

CHALMERS



SUSTAINABLE DEVELOPMENT INDICATORS FOR LAND USE IN SANTIAGO, CHILE

Master's Thesis in Applied Environmental Measurement Techniques

Alicia Matta

Department of Energy and Environment

Division of Environmental System Analysis

CHALMERS UNIVERSITY OF TECHNOLOGY

Göteborg – Sweden 2008

ESA Report No.2008:5

ISSN: 1404-8167

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Cover picture: Panoramic view of Santiago, Chile

Printed by Division of Environmental System Analysis

CHALMERS UNIVERSITY OF TECHNOLOGY

Göteborg, Sweden 2008

ABSTRACT

Human transformations of land systems are considered as the largest source of change on earth (Kok, Verburg et al. 2007). Human societies and land are both complex systems which are interconnected each other and co-evolve in mutual interaction permanently. Traditionally, conversions of natural land to human use have been linked to several environmental and social problems (Vollmer 2005). Assessment of sustainability for land systems are an unavoidable part for land-use planning, management and decision-making. They constitute a key issue pertaining to sustainable land-use. In Chile, as in most developing countries, land activities have transformed a large proportion of the nation's land surface, especially in larger cities and their surrounding areas, such as the Metropolitan Region of Santiago. Rapid growth experienced in Santiago in the past decades has increased economic development at the expense of losses in environmental quality and land resources availability. In order to propose sustainability indicators for land-use in Santiago, a multidimensional framework called The MAIN tetra is presented (Kain 2000). This analytical model allows interpreting through a four-pointed tetrahedron defined by MIND – ARTIFACTS – INSTITUTIONS – NATURE – the dimensions of sustainable development. Since land system is considered a dynamic system, proposed indicators look forward to represent changing trends for the natural land features, land ownership and land management characteristics. In parallel, interviews to selected stakeholders were conducted, in order to enrich the SDI construction with perception of stakeholders' approaches about land use and sustainability. Proposed indicators include a review of the whole land system and its parts, consider a multidimensional approach, and proposed time frame for further assessment. Indicators also focus on urban-rural development and pressure over the land resources, and propose a limited number of key issues for analysis and a limited number of indicators (37 indicators). The information obtained from this research can be used for contributing to planning and policy creation, support land use policy priorities, encourage debate and spark interest in sustainability issues.

Keywords: Sustainable development indicators, land-use, Santiago de Chile

RESUMEN

Las transformaciones sobre los sistemas territoriales debido a intervenciones del hombre son consideradas como la principal fuente de cambios sobre la faz de la tierra (Kok, Verburg et al. 2007). Tanto las sociedades humanas como el territorio comprenden complejos sistemas, los cuales están interconectados entre sí y co-evolucionan en permanente interacción. Tradicionalmente, la conversión del territorio desde un estado natural a uno intervenido para uso humano ha estado asociada a diversos problemas sociales y ambientales (Vollmer 2005). En Chile, como en la mayoría de los países en desarrollo, actividades intensivas en el uso del suelo han transformado grandes extensiones del territorio nacional, especialmente en las grandes ciudades y sus áreas circundantes, como es el caso de la Región Metropolitana de Santiago. El rápido crecimiento experimentado en la región durante las últimas décadas ha incrementado el desarrollo económico a costa de la cantidad y calidad de los recursos naturales. Con objeto de proponer indicadores de sustentabilidad para uso del suelo en Santiago, se presenta un marco metodológico multidimensional llamando MAIN tetra (Kain 2000). Este modelo analítico permite interpretar el concepto de desarrollo sustentable a través de un tetraedro de cuatro vértices definido por las dimensiones MENTE – ARTEFACTOS – INSTITUCIONES – NATURALEZA. De manera simultánea se desarrollaron entrevistas a un grupo de actores relevantes en estas materias, con el propósito de enriquecer la construcción de los indicadores, al incorporar en este proceso las percepciones y conocimientos de los entrevistados. Los indicadores propuestos incluyen una revisión de todo lo definido dentro del sistema suelo (territorio), considera un apronte multidimensional para tales efectos y sugiere una escala temporal de medición para futuras evaluaciones. Los indicadores también se enfocan en el desarrollo urbano y rural, y en la presión sobre los recursos naturales, proponiendo un número limitado de indicadores (37). La información derivada de esta investigación busca orientar futuros planes territoriales, además de apoyar y guiar políticas de desarrollo territorial y sus prioridades, abrir espacios para el debate en estos temas e incentivar el interés en materias de sustentabilidad.

Palabras clave: Indicadores de desarrollo sustentable, uso del suelo, Santiago de Chile

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ACKNOWLEDGEMENTS

I would like to take this opportunity to thank to Chalmers University of Technology for the opportunity of embracing this Master Programme; and to all my AEMT classmates, for the interesting international experience of studying abroad.

I would also like to express my gratitude to my supervisor, Professor Sverker Molander, for his motivation and assistance in writing reports and whose expertise, understanding, and patience, added considerably to my graduate experience.

I would like to gratefully acknowledge to Jessica Ulloa, Executive Director of the Chilean NGO *Corporación Ambiental del Sur*, for her support in this project and many others.

I could not have written many lines of this report without the interviewees who helped me in-world, told their own stories and shared their visions with me, which I have tried to faithfully reproduce. Thanks for your time and kind cooperation.

I wouldn't be here without them, so I would like to acknowledge my parents and brothers here, for their support even though they are still wondering what I was doing most of the time.

Finally, to Mauricio, whose love I cherish. I would like to express my deepest gratitude for the constant support, understanding and love that I received from you during the past years.

This Master Thesis project was supported by the Programme Alβan, the European Union Programme of High Level Scholarships for Latin America, scholarship No.E06M100097CL.

CHAPTER I

INTRODUCTION

**"PEOPLE ARE ENTITLED TO A HEALTHY AND
PRODUCTIVE LIFE IN HARMONY WITH NATURE"**

Rio declaration, 1992

1.1 BACKGROUND

Human transformations of land systems are considered as the largest source of change on earth (Kok, Verburg et al. 2007). Traditionally, exploitation of natural resources has been at the expense of them; giving habitat loss, degradation, ecosystems fragmentation, among other impacts, which all have dire effects on biodiversity. Consequently, the human–nature interactions, actions and decisions fashions the land, and unfortunately these processes have revealed to be traditionally overwhelming for the land. Changes in land use and land management affect land systems, its natural characteristics and processes, the landscape, etc. (Haberl, Wackernagel et al. 2004). For instance The Intergovernmental Panel on Climate Change (IPCC 2003) claims that land conversion is the single greatest cause of extinction of terrestrial species.

Land-use and land-use change have been remarkably intense since the industrial revolution and the explosive growth of the cities. As a result landscapes have become mosaics of natural and human-influenced patches, and once-continuous natural habitats are becoming increasingly fragmented (Harris 1984). Land use is the human modification of the natural environment into used land, such as fields, pastures, and cities. Land-use activities – whether converting natural landscapes for human use or changing management practices on human-dominated lands - have transformed a large proportion of the planet's land surface (Foley, DeFries et al. 2005). According to the Intergovernmental Panel on Climate Change (2007), the major effect of land use on land cover since 1750 has been deforestation of temperate regions. Land-use change, together with use of fossil fuels, are the major anthropogenic sources of carbon dioxide, a dominant greenhouse gas (IPCC 2007). More recent significant effects of land use include urban sprawl, soil erosion, soil degradation, salinization, and desertification (Kniivila 2004)

Although land-use practices vary greatly across the world, their ultimate outcome is generally the same: the acquisition of land for immediate human needs: food, housing, infrastructure, energy, etc. Hence, land use introduces a predicament. On one hand, many

land-use interventions are absolutely essential for humankind, because they provide basic human needs. On the other hand, some forms of land-use are degrading natural resources which are sources of these basic human needs (Foley, DeFries et al. 2005). The predicament talks about the current and future use of the land, either will these practices continue undermining land resources, and hence the long-term sustainability of human societies or decision makers will consider the challenge of reducing negative impacts of land use while maintaining economic and social benefits?

Effects of land use change are driven by the interaction in space and time between biophysical and human dimensions (Veldkamp and Verburg 2004). There are several attempts for understanding the dynamic and impacts of land-use change. For example, researchers in social sciences traditionally study individual behaviour of land systems at the micro-level, but at the same time agricultural economy are macro-scale studies related to land. On the other hand, physical scientists, geographers and ecologists focus more on land at the macro-scale, although soil researches are specific studies of the land at micro-level.

To better understand the land system - its structures, interactions, and the impacts of the interventions on the land – appears as a huge challenge. Land systems are areas of land, with characteristics patterns, tenancies and managements of the environmental variables, climate, geology, topography, soil and vegetation. Land systems are not soil units, but composite patterns of landform, vegetation and soils, productive activities, natural resources basis, etc. (Lambin 2007). Human societies and land are both complex systems which are interconnected each other and co-evolve in mutual interaction permanently. They are complex in that they are diverse and made up of multiple interconnected elements and adaptive in that they have the capacity to evolve in order to preserve their organization (land system), and learn from experience (human societies) (Odum 1994).

It has been traditionally thought that, while human society can alter natural systems to suit its own needs, natural systems are incapable of altering human society (J. Cairns and Bidwell 1996). Nevertheless, human-environment interactions may be viewed as a co-evolutionary

interrelationship in which the two sides change one another continuously by mutual feedback. Considering the systems view of the human-land relationship, it can be seen that the structure and function of land is sustained by synergistic feedbacks between human societies and their natural resources. The physical and biological features of land places basic physical constraints on the growth and development of the human society system (Mitsch and Jorgensen 1989).

Human societies as structured systems suffer changes in their structures as a result of their internal dynamics and their interactions with the land system. For example, the population growth in a certain area would be limited by the carrying capacity of the land system. The human system, in turn, actively modifies the physical and biological features of the land; carrying capacity of an area may be decreased through the degradation of life-support systems, or increased by organizing differently or using new technology that works with the environment. The dynamic processes of self-organizing and self-maintenance of the land is paralleled by the self-organizing ability and self-maintenance of the human system (Berkes and Folke 1991). These adaptations, in turn, shape the way in which society defines and uses natural resources, where land-use change appears as an important human developed process for modifying the land system.

Following pages introduces the subject of land-use, identifying through a diagram main driving forces that trigger land-use change, causes and consequences of it, and an overview about sustainable land-use. The figure illustrates the interaction, linkages and cause-effects relations on the land-use dynamics system. This diagram illustrates the proximate and underlying causes of land use change. The figure is divided in 5 sections, which are: indirect causes, direct causes, land, direct consequences and indirect consequences. The processes and linkages amongst them are described in figure 1 below.

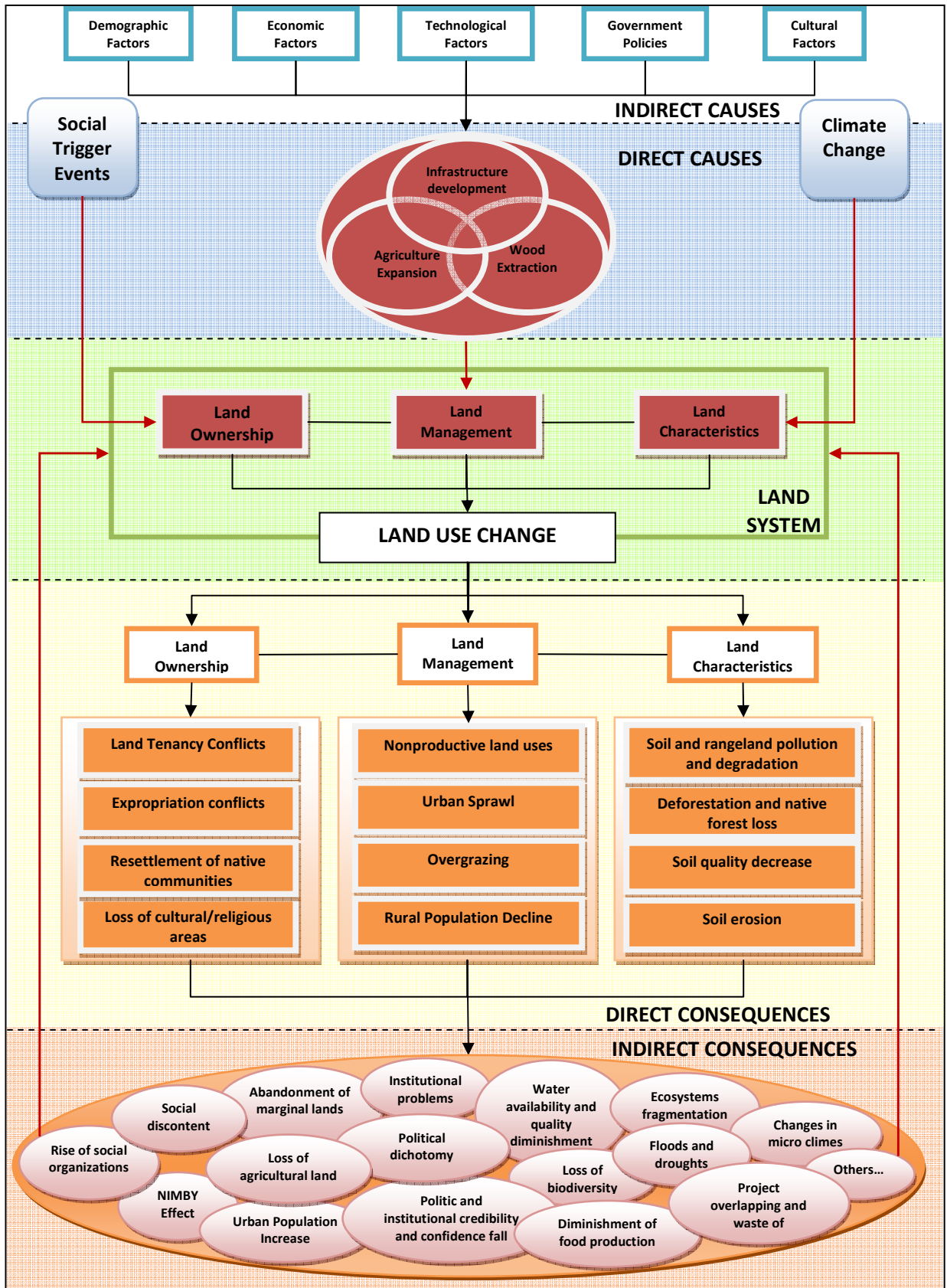


Figure 1: Direct and indirect causes and consequences of land-use change

In the first section, the indirect causes of land use-change are presented. Demographic, economic, technological and cultural factors and governmental policies were identified as the primary driving forces, which lead to more intensive or extensive use of the land.

Changing demographic, economic, technological and cultural pressures over the territory is notable. For instance, a population increase will demand more land for housing, infrastructure and cultural places as well as, economic growth will need new land for factories settling, infrastructure services and technological equipment. Thus, all the above mentioned driving forces are the indirect causes that lead to the more direct causes of land use change, presented in the second section of the diagram.

