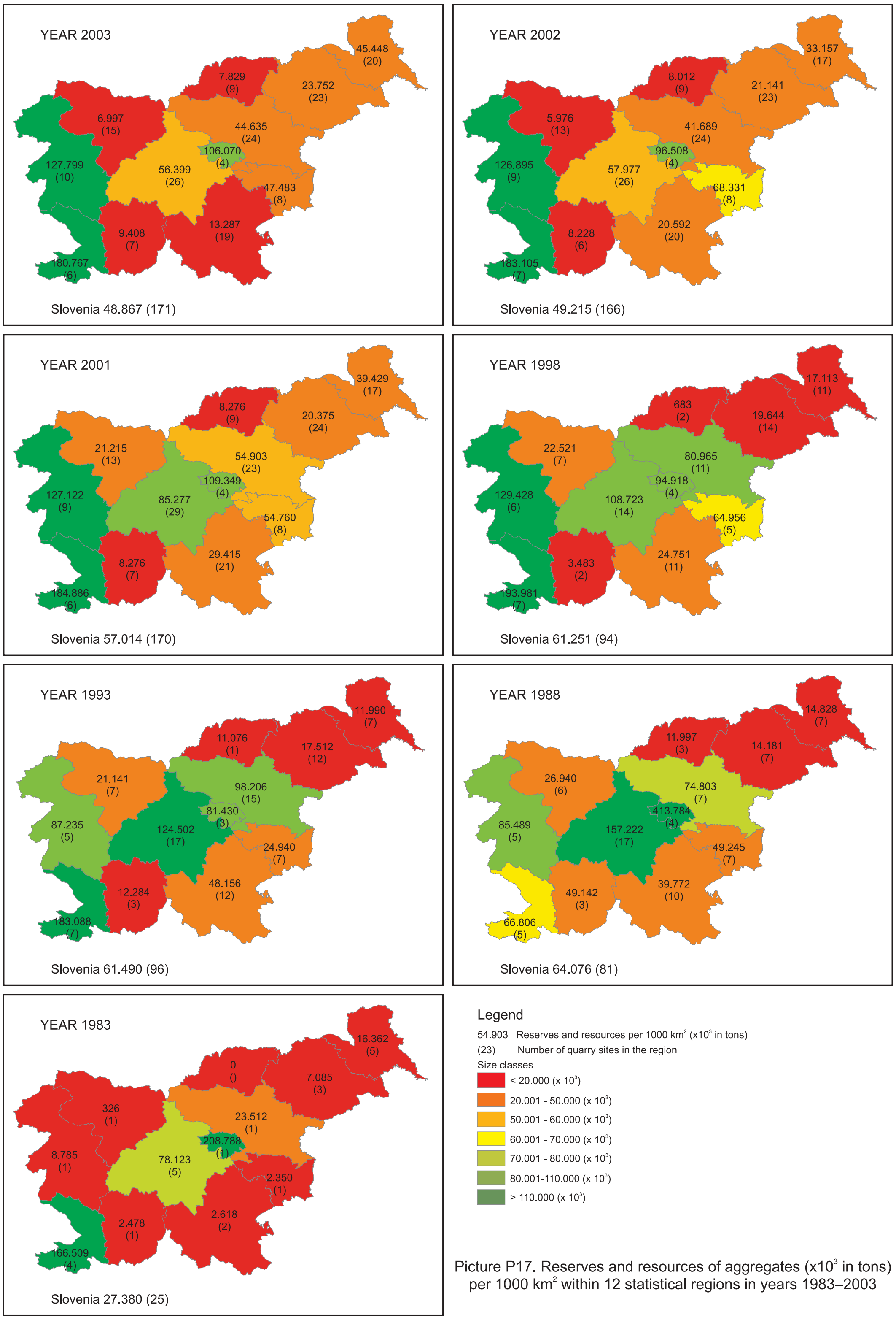
Picture P15. Reserves and resources of aggregates (in tons) per inhabitant within 12 statistical regions in years 1983–2003