In-between indirect and direct causes of land-use change, social trigger events and climate change are found, and their effects depend on the way they influence land-use change processes. For instance social trigger events, such as migrations or even refugees, may demand immediate occupancy of the land, a situation that evidently generate problems, first on the land ownership for resettlements and second in the land-use itself. Conversely, these social events can be considered as indirect cause as well, since migration can first demand more availability of food, which will lead to an agriculture expansion and infrastructure development.

On the other hand, climate change can impact directly on some land characteristic (topographic features, soil typology and quality, moisture, forest areas, protected areas, grasslands, etc.), not as immediate impact, but at large time scales. Evidence of the effects of climate change in loss of the productive capacity of the land, droughts, overflows, erosion and desertification, loss of natural land covers and biodiversity, have been acknowledged within the past three decades. According to recent assessments by the EEA, European Commission, OECD, the World Wide Fund for Nature, IUCN, and various UN bodies for Europe, in many regions there may be an increase in irrigated area and water abstraction for irrigation. In the northern temperate region, agro-climatic zones are likely to move

northwards as a result of climate change (Calvo and McGlade 2005). In the southern areas, current crop areas may be abandoned due to low availability of water.

The second section of the figure illustrates the main direct causes of land use change, which are infrastructure development, agricultural expansion and wood extraction. Those factors comprise human activities that can demand use of the land and provoke land use changes. Economics, recreational and cultural activities, roads and rail networks, airports, buildings and communications infrastructure are within this classification. Thus, these three causes can be defined as a man-controlled system, part of the human society system. They all interact with the land system and modify it.

According to the third section of the conceptual model, land is seen as a system composed of three subsystems: land ownership, land management and land natural characteristics. Whenever the land system is affected by direct or indirect causes, the system is altered and land-use change takes place. Red arrows represent these impacts on the land system.

Land ownership refers to the formal and informal land tenure, for private and public land; Ownership laws may vary widely among countries depending on the geopolitical systems of government of the country, which may have different legal interpretations concerning the ownership of land. Land management corresponds to the current use of the land, the administration and exploitation of the goods and services of the land and long-term planning of it. Land management includes also future developing policies for land use. Land characteristics relate to the pre-existing natural factors of the land and its artificial features as well, for what both describe the landscape and the territory as a whole.

To explain the consequences of land use-change, the same land-system above described is used, as illustrated in section four of figure 1. The descriptions of the direct consequences of land-use change are grouped on these three aspects. Thus, below each main aspect a series of direct consequences are listed in the orange boxes.

Direct consequences of land-use change fall on the land system, i.e. on the characteristics, the management and/or the ownership of the land, as it is showed in section four of the figure 1. For instance, land use-change may provoke land tenancy and expropriation conflicts; problems related to land management such as non-productive land uses, urban sprawl, overgrazing, etc. In addition, land characteristics that can be affected by land use-change are soil degradation, deforestation or soil erosion, amongst others. All these direct consequences have synergic effects with the human activities by altering the structure and functioning of ecological and social systems. These impacts are defined within the diagram as indirect consequences, since they are products of the relationships between the above mentioned direct consequences with the land.

At the end of the diagram several indirect consequences are presented, with the objective of describing the wide range of negative effect that can occur. Indirect consequences can be numerous, and grasp environmental, social, economical, political and cultural issues. Although at the same time indirect effects can fall on the land system directly and then become trigger causes for land use-change once again. For instance expropriation conflicts can generate social discontent and the rise of social organizations; consequently institutional problems and politic credibility fall. On the other hand, urban sprawl originates migrations phenomena and abandonment of marginal lands; increase the pressure over agricultural land and affects food production at the same time. Land use change influence soil quality and quantity for food production; thus there are ecosystem fragmentations and loss of biodiversity, among several other effects.

Therefore, it can be observed that land is a very complex system, which is set by highly dynamic driving forces. This system reveals particular and combined reactions to the synergies between human and natural subsystems, producing several consequences at different scale levels. Costanza et al. (1991) stated that "humans have a special place in the system, because they are responsible for understanding their own role in the larger system and managing it for sustainability." This cite leads to a natural question, if can land to be managed in a sustainable way? Before answering that, it is necessary to define sustainable development.

1.2 SUSTAINABLE LAND-USE

For an ecologist, sustainable land use would basically require the conservation of a healthy natural environment. On the other hand, for an urban planner, sustainability implies the provision of land for good quality housing, public spaces, industry and recreation, i.e. a functional and accessible city to support economic and social needs. Comparing both arguments it can be clearly seen that there is room for conflict between these two views, since they not only differ from their targets, but also conservation as traditionally opposed to development and building.

As an overall outlook, sustainable development argues about the recognition that both views are competing, and they need to be put into creative partnership, not into opposition. The Brundtland Commission defined Sustainable Development as development that "Meets the needs of the present generation without compromising the ability of future generations to meet their own needs" (United Nations 1987). Linking this definition with the land subject, it can be said that whenever economic and social demands are satisfied without regard to environmental impacts, the capacity of the environment to support human life will rapidly be degraded (Siu 1999). However, if economic and social needs are not satisfied for the sake of preserving a pristine environment, then adverse impacts can show up; for instance non-productive land uses and migration problems.

According to the Millennium Ecosystem Assessment (2005), "The past 50 years have faced far more serious change to the world's ecosystems than has ever been seen before." The use of resources such as food, water, and timber has increased rapidly, and continues to grow, sometimes unsustainably. The use of ecosystems for recreation, spiritual enrichment, and other cultural purposes is growing. However, the capacity of ecosystems to provide these services has declined significantly. In order to consider land system more than a source of resources for production of food and fibre (ESCAP 1994), it is necessary to recognise more of its functions, goods and services, as part of the ecosystem services:

- Production function: As the basis for many life support systems, through the production of biomass that provides food, fodder, fibre, fuel, timber and other biotic materials for human use, either directly or through animal husbandry including aquaculture and inland and coastal fishery.
- Biotic Environmental function: Land is the basis of terrestrial biodiversity by providing the biological habitats and gene reserves for plants, animals and micro-organisms, above and below ground.
- Climate regulative function: Land and its use are a source and sink of greenhouse gases and form a co-determinant of the global energy balance - reflection, absorption and transformation of radiative energy of the sun, and of the global hydrological cycle
- Hydrologic function: Land regulates the storage and flow of surface and groundwater resources, and influences their quality.
- Storage function: Land is a storehouse of raw materials and minerals for human use.
- Waste and pollution control function: Land has a receptive, filtering, buffering and transforming function of hazardous compounds.
- Living space function: Land provides the physical basis for human settlements, industrial plants and social activities such as sports and recreation.
- Heritage function: Land is a medium to store and protect the evidence of the cultural history of mankind, and a source of information on past climatic conditions and past land uses.
- Connective space function: Land provides space for the transport of people, inputs and produce, and for the movement of plants and animals between discrete areas of natural ecosystems.

All above mentioned functions of the land accrue to all living organisms, not only to humans alone, but also to animals and plants. However, there is a growing recognition of the importance to society that land functions, goods and services provide for human life.

Traditionally the production of crops has been recognised as one of the main purposes of land; however the suitability of the land for these functions varies greatly over the world. For that reason, bearing in mind that land misuse and degradation ruin lands functions and services - which consequently represents a loss of capital asset - land use planning should result in local land uses that are sustainable. Although it may sound as big words, especially for developing countries, national accounts should include measures of resources depletion, or elsewhere of land and renewable resources degradation (FAO 1995).

Land use planning should be a decision-making process that "facilitates the allocation of land to the uses that provide the greatest sustainable benefits" (Agenda 21, paragraph 10.5). It should be based on the socio-economic conditions and expected developments of the population in and around a natural land system, always taking into account the intrinsic value of the land system as well. This valorization starts with the recognition of the functions and limited services of the land and also the understanding of its fragility. Result of this multiple considerations should materialize as indications of a preferred future land use, or combination of uses, according to the carrying capacity of the land and the prospective medium and long term targets for a territory.

Land use and land use change impacts and effects can be effectively managed only through a thorough understanding of the driving forces shape land systems. Improving the management of complex environmental problems through land use planning has resulted in policy makers becoming increasingly aware of the need to place emphasis upon problem analysis. There is widespread concern over the need of planning the use of land and all natural resources, to have sustainable land systems and avoid land degradation. In response to the growing concerns about the social and environmental costs of sprawling current development patterns, a wide range of public policies for managing urban growth and protecting open space have been approached. These attempts can be developed at different scales: at the local, regional and/or state levels.

In this context, many groups of researchers are trying to define sustainability indicators and to devise methods to monitor them in field conditions. Hence, sustainable land use rises as an interesting concept which represents a challenge for academics, authorities and decision-makers, where the major goal is to plan and manage land use in an integrated and sustainable way. This paper is written in an attempt to propose sustainable development indicators for land use.

1.3 PROBLEM FORMULATION

Conversion of natural land to human use, sprawling patterns and incompatible location of development has been linked to many environmental and social problems (Vollmer 2005). Therefore, since the past decades policy-makers, land owners, environmental groups, ethnic communities and single citizens have become increasingly concerned about the potential negative impacts associated with the rapid growth of the cities, the urbanization process and its consequences. This phenomena has not been absent of controversies and conflicts, and nowadays there is an increasing common conscience that sustainable growth management is vital for promoting both, economic development and the conservation of natural resources (OECD 2002)

Therefore, sustainable development appears as an attractive concept whose incorporation and materialization into land use planning and assessment is consequently also necessary. According to the Agenda 21 text, "Indicators of sustainable development need to be developed to provide solid bases for decision-making at all levels and to contribute to a self-regulating sustainability of integrated environment and development systems" (United Nations 1992 b). In this context, land use intends to ensure the use of land resources in an organized fashion so that the needs of the present and future generations can be best managed.

In Chile, as in most developing countries, land use has been managed mainly from an economical point of view. Economical growth has been preferred in decision-making usually as part of short-term government policies (Sunkel 1996). An incomplete knowledge of the land system and the carrying capacity of the land resources have lead to deficient land planning. Thus, information appears as another downside of this situation. For instance, there are several land use classifications; according to agricultural characteristics of the soil; another class for general land uses; or urban land use categories. Furthermore, some of them are not up to date; some are incomplete or differ from each other. This figure shows that information for decision making, planning or research needs homogeny and improvement.

A premise of this paper is that if a sustainable development standpoint is considered in decision making, and citizen participation programs are developed, some problems could be reduced or minimized. Therefore, through a framework based on Sustainable Development, indicators for sustainable land use can be proposed and also assessments, recommendations and further uses of land can be approached.

1.4 AIM OF THE STUDY

Land use and land use planning have a concrete expression; despite what people do or stop doing over the territory, they have (dis)organized and shaped land in some extent. Nowadays in Chile, there is not a Land Use Planning Policy which looks forward to manage land under certain criteria. Therefore, it seems there are two visible alternatives for this subject: whether let spontaneous evolution of land ensures territorial cohesion – which seems to be quite unlikely and unsuitable – or accepting that current patterns have reach far enough to make impossible the delay of improvements. In other words, the challenge can point out to either implement a national policy of land-use or to adopt the policy of not having any.

On the other hand, it is also interesting to mention that at least there are initiatives and proposals which include the precepts of sustainability within their strategic guidelines. For instance, the Integrated Watershed Management Strategy recently published (2007), looks forward to direct the actions in a portion of land defined by natural boundaries as a watershed, considering the impacts of these actions in the land system.

In this context, this research seeks to study current patterns of land use, and aims to develop a set of sustainable development indicators for land use that can be considered as a planning tool. The purpose of this research is also to assess data sources to set the indicators, which must be available, updated, and easy to gather, identify and understand.

To achieve these goals, a study case was developed in collaboration with local stakeholders with well-based understanding of the changing human activities and socioeconomic conditions in Chile. The study consisted in interviews and the analysis of the findings. These results will serve as an input to construct a set of indicators of sustainability for land-use that combines environmental dimensions, local stakeholder concerns, long-term perspectives, and considerations for community involvement and stewardship.

Bearing in mind that land use can be approached from a Sustainable Development angle, this project pretends to identify main drawbacks of actual land use and positives aspects of it as well. Results of this research will allow concluding if under the framework proposed, land use could accomplish sustainability aims in Chile. Results and recommendations of this work will be presented to the environmentally related governmental agencies.

1.5 SCOPE

Considering that Chile is a long country and that there are several administrative regions within the country, the scope of this paper will be narrowed to the Metropolitan Area of the capital Santiago city, where available information allow to perform a better investigation, i.e. availability of information systems to support land information records, and to provide information associated with surveys and mapping. Also, the field work will be limited to the 20 interviews conducted in Chile.

CHAPTER II

FRAMEWORK AND METHODOLOGY

"OUR BIGGEST CHALLENGE IN THIS NEW CENTURY IS TO TAKE AN IDEA THAT SEEMS ABSTRACT - SUSTAINABLE DEVELOPMENT - AND TURN IT INTO A REALITY FOR ALL THE WORLD'S PEOPLE"

Kofi Annan, UN Secretary General, 2005

2.1 SUSTAINABLE DEVELOPMENT: CONCEPTS AND APPROACHES

The concept of sustainability, and particularly of sustainable development, is regarded among the most ambiguous and controversial in the literature (Gallopín 2003). Twenty years have passed since The Brundtland Commission officially presented the concept of Sustainable Development, and different approaches and connotations of the concept and its implications still remains. These divergences are even more noticeable and controversial when the discussion focuses on “*partial sustainabilities*” such as sustainable cities, sustainable economies, sustainable use of natural resources, and sustainable land-use: the subject matter of this paper. Hence, it is widely accepted that taking sustainability as the potential common term of reference for current social, environmental, cultural, political and/or economical issues, can be considered as a generator of problems to which responses must be found.

For that reason, the diverse perspectives, definitions and arguments about sustainable land use have been some of the main question marks when this matter has been discussed. In this context, land use and sustainable development are concepts that can be analyzed from a systems perspective. As explained in Chapter I, the human–nature interactions act over the land system, therefore in order to have sustainable land systems it is vital to consider Sustainable Development (SD) as a system as well, which can be assessed through some specific tools called Sustainable Development Indicators (SDI).

Nevertheless, before moving to the SDI subject matter, it is important to state that all living systems are changing systems; hence the essential point is not to eliminate change, but to avoid sources of renewal destruction from which the system can recover from the unavoidable stresses and disturbances (Gallopín 2003). For instance, land systems are exposed to several stresses; such as intensive forestry and agricultural activities, forest fires, urban sprawl, among others. Nevertheless, in order to analyse present and future development, the above mentioned influences needs to be considered, since the word “development” clearly points to the idea of change, evolution and adaptation.

The key issue appears when the desired level of change is called into question, ensuring that these changes affecting humanity look forward the better, and will not compromise with the ability of future generations to meet their own needs.

Therefore, sustainable land use shows for sure a dynamic state of change of the land, which cannot mean the everlasting preservation of the land in its existing situation. The central question points out to what should be sustained, what should be changed and developed and for how long a time (Parris and Kates 2003). Sustainable land systems imply change; by transforming the system to improve some of its outputs and the system itself.

2.2 LAND USE AND SUSTAINABILITY INDICATORS

Human transformations of land systems cause changes in land use. These changes occur due to land management, and affect the characteristics of land, states, properties, and functions of land systems (Kok, Verburg et al. 2007). Knowledge about land use and land use change has become increasingly important since nations plan to overcome problems of haphazard, uncontrolled development, deteriorating environmental quality, loss of prime agricultural lands, destruction of important wetlands, and loss of wildlife habitat (Anderson 1977). Therefore, there is a need for improved understanding of the interlinked processes between human societies and land systems.

Indicators are used to reduce complexity and simplify information, in order to get a better understanding of systems and intersystem relations. Developing partial models with most possible available information of the system can help the construction of assessing tools such as SDI, and therefore they can play an active role in improving policymaking processes. According to the Meadows (1998) *“Indicators are a necessary part of the stream of information we use to understand the world, make decisions and plan our actions”*. As such, they are partial reflections of reality, based on uncertain and imperfect models and can serve as important tools in the communication of scientific and technical information. They

can also facilitate access to this information for different groups of users and, in so doing, transform information into action (Guijt and Moiseev 2001).

Indicators, be they economic, social or environmental, are important because many social, economic and environmental processes are not directly visible on the scales on which political decisions are taken; e.g., on the regional or national scale (Haberl, Wackernagel et al. 2004). Thus, SDI for land use and management are important, since they can provide valuable information about the present status of the land system, the rate and direction of change, highlighting priority issues and guiding policy formulation.

However, indicator initiatives require a degree of "infrastructure" if they are to result in the kinds of changes sought by users (Winograd 1995). In other words, an effective framework should be capable of accomplish two important goals: first, it helps determine priorities in the choice of indicators; and second, it triggers the identification of indicators which may be more important in the future (Hardi and Zdan 1997). Frameworks used for SDI differ from state of the system intended to assess, as they are based on different models that combine social, economic, institutional and environmental aspects of the system, and the inter-relationships between them.

Several attempts to assess sustainability and produce SDI for land systems have been developed. Haberl et al. (2004) introduced a special issue in the *Land Use Policy 21 Journal*, where a set of papers that aim at deriving sustainability indicators based on the socio-economic metabolism concept are assembled. It focus on indicators that relate socio-economic metabolism to land use, one of the most dominant processes of society–nature interaction that contribute to environmental change. Haberl states that this approach is useful because it builds bridges between social and natural sciences. Alternatively, there are more attempts to face this subject. For instance, the MEFA framework (material and energy flow accounting), which includes human appropriation of net primary production (HANPP) approach.

Furthermore, there is the Ecological Footprint, a tool intended to assess if the regenerative capacity of the biosphere in a given year, with the given technology, is sufficient to regenerate the resources people have used in that year (Haberl, Wackernagel et al. 2004).

Other examples of SD frameworks include the ones developed by (i) The International Institute for Sustainable Development (IISD), (ii) The Statistical Office of the European Communities (EUROSTAT), (iii) The Driving Force - Pressure - State - Impact - Response Framework (DPSIR) developed by the European Environmental Agency (EEA), and (iv) The Pressure-State-Response (PSR) Framework used by the Organization for Economic Co-operation and Development (OECD), among others.

- (i) According with IISD, (László, Hardi et al. 2005) the development of the initial set of SDIs resulted in 134 indicators, grouped according to the dimensions of SD in four major categories: Social, Economic, Environmental and Institutional. Nevertheless, in this report, the possible need to link the SDIs to major international policy agendas is stated, since some issues appeared un-or under-represented on the indicator list, such as conflict and refugees, risk of soil degradation, vulnerability to climate change and biodiversity weighted land use change, among others.

- (ii) The EUROSTAT framework is based on ten themes, reflecting the seven key challenges of the strategy, as well as the key objective of economic prosperity, and guiding principles related to good governance (EUROSTAT 2006). The themes follow a general gradient from the economic, to the social, and then to the environmental and institutional dimensions. The SDI set also describes indicators which are not yet fully developed but which would be necessary to get a more complete picture of progress, differentiating between indicators that are expected to become available within two years, with sufficient quality ('indicators under development'), and those to be developed in the longer term ('indicators to be developed').

- (iii) The DPSIR systems analysis view developed by the EEA (Smeets and Weterings 1999), states social and economic developments exert pressure on the environment and, as a consequence, the state of the environment changes. Finally, this leads to impacts on human health, ecosystems and materials that may elicit a societal response that feeds back on the driving forces or on the state or impacts directly, through adaptation or curative action. Nevertheless, these framework points to reflect trends in the state of the environment and monitor the progress made in realizing environmental policy targets, therefore this framework is more narrowed to an environmental sustainability approach.

- (iv) The PSR Framework (OECD 1999) is described in a number of documents, including the OECD “Core set of indicators for environmental performance reviews”. This framework merely states that human activities exert pressures (such as pollution emissions or land use changes) on the environment, which can induce changes in the state of the environment (for example, changes in ambient pollutant levels, habitat diversity, water flows, etc.). Society then responds to changes in pressures or state with environmental and economic policies and programs intended to prevent, reduce or mitigate pressures and/or environmental damage. The PSR framework is now widely used but is continuing to evolve. One of the main problems has been trying to differentiate between pressure and state indicators, and the need to expand the framework to deal more specifically with the needs for describing sustainable development.

In consequence, it can be seen there is a continuing proliferation of not only indicator sets but also conceptual frameworks and methodologies. The variety of frameworks, however, reveals that there is conceptual uncertainty or at least ambiguity with regard to the specific elements of sustainability (László, Hardi et al. 2005). It also signals that different frameworks appear to resonate with different regions, organizations, cultures and political purposes.

On the other hand, developing and using a clear conceptual framework for guiding the assessment process is essential, since with a proper conceptual framework, indicators emerge more naturally, and can be adjusted to the needs of a given locale or set of decision-makers (Hardi and Zdan 1997). Therefore, in order to assess sustainability of a system it is compulsory to choose a set of indicators, small and meaningful enough to understand all the available and missing information of the system it is intended to be assessed (Bossel 1999), and also to articulate a vision for the future and have clear targets regarding what is to be assessed. The vision and targets together provide the starting point of any assessment.

For instance, a key sustainable development goal for land use is to balance the competing demands for the finite quantity of land available. Park et al (2005) present the following example for SDI:

The main issues are to minimise the loss of rural land to development and to maintain the vitality and viability of town centres with people living close to where they work. The indicators relevant to these issues are: the area of land covered by urban development, household numbers, re-use of urban land for development, the amount of land used to build new roads, money spent on urban regeneration, and green spaces in urban areas for recreation, among several others.

The various proposals and interests noted above represent a remarkable group of experience and insight from which to draw. Reviews of the Bellagio Principles for Assessment (1997) serve as guidelines for the whole of the assessment process, including the choice and design of indicators. Table 1 presents the 10 principles and the proposal of each one.

Table 1: The Bellagio Principles for Assessment

Principle	Assessment of progress toward sustainable development should:
Principle 1 Guiding Vision and Goals	<ul style="list-style-type: none"> – Be guided by a clear vision of sustainable development and goals that define that vision
Principle 2 Holistic Perspective	<ul style="list-style-type: none"> – Include review of the whole system as well as its parts – Consider the well-being of social, ecological, and economic sub-systems, their state as well as the direction and rate of change of that state, of their constituent parts, and the interaction between parts – Consider both positive and negative consequences of human and ecological systems, in monetary and non-monetary terms
Principle 3 Essential Elements	<ul style="list-style-type: none"> – Consider equity and disparity within the current population and between present and future generations, dealing with such concerns as resource use, over-consumption and poverty, human rights, and access to services, as appropriate – Consider the ecological conditions on which life depends – Consider economic development and other, non-market activities that contribute to human/social well-being.
Principle 4 Adequate Scope	<ul style="list-style-type: none"> – Adopt a time horizon that spans both human and ecosystem time scales to ensure that the needs of future generations are addressed while responding to current short-term decision making requirements – Define the space of study large enough to include not only local but also long distance impacts on people and ecosystems – Build on historic and current conditions to anticipate future conditions — where we want to go, where we could go
Principle 5 Practical Focus	<ul style="list-style-type: none"> – An explicit set of categories or an organizing framework that links vision and goals to indicators and assessment criteria – A limited number of key issues for analysis – A limited number of indicators or indicator combinations to provide a clear signal of progress – Standardizing measurement wherever possible to permit comparisons – Comparing indicator values to targets, reference values, ranges, thresholds, or directions of trends, as appropriate

Table 1: Continuation...

Principle	Assessment of progress toward sustainable development should:
Principle 6 Openness	<ul style="list-style-type: none"> – Make the methods and data that are used accessible to all – Make explicit all judgments, assumptions, and uncertainties in data and interpretations
Principle 7 Effective Communication	<ul style="list-style-type: none"> – Be designed to address the needs of the audience and set of users – Draw from indicators and other tools that are stimulating and serve to engage decision-makers – Aim, from the outset, for simplicity of structure and use of clear and plain language
Principle 8 Broad Participation	<ul style="list-style-type: none"> – Obtain broad re presentation of key grass-roots, professional, technical, and social groups, including youth, women, and indigenous people — to ensure recognition of diverse and changing values – Ensure the participation of decision-makers to secure a firm link to adopted policies and resulting action
Principle 9 Ongoing Assessment	<ul style="list-style-type: none"> – Develop a capacity for repeated measurement to determine trends – Be iterative, adaptive, and responsive to change and uncertainty because systems are complex and change frequently – Adjust goals, frameworks, and indicators as new insights are gained – Promote development of collective learning and feedback to decision-makers
Principle 10 Institutional Capacity	<ul style="list-style-type: none"> – Clearly assigning responsibility and providing ongoing support in the decision-making process – Providing institutional capacity for data collection, maintenance, and documentation – Supporting development of local assessment capacity

Bearing in mind these principles for assessment of progress toward sustainable development, and considering there are several approaches for this subject; SDIs for land-use will be presented in this paper.

The proposed indicators will be developed according to a framework that can supply a model for constructing these indicators by translating physical and social science knowledge into manageable units of information that can facilitate the decision-making process, and the understanding of these decisions by most stakeholders as well.

On the other hand, according to Bossel (1999), coming up with good and objective indicators is a challenge, because quantitative and qualitative indicators must be clear in value and content and suggestive; policy relevant and aim for participatory processes; feasible to measure at reasonable costs in understandable units, timely comparable, appropriate in scale, hierarchical, leading to take action when needed and tentative to assess and update, according to the dynamic of change of the system. These features were already discussed in chapter 1, whereas variability of land systems not only depend on natural processes over the territory, but also and mostly in processes of society–nature interaction.

In order to come up with SDIs for land-use bearing in mind the previous analysis, and in an attempt for taking into consideration restraints and drawbacks present in the above mentioned SD frameworks, a multidimensional framework will be used, which is called The MAIN tetra, since it works with 4 dimensions of sustainability. These four dimensions are Mind, Artefact, Institution and Nature (Kain 2000). This framework will be detailed in the following section.

2.3 THE MAIN TETRA FRAMEWORK FOR SUSTAINABLE DEVELOPMENT

For analysis of the sustainability of land-use, a multidimensional framework called The MAIN tetra is presented. This framework introduces a 4 dimension model of sustainability, which are Mind, Artefact, Institution and Nature (Kain 2000). The following figure shows the inter-connections amongst these dimensions.

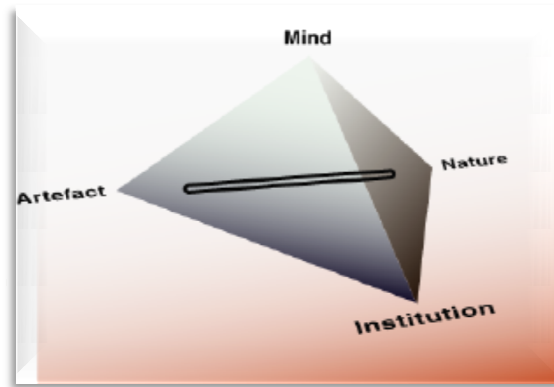


Figure 2: The MAIN tetra

This model aims to skip the drawbacks of previous models of sustainable development, by not embracing environmental approaches of sustainability. Also the framework intends to integrate the traditional expressions social and economic into transversal boundaries such as Mind and Artefacts, since for instance, land use planning should include an integrated view of the land, bearing in mind that social activities take place there, which are framed by specific local conditions and influenced by external driving forces (legislation, market, etc.) and other relations to the surrounding world at local, regional, and global levels (Keiner, Zegras et al. 2004).

In this model, the four dimensions represent partial aspects of a whole with the purpose of linking concepts traditionally disaggregated. This approach supports the widely accepted statement that traditional sectorial, disciplinary approaches are not longer enough to understand and assess sustainability (Malbert and Kain 2004). Moreover, a transversal approach such as the hereby proposed to settle on that economic, social and environmental concerns need to be seen and solved in the context of each other through interdisciplinary research that cuts across traditional boundaries between the social, economical and cultural dimensions on one hand, and natural dimension on the other ((Haberl, Wackernagel et al. 2004).

For example, the human-made structures (e.g. buildings, constructions and technical infrastructure), the social institutions (e.g. formal and informal social organization and power-relations), and the natural systems (e.g. flows and ecosystems dependent of geology and climate) shape the specific local conditions of the land system and the interrelations with the human society system.

Based on a multi-dimensional framework this analytical model allows interpreting sustainable development contextualised for land-use through a four-pointed tetrahedron defined by:

- **The Mind**

This dimension corresponds to the awareness of the individual subject. It represents ethics, worldviews, knowledge or readiness of action of different actors, skills and other human attributes (Malbert and Kain 2004). When dealing with land-use issues, it can be seen that Mind is always particular; it grasps different worldviews which can also be antagonistic, since perception of land value or landscapes appreciations can vary from person to person. This dimension also depends on socio-cultural levels and frequently can be conditioned by positions and personal commitments. Therefore, it is possible to find conflicting interests within the minds; nevertheless, all these different awareness and knowledge can also enrich this dimension.

- **The Artefact**

This dimension considers all the man-made material assets, technical systems and products, the instruments, machinery, physical structures and networks. Considering that every single work of art or construction is built in a real place, over a portion of land, and with materials extracted from the land itself, this dimension can be understood and linked to the land-use directly, since land is the source of assets for developing and locating all artefacts.