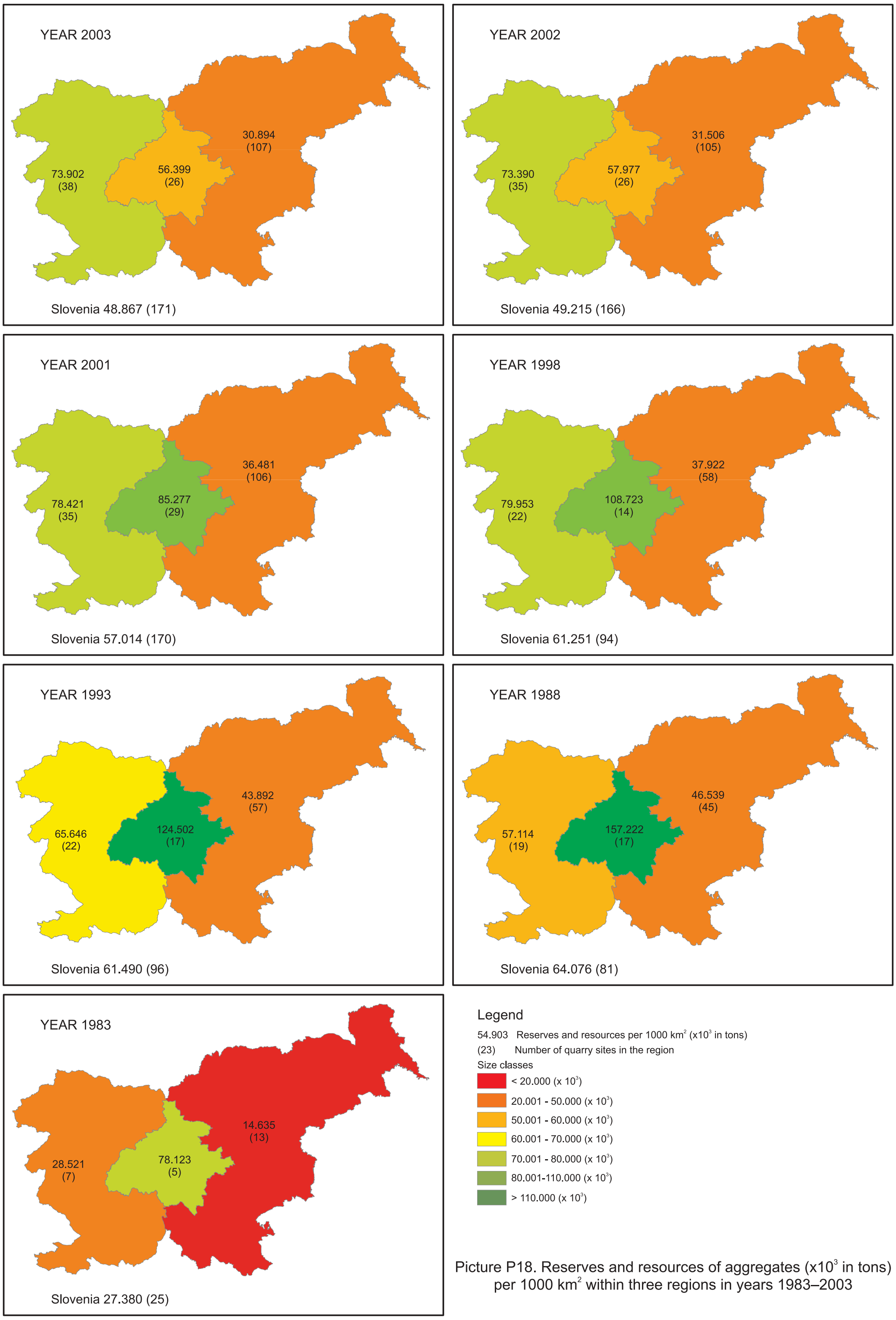




Picture P16. Reserves and resources of aggregates (in tons) per inhabitant within three regions in years 1983–2003



Picture P17. Reserves and resources of aggregates (x10^3 in tons) per 1000 km^2 within 12 statistical regions in years 1983–2003



Picture P18. Reserves and resources of aggregates ($x10^3$ in tons) per 1000 km^2 within three regions in years 1983–2003