- **The Institution**

Institutions are social mechanisms, formal establishments or structures that fashions the social realm, human interactions and activities. This dimension relates to the organization of the society and the formal and informal relation between people, levels of participation, relational webs of all sizes and directions, political structures, information systems and codified knowledge.

There are several social mechanisms related to land-use, but in this context, this dimension points out to identify the social structures that dwell in a territory, where human interactions take place, and can influence the land system.

- **The Nature**

This dimension comprises all natural capitals, from the ecosphere to the lithosphere, including stocks of non-renewable as well as stocks of renewable resources. It is important to notice that this tetra model enhances the difference between man-made capital (artefacts) and natural capital. It is this dimension where land lays, the only one that cannot be negotiated, but only modified.

According to this tetra model, it seems to be impossible that man-made assets, social and human capital can increase at the same time at the same amount, moreover preserving natural capital; there is always a mayor development of one or two of the above mentioned dimensions. For instance, poor and developing countries look forward to increasing man-made capital, through economic growth and infrastructure equipment; leaving behind social concerns and depleting natural resources in the process. On the other hand, developed countries put a bigger effort in preserving natural resources and hence, the natural resources exploitation can be restrained in order to assure pressure over the natural dimension will not endanger it. Therefore, in order to achieve sustainability, regards and balance in the four dimensions are needed.

In spite there are several attempts and models that illustrate and explain the sustainable development, one of the problems is that they often give only fragmented and sector-related knowledge about the complex local situation (Link 2006). The tetra model provide a strategic advantage over the traditional definition of sustainable development and other SD models, since its four main knowledge domain are more unambiguous, therefore, evading confusion and misunderstanding (Kain 2000).

On the other hand, a prism forces the interpreter to discern the variety of problems and to use different scientific approaches to understand this variety (Edén, Birgersson et al. 2003); therefore a more integrated view of the system can be achieved, following the holistic perspective of The Bellagio Principle Nr.2: including a review of the whole system as well as its parts.

2.3.1 SDI CONSTRUCTION

As mentioned in section 2.2, there are several approaches to assess sustainability of land-use, and there are also several different frameworks available to build SD indicators. Nevertheless, a particular framework will be presented in following lines, based on Kain's framework of SD and the three dimensions of the land system introduced in section 1.1.3.

In order to suggest SDI's for land-use, the linkages between the 4 dimensions of the MAIN tetra model and the land system showed in figure 1 are proposed. In this task, land is considered according to its ownership (the formal and informal land tenure), management (current use, administration and exploitation of the goods and services of the land) and to its natural characteristics. As result of this "linking formula" a 4X3 matrix result, containing for each cross general ideas of the indicators; next step corresponds to the consequent analysis, where SDI for land-use for each cross are presented.

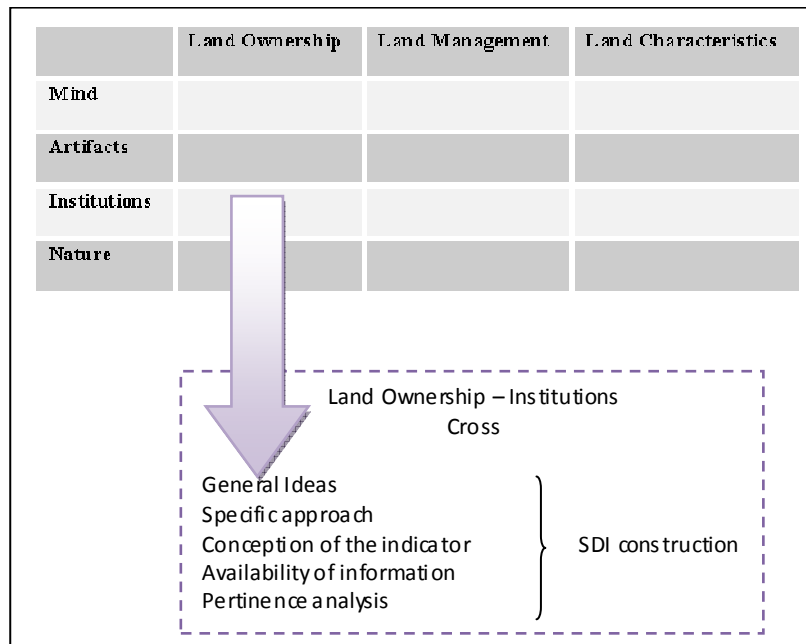


Figure 3: Example of the construction of SDI

In parallel, a field work is carried out, whose intention is to conduct a study case focused on land-use in Santiago de Chile. SDI proposed in this paper are related to land-use in this study area, for the field work methodology aimed to conduct interviews to local stakeholders as explained in Chapter I, section 1.3.

The analysis of the findings of the interviews provided important information to future develop the set of SDI resulting from the above mentioned linking stage, as illustrated in figure 3. The target is to link the indicators with the study area and its features, in order to scale down this academic research to a local reality.

2.4 FIELD WORK METHODOLOGY: STAKEHOLDER ANALYSIS AND INTERVIEW FORMAT

The field work consisted in the application of interviewing a group of selected key informants and the subsequent coding of the relevant content and findings of the questions and answers. Full text of the interview guidelines can be found in Appendix I. A complete list of the respondents and their general characteristics can be found in Appendix II

Five different groups of actors were considered: the public sector, the private sector, the politic sector, the academic sector and the civil society. From each one of these groups, interviewees that deal with land-use issues were selected. A total of twenty interviews were conducted in-person between August and October 2007. Potential interviewees were identified through a sequential sampling process, beginning with one contact widely known within each defined group of actors mentioned above. This person was interviewed and asked to recommend more people to interview. This procedure is called “snow ball sampling”, and it is demonstrated to minimize the number of interviews necessary in field studies and yet retain accuracy of results possible only through adherence to sound statistical methods (Birt and Brogren 1964).

The purpose of conducting interviews was to enrich the SDI construction with the perception of stakeholders' approaches about land use and sustainability.

2.5 INTERVIEW DESCRIPTION

The interviews were conducted in the work places of each interviewee and lasted approximately one hour and a half. The questions of the interview were asked in different order, allowing to the interviewee to talk at length about the subjects that were most well-known for each one of them. Answers and comments result of the interview were written down and then translated into English.

The interviews were not recorded as a suggestion of the first interviewee, who claimed that recording could be inconvenient, cause incommodity to some persons, and restrain the liberty of their opinions. All information was handled with confidentiality and regards, and the answers collected from the interviews were not attributed to individual respondents. In addition, all interviewees were asked to recommend documents to read and places or institutions to visit that could contribute to improve the investigation.

The interview intended to capture information related to the following topics:

1. Land-use decision-making in Chile: Procedures, criteria, advantages, limitations and challenges
2. Sustainable Development Indicators and Land-use: Conception, key drivers and the feasibility and potential role of the SDI
3. Land-use problems, conflicts and power analysis: Stakeholder analysis and key barriers

For a better understanding of the field work and a proper contextualization of the research, Chapter III of this paper introduces briefly the study area, the historic and current land-use of Chile, presenting economical, political, social and ecological aspects of this matter.

CHAPTER III

STUDY CASE: LAND-USE IN SANTIAGO, CHILE

*"A LONG NARROW STRIP OF LAND BETWEEN
SNOWCAPPED PEAKS OF THE TOWERING VOLCANIC
ANDES MOUNTAINS AND THE PACIFIC OCEAN..."*

Chile in a few words, 2008

3.1 DESCRIPTION OF THE STUDY AREA

Chile is a country in South America occupying a long and narrow coastal strip wedged between the Andes Mountains and the Pacific Ocean. The Pacific forms the country's entire western border, with Peru to the north, Bolivia to the northeast, Argentina to the east, and the Drake Passage at the country's southernmost tip (Chilean Government 2007). Chile stretches approximately 4,270 km from north to south but its average width is less than 180 km; and has a total area of 756,626 sq km. Santiago city is Chile's capital and largest city, located in the central valley.

The estimated population for the current year is 16,284,741 inhabitants, giving the state an overall population density of 22 persons per sq km. Chile is one of the most urbanized countries in South America. About 88 percent of the population lives in urban centers, and nearly one-third of the country's population lives in the capital city of Santiago (LyD 2007). In 2005 the national budget had \$21.6 billion in revenues and \$28.1 billion in expenditures. Chile's estimated gross domestic product (GDP) in 2005 was \$115.2 billion - \$7,073 per head (Microsoft® Encarta® Online 2007).

Chile is divided into 15 regions, each which is headed by an Intendant appointed by the President (Chilean Government 2007). Every region is further divided into provinces, with a provincial governor also appointed by the President. Finally, each province is divided into communes, which are administered by municipalities, each with its own mayor and councilmen elected by their inhabitants for four years. Each region is designated by a name and a Roman numeral, assigned from north to south, as showed in figure 4. The only exception is the region housing the nation's capital, which is designated RM, which stands for Región Metropolitana (Metropolitan Region). Two new regions were created in 2006: Arica-Parinacota in the north and Los Ríos in the south. Both became operative in October 2007.

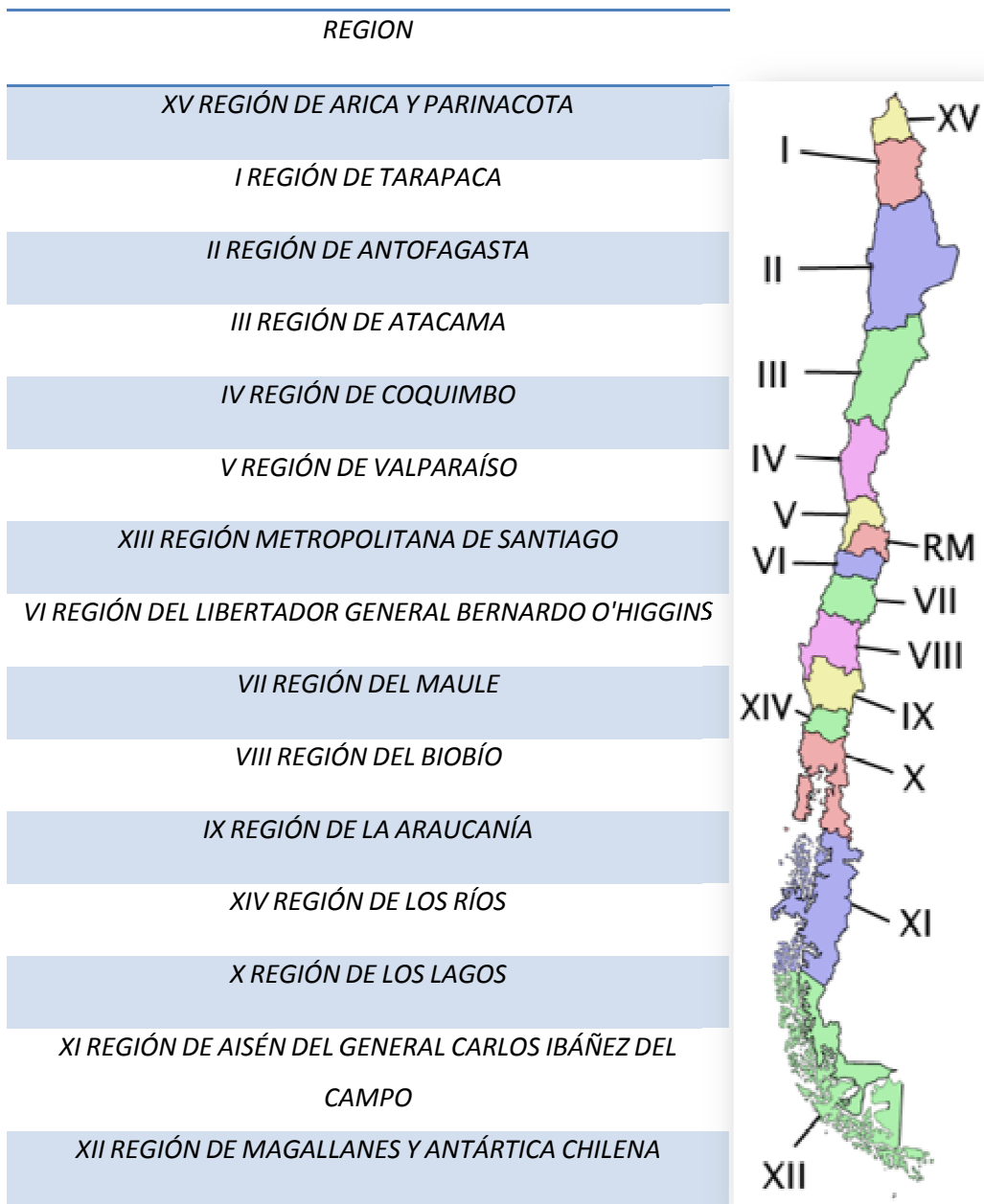


Figure 4: Politic-Administrative Map of Chile

3.2 LAND AND RESOURCES

Chile can be divided along its length into three topographic zones: the lofty Andes on the east; the low coastal mountains on the west; and the plateau area, which includes the Central Valley between these ranges (Microsoft® Encarta® Online 2007). The country has three major geographical and climatic regions: the dry northern region; the central region, with a Mediterranean (mild to warm) climate; and the southern regions, with a temperate sea climate.

In the central region, the plateau gives way to the Central Valley, which is 1,000 km long and ranges from 40 to 80 km in width. The central region is the most heavily populated area of the country, with nearly 90 percent of Chile's people. It also forms the agricultural heartland of Chile. About 13 percent of the labor force of Chile is engaged in agriculture, forestry, and fishing, and these sectors account for 6 percent of the GDP.

The bulk of Chile's agricultural activity is concentrated in the Central Valley except for sheep raising in the far south (Microsoft® Encarta® Online 2007). While only 3 percent of Chile's land area is currently under cultivation, agricultural production has increased significantly since the early 1980s. Forests cover 21.5 percent of Chile's land area. About 46.1 million cu m of timber was cut in 2005. The forestry industry accounts for about one-tenth of annual exports. On the other hand, Chile has an extensive protected area system made up of 30 national parks, 36 national reserves, and 10 natural monuments (CONAF 2003), but it excludes many important ecotypes, especially those of the central and northern regions. Overall, nearly 20 percent of the land was protected by the late 1990s.

3.3 LAND-USE, LAND-USE CHANGE AND LAND- USE PLANNING INSTRUMENTS

Land-use and land-use planning are matters recently incorporated in the public agenda of Chile, and such approaches date from few years ago, especially at the local level, where municipalities have taken some initiatives by developing or updating their land planning instruments (Saa, Hermosilla et al. 2003). At the international level, it can be stated that this subject has long tradition. In the second half of the XX century land-use starts to be considered explicitly as an issue, moreover than an urbanism element (Barnes 2003).

3.3.1 LAND-USE IN CHILE

In Chile land-use can be considered as a recent concern, although the urban visage of land has long record. This situation explains the strong urban connotation of the land still present in the country. This can be seen in numbers, for example in the year 2005, 54.2% of the occupied urban land was concentrated in the 3 biggest Metropolitan areas (90.179 ha); about 88 % of the population lives in urban centers, and nearly one-third of the country's population lives in the capital city of Santiago (Microsoft® Encarta® Online 2007).

The total surface of the country is of 756,626 sq km. When considered in general terms that this total land area can be classified for three different types of land use - arable land (land cultivated for crops that are replanted after each harvest); permanent crops (land cultivated for crops that are not replanted after each harvest); any land not arable or under permanent crops (including permanent meadows and pastures, forests and woodlands, built-on areas, roads, barren land, etc.), the percentages for each category (for the year 2005) are:

- arable land: 2.62%
- permanent crops: 0.43%
- other: 96.95%

Over the past years, land use planning issue has intensified in the country as a result of recent environmental problems which affect the health and quality of life of the population. The perception of a gradual deterioration and exhaustion of natural resources - which play an important role in the economic growth of Chile as a primary producing country - have further strengthened this development.

3.3.2 STUDY-CASE: THE METROPOLITAN REGION OF SANTIAGO DE CHILE

Similar to many other nations in Latin America, Chile has a heavy share of its population and economic activities concentrated in one city, in this case the Chilean capital of Santiago (GORE 2005). Located in the Metropolitan Region (Region Metropolitana or RM), Greater Santiago accounts for nearly 90% of the RM's population, or roughly 40% of the nation's population. The RM accounts for 47% of national GDP and accounts for 53% of the nation's industrial activity and 68% of the nation's commercial activity. Santiago is home to most of the country's most important centers of higher education and virtually all headquarters of Chile's major economic groups, including all foreign and national banks (Carlos A. De Mattos, Pérez et al. 2001). The economy of the Metropolitan Region has already become highly service-oriented, with commercial and financial services accounting for nearly 60% of the Gross Regional Product (GRP) - 30% and 27%, respectively - (Banco Central de Chile 2006) and government, social services and commercial activities accounting for 50% of all employment.

Although institutions and procedures for characterize the state of economy of the country is well developed, different figure for land issues is seen. For example, in Chile there is no public service or institution responsible of the characterization and measurement of the urban sprawl of Santiago. The Ministry of Housing and Urban Development (MINVU) carries out some studies yearly related to this matter. Figure 5 shows a satellite image of Santiago; where gray color indicates urban areas.



Figure 5: Satellite image of the Greater Santiago

According to a report of the Chilean Environmental Agency (2001), when comparing the urban spot of Santiago between 1986 and 1998 it can be seen that the city has “eaten” 32.000 ha. of land, frequently the most productive land of the region and the country. Land use in the Metropolitan area is restrained by zoning and development guidelines contained in the Metropolitan Regulator Land Planning (PRMS) which was developed by the MINVU in 1994; all Municipal land plans (PRCs) must meet the terms of the PRMS.

Today, The Metropolitan Region consists of 52 different Municipalities (MIDEPLAN b 2006). Greater Santiago extends throughout 37 municipalities and covered 64,140 ha in 2002. The majority of Santiago lies within the same named province, with some peripheral areas contained in the provinces of Talagante, Maipo and Cordillera. Specifically, Santiago joins the cities of San Bernardo (Maipo province) and Puente Alto (Cordillera province) to form the Greater Santiago conurbation.

In addition, land use in the region can be classified according to several categories, nevertheless, one of the available and most updated ones is provided by the Environmental Agency CONAMA (SINIA 2005), which defines 8 categories of land use, plus some areas with no information, as illustrated in figure 6:

1. Area with no vegetation cover
2. Urban and industrial area
3. Forests
4. Water bodies
5. Wetlands
6. Ice cover and glaciers
7. Grassland and brushes
8. Agricultural and farming
9. No information

It can be seen in figure 6 that most area with no vegetation and ice covers and glaciers corresponds to the Andes Mountains at the east of the region; the urban and industrial area corresponds to the Greater Santiago area, and most rural lands are located at the west of the region. Urban land comprises a minor part of the total area of the region, although city is expanding, it cannot be seen the urban sprawl in the agricultural lands; nevertheless, by comparing figure 6 with figure 7 this phenomena can be noticed.

Land - use in the Metropolitan Region of Santiago

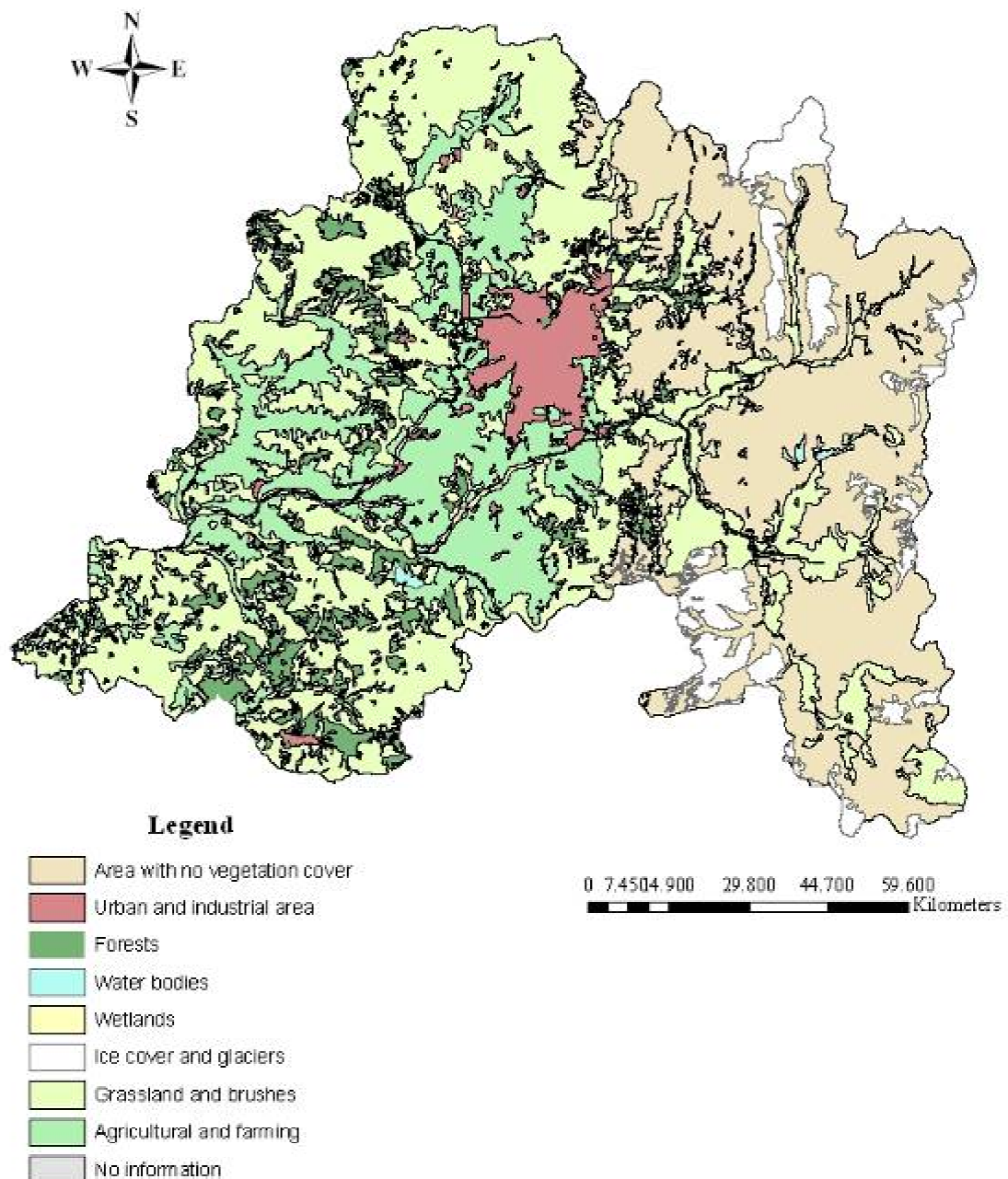


Figure 6: Land – use in the Metropolitan Region of Santiago (Source: SINIA, 2005)

3.4 RURAL AND URBAN LAND –USE: AN INSTITUTIONAL DICHOTOMY

Traditionally, the city has been shaped according to immediate needs and economic growth demands for the land (Galetovic and Jordán 2006). Land use plans are modified constantly in order to respond to city expansion, as can be noted in figure 7. Two of the most powerful planning instruments that have allowed the urbanization of most agricultural lands are:

- Article 55 of the Decree DFL 458 – General Law of Urban Development and Construction
- The decree DL 3516 – Rustic Real Estates Law

The first regulation is the administrative procedure for land-use change (SAG 2007), and it is a sectorial authorization which allows changing the use of agricultural or rural land to different uses such as housing or industrial. This law promotes the development of new industrial spots, as well as urban expansion; even so, at the same time it restrains agricultural use of the land, since many of these land-use changes are carried out in good agricultural quality lands. Decree 3516– Rustic Real Estates Law –allows the subdivision of agricultural real estates in 5.000 square meters sets. This subdivision promotes urbanization of rural land as well as the diminishment of agriculture profitability due to increasing speculation related to the price of urban land in the Greater Santiago (Strasma 2000). Following paragraphs of this chapter explains the rural-urban conflict of the land in more detail.

Urban sprawl and city expansion has become an environmental problematic issue, taking into account the impacts that urban activities cause in the cities. Hence, as many larger cities, Santiago has needed to expand its boundaries constantly. Nevertheless, the growth rhythm has been particularly high in the past 15 years. Both situations, among other factors, have contributed to the rapidly changing situation, clearly illustrated in figure 7, which shows the urban expansion of the city fashioned as an ink spot between 1980 and 2002. Several authors agreed that the liberalization of the real estate market favored this kind of expansion; therefore, the private investors would have been free will to expand the city at their own convenience (Galetovic and Jordán 2006).

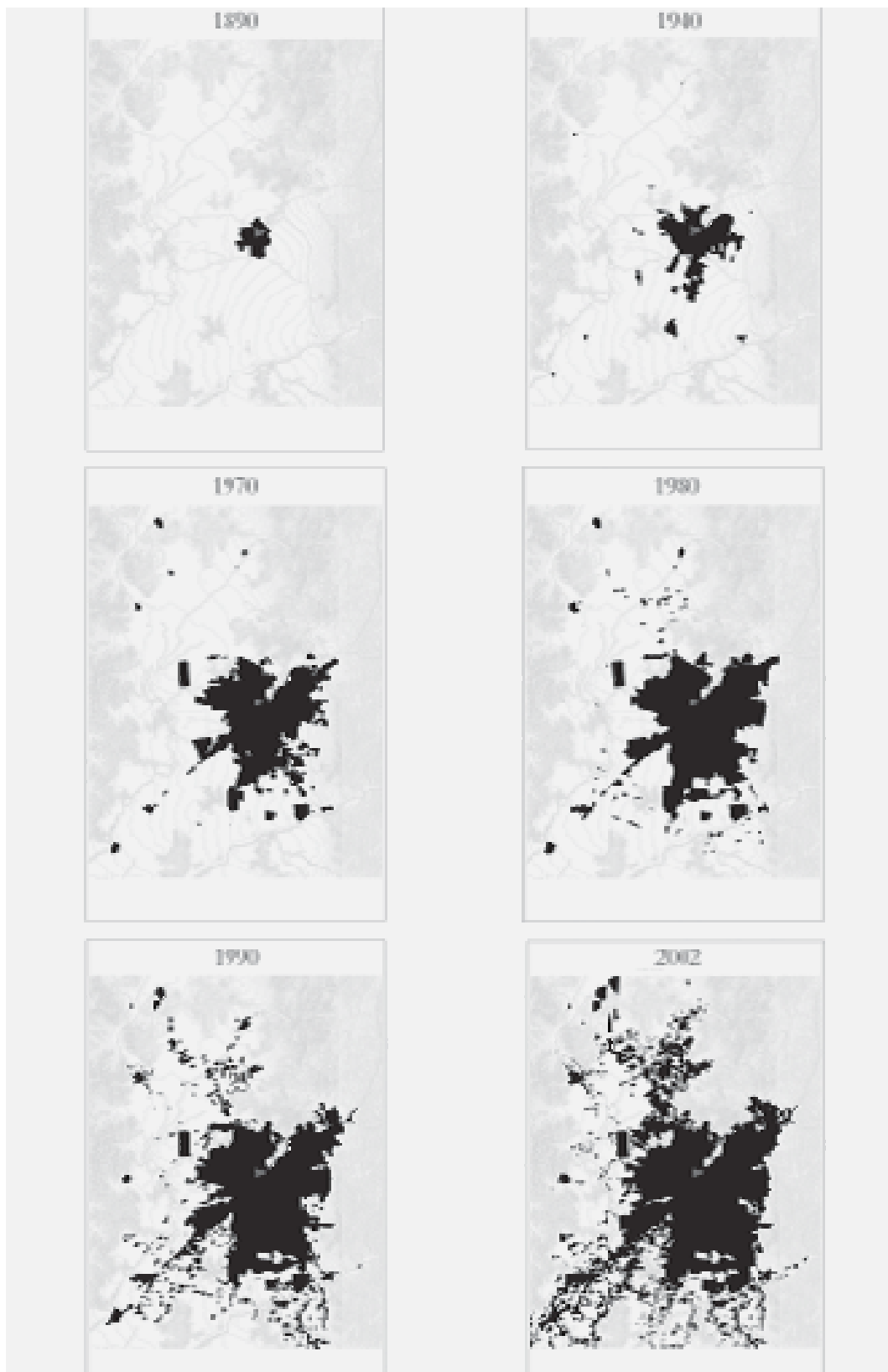


Figure 7: Urban sprawl of the Greater Santiago between 1890 and 2002
Source: (Galetovic and Jordán 2006)

On the other hand, since 1980, when the decree 3516 came into force, an urbanization process for rural land in Santiago began to be developed, and this process is still in progress. This process promoted the urbanization of agricultural lots, accelerating transformation of rural land and land-cover change (Armijo 2000). As a result, land owners started to sell their lands; the direct beneficiaries were agricultural exporters and afterwards, estate agents. These estate agents have dynamized the land market, by developing elite urbanization processes for urban residents around the city, in traditionally agricultural lands.

It is worth to mention that the biggest proportion of poor people lives in rural zones; the same trend saw in most developing countries. However, despite a quick reduction of rural poverty - from a 51% in 1987 to 31.6% in 1994 - it is still a significant problem (Marquez 2006).

Following images illustrate part of this reality, where it can be seen that zones with more agricultural area (dark green color) matches with highest percentages of poor population (dark red color). These images were elaborated the year 2006, and show for the 52 communes of the Metropolitan Region the agricultural surface for each commune (figure 7) and the percentage of population in poverty condition (figure 8) (GORE 2006).

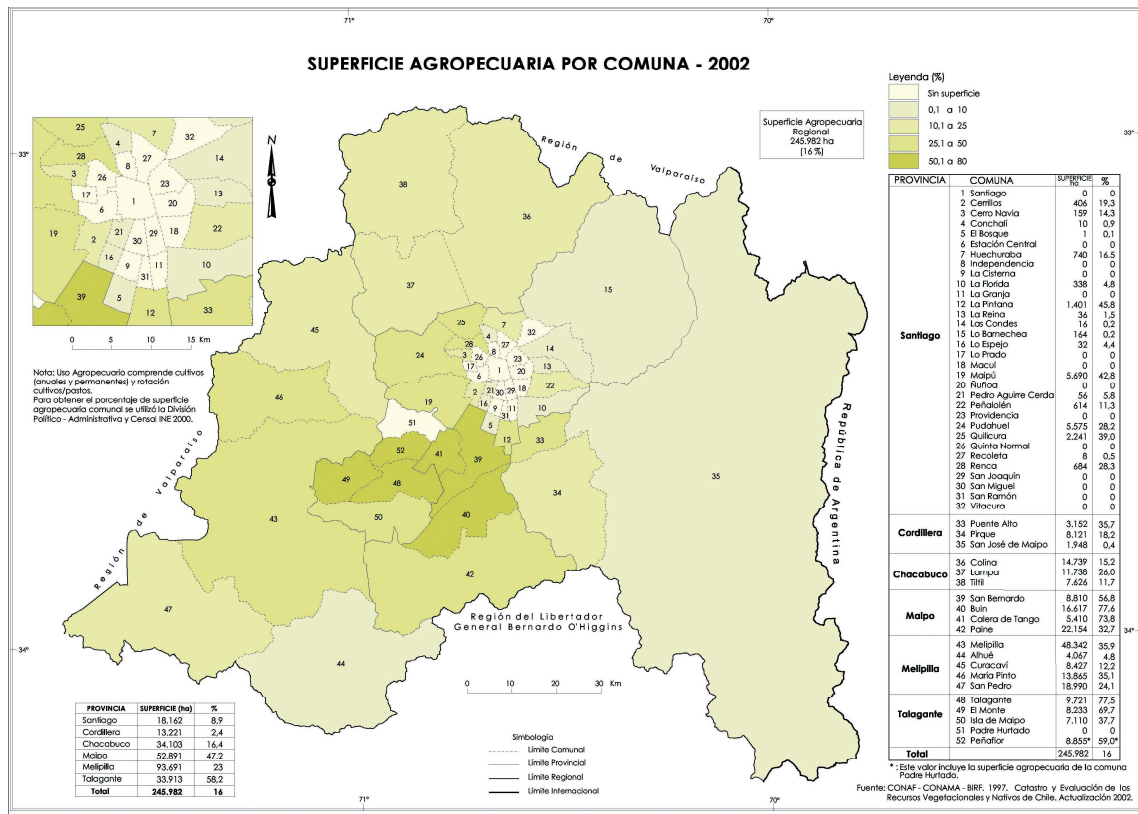


Figure 8: Agricultural areas of the Metropolitan Region – 2002 (Source: Gore 2006)

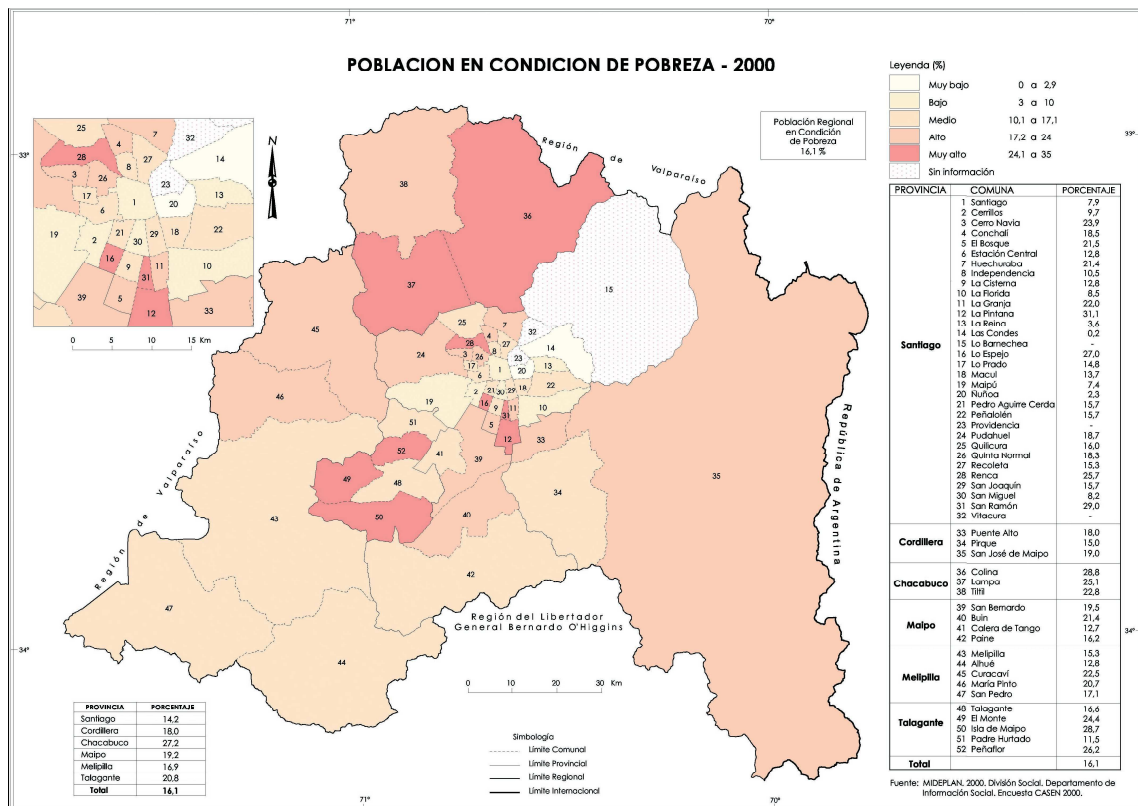


Figure 9: Population in poverty condition of the Metropolitan Region – 2002 (Source: Gore 2006)

3.5 STAKEHOLDERS ANALYSIS: LEVEL OF INVOLVEMENT, PARTICIPATION AND DECISION-MAKING

Public participation is a key element to successfully develop a country, and lessons learnt from our history has taught us that biased land planning has led us to several social, economical, political and environmental problems, which are clearly hard to fix or to revert (Barnes 2003). In this context, public participation involves a citizen effort as for the future of the city, since it comprises the basis of a commonly agreed project for land-use ((Montes 2001). The biggest achievement of this participation process consists in generating commitments in further planning processes; by establishing co-responsibility models.

Hence, land-use planning can effectively incorporate open participation processes, looking forward to including stakeholders' considerations when possible. Consequently, participation appears as a permanent and continuous process legitimating any plan or program for land-use in each one of their stages, i.e. the formulation, implementation, assessment, revision and modification of these plans and programs.

Another key aspect of the public participation is collaboration of the private sector as main investors and project developers. These stakeholders have important power quotas, and can influence decisions of future land-use. Traditionally, it was assumed that municipalities were able to control every land-use change in the communal territory, and effecting the respecting inversions for each case. Nowadays it can be seen that privates are assuming part of this municipalities' role, by leading the private investments for the development of the cities. As a summary of this figure, main stakeholders that deal with land-use and the role (or challenge) that they achieve are displayed in the following table:

Table 2: Stakeholders and some of their role in land-use planning

Stakeholder	Description	Role (challenge)
The public sector: the government, state agencies and municipalities	As public institutions, these stakeholders are responsible for developing tools to carry out policies, plans and programs in consequence with public goals for the whole territory; they are also responsible of providing services which directly affect the lives of their residents.	The distribution of the public resources, budgets and public works, framed in politics and plans according to sustainability land-use goals. To create and enhance effective participation channels and to increase different stakeholders involvements into decision making-processes.
The market or private sector	The private sector is attached to the success of the overall economic development strategy of the country. These stakeholders are responsible for retaining and expanding basic industry and other businesses within the country and hence, contribute to employment.	Real estate companies and the infrastructure industry should collaborate with the public sector in order to make from their business opportunities a real chance for reaching a symbiotic relation with social actors and improve their projects with the knowledge of the population through participation. In other words, to support sustainable economic growth and poverty reduction.
The people and civil society and their organization.	Civil society able and willing to involve, can both complement government enforcement efforts and encourage the government to maintain and sharpen its focus on citizens concerns. For example, civil society could act as knowledge creators if they have effective channels of participation.	In order to promote good governance, this group of actors should be incorporated and integrated in political debates and decisions about future land-use, especially strategic aspects related to land-use planning, since they have a know-how that other stakeholders lacks of.

In Chile, like in many Latin American countries, the centralization of the State and resources distribution is very dominant (Galetovic and Jordán 2006), but nowadays the situation is changing. Since there are important economic groups, it seems indispensable that regional and local governments have a high and democratic legitimacy within the population. This picture is more visible in larger cities such as Santiago, where important investments and decision-making are at glance. This image also shows that it is usual to find large companies - such as financial and real estate firms - investing their profits in international markets, instead of re-investing part of their incomes in local economies.

Participation and agreements with innovation in this area may help to avoid environmental-social conflicts with the civil society. This last stakeholders group includes not only individuals and local organizations, but also incorporates universities, research institutes, NGO's, among others. Civil society organizations are supposed to be considered as qualified stakeholders, to contribute with their know-how and to represent citizens' interests in some extent. Therefore, their participation should be considered, since they are usually better familiarized with local problems; sometimes better than urban developers and investors that do not know about daily contingence.

In order to reach efficient participation processes for land-use planning, it is important to grasp there are different territories and therefore, assessment and planning tools might achieve better results considering the diversity of capitals surrounding land, i.e. natural, human, social and cultural capital. In conclusion, the big challenge for reaching (or start approaching) sustainable land-use is to connect worlds currently apart, the politic-administrative system and planners' sphere with a world called local "everyday life space".

For instance, from the perspective of sustainable development, some principles have been emerging concerning work in territorial regulation as a basic strategy to obtain an adequate physical and spatial planning (Cervantes 2007). The goal of those principles has been to supervise the good use of natural resources, to appropriately locate productive activities,

and to increase infrastructural and urban facilities for a more equitable development, as well as a more successful fight against poverty and marginalization.

Following chapter will present an attempt to grasp all these ideas (and ideals) by constructing a model to propose Sustainable Development Indicators for Land-Use in Santiago, looking forward to see whether is sustainable land use a reality in the short (or long term), or how far are we from reaching that picture.

CHAPTER IV

RESULTS

*"IF WE COULD FIRST KNOW WHERE WE ARE, AND WHITHER WE ARE TENDING,
WE COULD THEN BETTER JUDGE WHAT TO DO, AND HOW TO DO IT"*

Abraham Lincoln, 1858

4.1 RESULTS OF THE INTERVIEWS

This chapter presents the results of this project, and aims to fulfill the objectives of this study at the end of this chapter, by presenting SDI for land use keeping in mind the considerations and remarks mentioned in previous chapters.

In order to accomplish that, this chapter is divided in 4 sections; first part presents the results of the interviews, in order to maintain the scope of the project and to show main conclusions that will adjust and/or redefine the indicators further on this chapter. Second part introduces what will be defined as an SDI, starting from the main idea and ending with the first version of the SDI for land use. The third part analyses quality of available information to set up the indicators, acting as a filter that will help narrow the work. Part four present the SDI for land-use in Santiago.

4.1.1 LAND-USE DECISION-MAKING IN CHILE: PROCEDURES, CRITERIA, ADVANTAGES, LIMITATIONS AND CHALLENGES

In Chile, decisions related to land-use are commonly taken under the approval of certain legal instruments. There are official Land-Use Planning Instruments (TPI) that are managed by the Ministry of Housing and Urban Development (MHU), but since these Instruments regulate urban land and inter-communal rural land, there is a permanent debate about the need of developing more specific instruments for rural land.

Planning land use

The lack of Rural Land-Use Planning is a common perception for rural municipality planners, which also perceive urban expansion of Santiago as a menace that lacks of strategic visions

and prioritises the cities as signs of development, in detriment of agriculture development. For instance, a rural municipality planner talks about the way land is fashioned in Santiago: *“While the urban world fashions its land with concrete instruments, the surrounding rural world does it by default”*

Changes in land use can be caused by 2 different kinds of processes. One of them is physical phenomena, that is, where a change on the land characteristics affects its features and hence its purposes. For instance, soil degradation can have larger negative consequences on agriculture production, and many times eroded arable lands cannot be used for agriculture activities. The second process deals with administrative procedures and it is known as a planning instrument. It is when people estimated that some areas of land can be used in other way, in order to gain an economical benefit through the development of productive activities, wild area protection, and military areas amongst others. Thus, larger agriculture areas have been changed into urban areas, since the monetary value of urban land is much higher than the rural ones.

In this context, the main instrument for rural land-use planning is land-use change – which allows changing agricultural or rural lands into other uses such as housing or industrial. Nevertheless, any time a land-use change authorization is issued, effects over land occur such as increase in new industries or companies' development, urban sprawl.

In Chile, land-use change is performed under a well-known methodology sustained in laws and norms, and the authorization issued only by a unique public institution. When asked about the main advantage of land-use change in Chile, most of the interviewees converged in one aspect: this administrative process cannot be skipped or avoided. This was called a functional advantage. Nevertheless, parts of these processes can always be “customized”, usually for economic purposes. This was called an operative disadvantage.

The “City-Country Dichotomy”

Although land-use change can restrain agricultural land-use and eventually reduce natural areas, it was a frequent opinion that urban development equals to life quality improvement. Interviewees of the civil society agreed on that land use-change seem to obey to more economic and/or politic criteria instead of technical criteria. A particular opinion stated that *“Large real estate agents change land-use without considering social and environmental variables and sometimes skipping natural risks considerations. This situation has influenced land price, which can be up to 10 times the rural land price”*. This idea was also shared with some academics and private consultants, which also agreed on that this phenomena not only happens in Santiago, but also in most of the largest cities of the country and their surrounding county towns. It was also often mentioned the long-established “City-Country Dichotomy”, as a way to explain some of the above mentioned situations and the differences in management for urban and rural land.

Another concept that raised in interviews is hereby summarized as the *“positivist tradition”*, which declares that the State (or the “intellectual elite”) should be responsible of taking all decisions. In this context, it was noticed that Citizen Participation appeared very incipiently developed, and that investors and the real estate agents decides future land use without participation processes. For instance, the restructuring of the agriculture to intensive production; to industrial farming or to forest activities are processes usually conducted without environmental assessment. This situation was also expressed by rural municipalities' interviewees.

The role of the market

On the other hand, from the Ministry of Public Works and the Ministry of Housing and Urban Development it was also accepted the important role the market has in promoting opportunities and incentives for land use change in those places whose natural features are

unsuitable for investment. The concept of *“Innovative Development Programs”* was explained whenever the market addressed technology and innovation to make fruitful investments where natural limitations impede it. For instance, innovative agriculture programs in desert lands. In this context, land-use change restrictions could not be favorable for such developing programs.

Nevertheless, private sectors along with academics and the civil society interviewees, it was agreed on that it is usually seen that every Ministry has different visions and proposals for land-use, thus plans and programs not always point in the same direction nor share same objectives. Hence, projects overlap occurs, and therefore ineffective resources handling; and as consequence unproductive land-use. *“The challenge is to reach coordination”* stated an academic researcher and consultant: *“A coordinated territorial vision between and within governmental agencies involving also an organized 3rd. sector: the citizens, which eventually should develop “accountability” practices”*. In this scenario, decision makers are accountable to the citizens when the firsts are obliged to inform the people about the decision maker's (past or future) actions and decisions, to justify them, and to be punished in the case of eventual misconduct (Schedler 1999).

Rural development

In order to manage and promote rural development without confronting urban development, it raised the idea of the need of a Framework Law, for organising rural land-use regulations, and also a corresponding governing body; since it is in cities where most of the population resides, and that cities are expanding without *“considering carrying capacities”* of the land. This situation can be explained with numbers. According to agriculture researcher, in Chile there is scaring inhabitable land, in comparison to the whole surface of the country: From a total continental surface of 749.000 km², most of this area is uninhabitable; where you can slide, freeze or fry (Astaburuaga G. 2004). Therefore, the areas suitable for human habitation are roughly equal to the potentially arable land – which scarcely reaches 4.25 millions of ha (< 6% of the total area).

The result is that Chile have a high actual population density (3.7 habitants per hectare), and this high density is found in larger cities located in central valleys where better agricultural lands lay.

Asked about who should assume the challenges for improving rural development, the answer pointed out to the Ministry of Agriculture. A suggestion mentioned was to develop proper rural land use planning instruments. For instance, land use change guidelines, which may be compulsory to fulfil before issuing land-use change authorizations. Investors and real state agents should adapt their needs to prior restrictions set to be fulfilled.

Agriculture protection?

On a different topic, it was of interest to pay attention to a restraint found in language related to agriculture and land use. For instance, there is a belief that agriculture in Chile must be “protected”. This can be observed reading the labels of several divisions at the Agriculture and Livestock Service of the Ministry of Agriculture (MA), such as Agriculture Protection, Livestock Protection and Renewable Natural Resources Protection. Thus, etymologically speaking, it is accepted that agriculture claims for defense and protection.

Further challenges

Improving research appeared as further, and to conduct interdisciplinary studies. It was also suggested the creation of an “Ombudsman”, as defender of future generations interests. On a technical aspect, there was a proposal of modifying the General Law of Urbanism and Construction –the Rector Law of land-use planning in Chile. This modification suggested the definitive incorporation of the Strategic Environmental Assessment (SEA) in Land-Use Planning Instruments, as an attempt to consider synergic effects of interventions in the land in decision making.

4.1.2 SUSTAINABLE DEVELOPMENT INDICATORS AND LAND-USE: CONCEPTION, KEY DRIVERS AND THE FEASIBILITY AND POTENTIAL ROLE OF THE SDI

As a main impression of the interviews, it can be concluded that the concept of SD, although frequently used, is not well understood. The same impression shared academics when consulted about it.

Understanding and incorporating the concept

At institution levels, most of consulted organizations and agencies informed that there were at least some ideas related to SD within the guiding principles of each organization; i.e. the Native Forest Law (recently came into force), the Policy of Organic Agriculture of the MA and the new Urban Agenda of the MHU. According to an interviewee from MHU, this Agenda includes Sustainability, Equity and Competitively approaches within its guidelines. In addition, there are some isolated efforts within this agenda, such as urban localization allowances, but these are recognised as punctual programs and do not belong to a main institutional framework.

In order to move towards SD, some key drivers were identified in the interviews. The following list summarized the ones shared by most of the interviewees:

- Decision makers should shift some current strategies related to land use, and look forward to developing strategies for "closing the achievement gap" in this matter.
- Transparency is imperative, in decision making and policies creation; with long-term vision and citizen participation. A voice from the National Environmental Agency stated that it is essential to *"Stop conceiving the regulations and changes as obstacles instead as improvements or opportunities to make things better."*

- Strengthen the Environmental Impact Assessment System (EIAS) and the citizen participation (CP), specially the section that regulates land-use change; since these changes are carried out with few requirements, mostly administrative procedures, and without CP.

Reaching Sustainable Land Use

It is widely accepted that the territory in Chile is divided according to politic-administrative regions that have their nests in the Military Government. Hence, the above mentioned divisions respond to a military strategy, not to a territory criteria based for example on natural modules of watersheds (Chile is composed of several watersheds in sequence from north to south).

According to a public service employee, land in Chile is considered particularly fragile, meaning that Chile is a very long and thin country, it is often said that land hangs from the mountains to the sea. Therefore, in order to reach Sustainable Land-use, the first step identified was to count with a National Policy of Land-Use. It was also agreed within the public agencies that in order to reach sustainable land-use, it is essential to recognize the environmental services of the territory, and with this input to reduce the gap between the market value and the real value of the land.

Asked if land can be managed in a sustainable way in Chile, with a few exceptions the answer was affirmative. Nevertheless, to reach sustainability depends on political commitment and in the development of a transectorial collective work. Sustainable land-use is recognized as an immediate need. According an interviewee from a rural municipality, *“land-use change can finish up with most of the remaining good quality land for agriculture, within a few years”*.

Land as a sustainability element

As main finding, it can be stated that in Chile, there are not SDI's in public institutions or private organizations' frameworks, neither in general terms nor as SDI for land-use. This may have an explanation in that SDI's are not compulsories or have a legal framework. Nevertheless, it is accepted that SDI would be useful, to set goals and verify the degree to which objectives have been fulfilled, to picture trends of retreats and progresses. SDI's would also enable to look at the land as a sustainability element and to develop a strategic view of the territory. Hence, the perception of this instrument as a management tool seems to be miles away, as a result of the scarce research and interest in this subject.

Academic interviewees showed more knowledge about this issue, and realize the importance of developing SDI and applying them for decision-making. A Senior Professor and independent consultant suggested the idea of including them within the TPI and making them part of other Municipal Management Plans and Ordinances.

4.1.3 LAND-USE PROBLEMS, CONFLICTS AND POWER ANALYSIS: STAKEHOLDER ANALYSIS

In Chile, the policy of "*Contingency*" is widely accepted. It can be observed that goals of the actual administration - at general and local level - point out to solve immediate needs and to usually plan in short terms. In this scenario it is possible to identify differences between Government and State Policies; hence land use can be identified within a Government Policy with usually a short term vision. Nowadays, long-term planning – for any subject – barely is conceived neither to 10 years nor to 20 or 50 years. For instance, it is often seen that public programs and policies that seek for improvements in environmental issues do not persevere, since whenever there are local or central elections, important decision makers leave their positions; thus current administration not always continues what the previous one started.

Conflicts and the power of land

The interaction between the people and the land often generate socio-environmental problems which result in the loss of public spaces and the loss of cultural identities. For instance there are historical conflicts between public services with ethnic population, about the stewardship of the land and water rights. Some conflicts are related to the poverty, since expropriation and relocation of human settlements usually affect more negatively to the more needed people and ethnic groups.

As notable finding, it can be mentioned that all interviewees agreed in that land is synonymous of power, hence it is also conceived that land is the most important resources supplier, where most of the production relies, and following Homer-Dixon, the scarcity of this resource may generate conflict. The roots of these conflicts can be identified in the above mentioned short term planning vision for land. For instance, the country lacks of an Agenda of Sustainability, therefore, decisions for future land-use does not follow sustainability goals.

According to a lawyer, *“It is a duty of the State to promote sustainability in all facets of the Central and Local Administration, because as Subject of International Law Person, the State should accomplish all International Agreements and Compromises”*. Some of these commitments talk about sustainability and hence they must be undertaken.

Land ownership and the Generational change-over

In Chile, as in many countries, land is not owned precisely by younger generations; on contrary, at present former generations with land tenure determine land future ownership. A reflection from the youngest interviewees talked about that for currently land owners, sustainability concept is not of their concerns.

Moreover, land ownership is supported by the Property Law, defined in the Constitution of Chile. According to our “Magna Charta”, the right of ownership over all classes of corporeal and incorporeal property specifies (Republic of Chile 1980):

“Only the law may establish the manner to acquire property and to use, enjoy and dispose of it, and the limitations and obligations derived from its social function. Said function includes all the requirements of the Nation's general interests, the national security, public use and health, and the conservation of the environmental patrimony.”

On the other hand, it was widely accepted that there is not a single actor with the power of changing or improving things. Citizens were identified as able to make the changes. There was also consensus about that individual responsibility with future generations also exist.

Concerns and Conclusions

Land use and land-use change, as well as the land-use planning are subjects of discussion and research, usually for what is so-called “*the intellectual elite*”. There is lack of conscience about the immense impact of continuing growing cities with no integral planning strategies. Nevertheless, there are new approaches in the so-called “Watershed Integrated Management” and “Strategic Environmental Assessment”. Both are strategies which points out to identify relationships between all elements and their interactions, functions and services. This mainframe would consider land not only as rural or urban but also buffer or contact zones, vulnerable areas, among other characteristics of the land.

Another concern identified is related to the desertification, since it is a fact that deserts are moving ahead the national territory with increasingly droughts and erosion problems. Associated with these situations there are degraded lands, which are believed to be lost resources or death lands, therefore they become misused lands. Cities are also subjects of a

concern, since in cities most of the population of the country resides at (80% of the population approximate).

In conclusion, it can be seen that at least formally, there is not a will of moving forward sustainable land-use. There are individual attempts, but there is still a large road for making of these marginal efforts a collective approach, which seek to build a country through a consolidated strategic view.

4.2 SUSTAINABLE DEVELOPMENT INDICATORS SET UP

Indicators set up will be developed according to the framework introduced in chapter 2, using as an analysis tool the MAIN tetra multidimensional framework proposed, and combining it with the conceptual model showed in chapter 1 (Figure 1). According to this conceptual model, land is understood as a system composed by three main aspects showed in figure 10: Land characteristics, land ownership and land management.

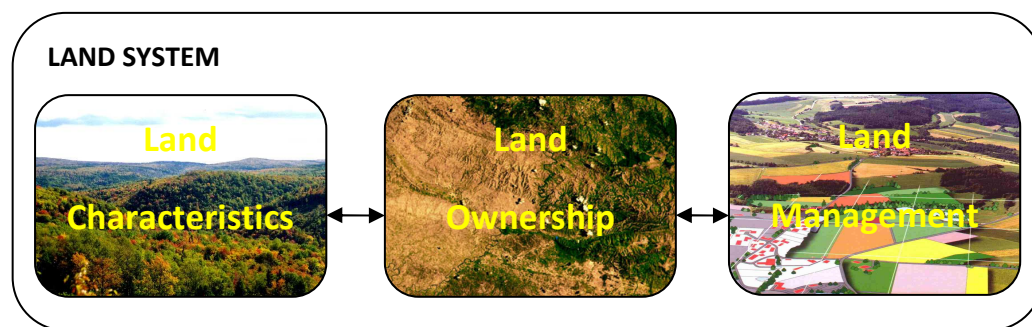


Figure 10: Land system

In this figure, land is described as a system composed of subsystems interrelated to each other and to the human society system, as explained in Chapter 1. The figure expresses the interdependence between people and the surrounding world. As result, the 4x3 matrix showed in figure 2 will be used to come with a first approach to define SDI for land use. The resulting 12 boxes of this approach are shown in table 2.

Table 3: SDI set up matrix

	Land Ownership	Land Management	Land Characteristics
Mind	This section points out to characterize interests and/or worldviews of land owners; and also under which perspective land tenure is handled. This may help to understand why some decisions are taken.	This part shows management strategies and guidelines orientation, objectives to pursue and practices conducted for land use and land use planning.	Minds can be influenced by land characteristics, through perception and appreciation of natural features of a territory; such as views, ecosystem services and biodiversity preservation awareness.
Artifacts	Shows infrastructure and systems present in a territory set up by land owners, ranging from basic wells to complex buildings, passing through small scale interventions in landscapes to fully urbanized areas and agroecosystems, looking forward to reflecting the impact of these artifacts in land use change.	This section provides information about the man-made materials, physical structures, land price evolution, etc. It points to describe land use planning instruments, which guides future interventions, goods and services exploitation, among others.	Since land characteristics also deals with artificial features of the land, this section points out to show evolution of natural/artificial characteristics of the land, such as urban sprawl, green areas development or natural protected areas adding up.
Institutions	Describe the social structures behind the land tenure connections; the levels and forms of participation and relationships between private and public land owners.	This part is related to the organizational and structural net of the land managers, the strategies and aims of the institutions responsible for land use and land use change; the formal and informal organizations in charge of the decisions.	This section is specific for land use institutions responsible of describing, producing and updating information about land characteristics; the involvement level these institutions have, the relevance of their work to support decision makers and policies formulations.
Nature	Description of the natural features of land, focusing on privatization of public areas phenomena, and the agroecosystems development, especially those involving large amounts of territory whose land owner has changed.	This section will be focused in management of natural space, considering the different land classifications set by official authorities and the evolution of the National Wild Protected Areas System.	Describes pre-disposing natural features of the territory, characteristics of the resources, and the evolution of natural assets, landscape and the resiliency.

The following step is to refine this approach according to availability and quality of information, in order to come out with a set of indicators that accomplish most of the characteristics described by Bossel (1999) and also narrowed to study area boundaries.

Nevertheless, before presenting the indicators, some analysis is required; regarding goals and purpose of the indicators, data availability and quality, valuation criteria, among other considerations. This analysis is presented in following section.

4.3 AVAILABILITY, ADEQUACY AND QUALITY OF INFORMATION ANALYSIS

Land is a complex system, and developing a method for finding a suitable set of indicators for such a complex system must first start by trying to get the aim of this task, the consumers of these instruments and further applications of it. In this quest, it is possible to find a large number of potential indicator candidates, but it must always keep in mind that the set of indicators must be relatively compact if it is to be of any value (Bossel 1999).

In Santiago, at least 10 different public agencies can be identified as collecting data relevant to the construction of SDI's. Table 4 (Keiner, Zegras et al. 2004) distinguishes between how the data is typically presented (i.e. spatial scale of aggregation) and how it is generally made accessible by others. As can be seen, data is not always collected at the same spatial scale and/or not always geo-coded. This situation presents a challenge to the development of scalable and scale-consistent indicators.

Table 4: Data sources for SDI's in Santiago. Source: Adapted from Keiner et al. 2004

Source	Type of data	Geographic level	Access
INE	<ul style="list-style-type: none"> - Population - Education levels - Socioeconomic conditions - Building construction permits 	National aggregated data, regional, provincial, municipal, block	Detailed at municipal and household level Project information available at municipal level Online data available
MIDEPLAN	<ul style="list-style-type: none"> - Socioeconomic survey (CASEN survey) - Household spending - Housing dimensions 	Municipal level	Municipal level
SII	<ul style="list-style-type: none"> - Real estate activities (residential, commercial, industrial, etc.) 	Regional and municipal	Limited access due to confidentiality
CONAMA	<ul style="list-style-type: none"> - General data on environmental conditions, protected areas, land use characterizations, etc. 	National and regional	General and specific data and research Online data available
ASRM	<ul style="list-style-type: none"> - Air pollution data, noise, illegal dumping 	Regional, monitoring sites	Hourly/daily pollution levels Location of dumping
MHU	<ul style="list-style-type: none"> - Constructed/approved public housing - Urban areas dimension 	Regional, lot, municipal	Available at municipalities and at the Urban Observatory
MOP	<ul style="list-style-type: none"> - Infrastructure projects and investment - Water rights 	Regional and per project	Report internal documents, online information and some accessible per request
SAG	<ul style="list-style-type: none"> - Agricultural land use - Land use changes authorization 	Regional	Reports and web page
Universities and research centers	<ul style="list-style-type: none"> - Specific reports on land quality, GIS, maps, databases, etc 	It depends on the report	Private information
Private companies	<ul style="list-style-type: none"> - Waste disposal - Land ownership 	It depends on the information	Private information

Notes: INE : National Institute of Statistics
MIDEPLAN : Ministry of Planning
SII : Internal Tax Office
CONAMA : National Environmental Agency
ASRM : Sanitary Authority Agency
MHU : Ministry of Housing and Urban Development
MOP : Ministry of Public Works
SAG : Agricultural and Livestock Agency

In order to grasp most of the information about the land system gathered through research, and also through information provided by interviews, some questions need to be answered, before moving into next step of indicators set up and selection. This analysis is summarized in table 5:

Table 5: Prior concerns for SDI selection

<i>What is the purpose of the indicators?</i>	To monitor land development trends in Santiago and to help evaluate the success of future land use planning policies in achieving their desired outcomes, reporting on progress towards sustainable development.
<i>Who can be interested in the results?</i>	Further assessments and key messages are targeted mainly at policy makers, who could use the outcomes to inform progress with their policies. Researchers and experts can use the indicators as a tool for their own work by using the framework and methodologies to do their own analysis. They can also look at the methodology and set critically, give feedback and contributing to future research.
<i>What can be done with the results?</i>	The information obtained from indicators can be used for contributing to planning and policy creation, support land use policy priorities, encourage debate and spark interest in sustainability issues.
<i>What is needed to be measured? What are the features of the phenomena that will be measured?</i>	Sustainability of land use needs to be measured in some extent; by considering land as a system with own features, owned by someone and managed through certain constraints.
<i>What are the information sources?</i>	Most information sources rely on public agencies databases and researches. At the academic level there are also information sources, although that can be considered private information and obtaining it might be difficult.

4.4 SDI FOR LAND USE IN SANTIAGO, CHILE

From table 2 each one of the SD dimensions will be analyzed further on, and from this exercise, the first indicators will come into view. Following tables present the indicators proposed for each dimension of the MAIN tetra framework, and the purpose of the indicator as well taking into account the analysis performed for prior concerns presented in table 4. Tables 6 to 9 show this work, in an effort to set up SDI one step ahead. On the other hand, as an attempt to connect these suggested indicators with the interviews, is also mentioned current data availability and ownership.

Table 6: SDI for the Mind Dimension

	Indicator	Purpose	Data availability
Land Ownership	Public – Private land use research programs	To show a rate for research program conducted by public vs. private land owners	Information related to research programs conducted by public agencies is available but disperse. Private research information is not available.
Land Management	Land use planning instruments with – without Stakeholders participation	To identify level of involvement for communities granted by public agencies for land use planning instruments development	Public information should be available mostly in municipalities, in particular records of public participation processes.
	% regional investment/ land recovery program	To show a yearly trend for land recovery programs investments; and the percentage they represent in the total regional budget; been these programs for reforestation, soil recovery, desertification, etc.	Since an Environmental Impact Assessment must be conducted for each land recovery program and also for Land use change, this information must be available within the Environmental Agency records.
	Approved land use change applications	To identify trends of urbanization or industrialization processes.	
	% Private – Public agricultural holding	To show the evolution of agricultural production for private and public land	Agricultural holding information is available at the Farming and Livestock Agency.
Land Characteristics	Identified Natural hot spots	Landscapes and wildlife recognition and appreciation through the identification of natural hot spots.	Natural Hot Spots identifications are part of the Actions for Nature Protection Program of the National Environmental Agency.

Table 7: SDI for the Artifact Dimension

	Indicator	Purpose	Data availability
Land Ownership	Public - Private expends in land recovery programs or green areas development	To compare public and private investment for developing land recovery programs or similar ones.	Information related to investments is not all available; further research is needed.
Land Management	Degree of urbanization of Santiago	To show the percentage of land covers that urbanized every year	Urban sprawl information is monitored by the Ministry of Housing and Urban Development; percentages of urbanized surfaces of the city, number of urbanization plans, and land prices information are available - but disperse - also at the Ministry of Agriculture.
	New housing units in urban/rural areas	To compare urban housing development with rural housing.	
	Degree of concentration of population in urban – rural areas	To see trends in urban - rural density population per year	
	Ratio of land consumption to population growth	To see percentages of population increase along with the percentage of increased in developed land, every 10 years	
	Income fraction from agriculture, forestry and tourism	To show the evolution of the income fraction of these land uses	
	Total urbanization vs. agricultural plans per year – Public and Private ones	To compare development goals of the region, for public projects and private ones separately.	
	Indicator of Urban – Rural Land Prices	To show rise (or fall) of land price, according to land use and the intensive uses like industry or housing.	
	Employment in urban/ rural areas	To compare working forces in urban and rural areas and its evolution	
Land Characteristics	Urban green areas/ Natural green areas	To see how urban green areas have been developed in comparison with natural areas preservation	Information related to urban and natural areas, along with impermeability percentages can be found in records of the Environmental Agencies and the Farming and Livestock Agency.
	Square meters of land conversion from natural state to be further developed	To show habitat alteration, from natural state to artificial state; for example, road network density, change in land cover, etc.	
	Surface impermeability rate due to urbanization	The average sum of specific impermeability rates for different land uses areas	

Table 8: SDI for the Institution Dimension

	Indicator	Purpose	Data availability
Land Ownership	Percent of organizations under Good Agricultural Practices Programs	To describe social organizations evolution for good practices programs	Public information available mostly in municipalities and in the Farming and Livestock Agency.
	Urban settlements areas authorized vs. unauthorized ones	To show patterns of unauthorized land use for housing	
	Total land owners participating in public consulting committees	To show the representation of land owners in land use planning programs	
Land Management	Number of institutions embracing the Integrated Watershed Management Strategy	To see inclusion trends for this policy in concrete land use managers for plans and programs	Public information to gather, since it may be under development or it can be diffuse among public agencies. Further research to gather most of this information and is required.
	Percentage of forest area (native and commercial forest) that is under regulation	To show which fragment of the total forest area is under regulation and the evolution of this yearly	
	Inspections field visits by public agencies, assuring land use standards fulfillment	To show evolution of the role public services have as inspectors.	
	Percent of government projects that have to be changed or abandoned	To see effectiveness in public projects related to land recovery or agriculture development	
	Degree of decentralized responsibility initiatives	Innovative decentralized programs introduced and completed by the government	
Land Characteristics	Research products and information (reports, Aerial Photos, Satellite Images, Maps, database, etc.) available for public reference.	To show trends on public information generation for land use to support research and decision making and policies formulations.	This information is only partially available, further research and update is required.

Table 9: SDI for the Nature Dimension

	Indicator	Purpose	Data availability
Land Ownership	Public areas privatized per year and as fraction of the total remaining public areas	To see relation between private and public ownership and its evolution in time.	Public information available at the Environmental Agency, although it might need to be updated
Land Management	Square meters of land with no vegetation cover	To show evolution of this part of the territory and assess policies relevance for this subject	Public information available at the Environmental Agency, although it might need to be updated. Further research to update, gather and summarize this information is needed.
	Rate of increase of sealed surfaces	To identify proportion of protected lands in comparison with the total territory	
	Environmental Susceptible Areas / Total land area	To see the ratio of fragile ecosystems identified vs. total land area	
	Forest area as a percent of land area	To describe the percentage of forest area in Santiago	
	Arable land surface per inhabitant	To show the area that can be used for agriculture activities per inhabitants	
Land Characteristics	Percentage of arable land loss	To show soil loss trends every year	Public information available at the Environmental Agency, the Farming and Livestock Agency and at the private organization the Natural Resources Research Center. Most of this information is not up to date and therefore further research is needed to gather and link the available data.
	Land surface affected by desertification	To show desertification evolution	
	Primary forests recover / Total primary forest remaining	To show rate of primary forest recovery (or loss)	
	Vegetation patches quantity and interpatch zones	To show evolution of attrition and fragmentation phenomena and the degree of species isolation in the study area	

Concluding the cross analysis for indicators set up, following step will consist in presenting a final list with the indicators, and the proposed time frame for each one, according to available of information required to fill each indicator.

Table 10: Final list of SDI for land use in Santiago, Chile

Dimension	Proposed Indicator	Proposed Time frame
MIND Dimension	1. Public – Private land use research programs	Once per year
	2. Land use planning instruments with – without stakeholders participation	Once per year
	3. % regional investment/ land recovery program	Every 5 years
	4. Approved land use change applications	Once per year
	5. % Private – Public agricultural holding	Every 5 years
	6. Identified Natural hot spots	Every 2 years
ARTIFACT Dimension	7. Public - Private expends in land recovery programs or green areas development	Every 2 years
	8. Degree of urbanization of Santiago	Every 5 years
	9. New housing units in urban/rural areas	Once per year
	10. Degree of concentration of population in urban – rural areas	Every 5 years
	11. Ratio of land consumption to population growth	Every 5 years
	12. Income fraction from agriculture, forestry and tourism	Once per year
	13. Total urbanization vs. agricultural plans – Public and Private ones	Once per year
	14. Indicator of Urban – Rural Land Prices	Once per year
	15. Employment in urban/ rural areas	Every 2 years
	16. Urban green areas/ Natural green areas	Every 5 years
	17. Square meters of land conversion from natural state to be further developed	Every 5 years
	18. Surface impermeability rate due to urbanization	Every 5 years
INSTITUTION Dimension	19. Percent of organizations under Good Agricultural Practices Programs	Once per year
	20. Urban settlements areas authorized vs. unauthorized ones	Every 2 years
	21. Total land owners participating in public consulting committees	Every 2 years
	22. Number of institutions embracing the Integrated Watershed Management Strategy	Every 5 years
	23. Percentage of forest area (native and commercial forest) under regulation	Every 5 years
	24. Inspections field visits by public agencies, assuring land use standards fulfillment	Once per year
	25. Percent of government projects that have to be changed or abandoned	Once per year
	26. Degree of decentralized responsibility initiatives	Every 2 years
	27. Research products and information available for public reference.	Once per year
NATURE Dimension	28. Public areas privatized as fraction of total remaining public areas	Once per year
	29. Square meters of land with no vegetation cover	Every 5 years
	30. Rate of increase of sealed surfaces	Every 5 years
	31. Environmental Susceptible Areas / Total land area	Every 5 years
	32. Forest area as a percent of land area	Every 5 years
	33. Arable land surface per inhabitant	Every 5 years
	34. Percentage of arable land loss per year	Once per year
	35. Land surface affected by desertification	Every 5 years
	36. Primary forests recover / Total primary forest remaining	Every 5 years
	37. Vegetation patches quantity and interpatch zones	Every 5 years

Time frame proposed for each indicator corresponds to the time horizon that is feasible to measure at reasonable costs. Natural dimension indicators are related to most expensive and sophisticated measurement techniques, hence time frame proposed for most of them

are every 5 years. In addition, natural features dynamic of change of the land system are expected to be at lower extent than institutional or artifact changes. Institution and artifact indicators can be measured mostly by gathering information that is produced every year for economic/social/institutional indicators. These indicators stand for an ongoing assessment, since they respond to change and uncertainty of social and economic features of the land system. Proposed indicators to be measured every two years correspond to those whose data collection and update seems more uncertain and specific research is needed in order to gather information for constructing them.

Comparing the proposed indicators with the Bellagio Principles for Assessment (1997) listed in table 1, it can be concluded that the SDI's fulfill many of the criteria for assessment of progress toward sustainable development for land use in Santiago:

- SDI's proposed are guided by a clear vision of SD (Brundtland's definition), although the goals that define a vision for sustainable land use is required
- Indicators include a review of the whole land system and its parts, consider a multidimensional approach, the state of each dimension and proposed time frames for further assessing rates of change
- Consider equity and disparity assessment elements, focusing on urban-rural development and pressure over the land resources
- Defines as study area a region (Metropolitan Region), large enough to include local and regional impacts on the land system
- Current conditions can be assessed with the proposed SDI's but a retrospective analysis could be difficult to perform due to data availability and quality.
- Proposed indicators have a practical focus since they follow a framework that made indicators emerge naturally (tables 6 to 9), and indicators can also be further adjusted to the needs of a given locale or set of decision-makers
- A limited number of key issues (land system) for analysis and a limited number of indicators (37 indicators) are proposed.

- Regarding openness, the framework proposed is now well known, but it is accessible to all. Although data accessibility and uncertainties can be a drawback for indicators construction.
- Proposed indicators were designed looking forward to address the needs of further users and intended to be clear in language. Field work interviews aimed to achieve that target and to obtain some representation of key grass-roots, professional, technical and social groups to include diverse perspectives.
- Since land system is considered a dynamic system, proposed indicators look forward to represent changing trends – for the natural land features, land ownership and land management.
- Regarding the institutional capacity, proposed indicators do not assign responsibilities or provide ongoing support for decision-making processes. Looking forward conclusions from field work, it can be seen that first step for enhancing institutional capacity starts with understanding the concept of sustainability and including it within public agendas.

Although the proposed indicators are well structured and follow a logical framework, it can be acknowledged that for many indicators the picture is still incomplete in the sense that for example, some assumptions and uncertainties in data and interpretation are sometimes weakly defined. Nevertheless, the proposed indicators does however present a list of SDI for land use from which further studies can state as starting point to develop indicator initiatives. For instance, efforts to identify interlinkages and issues of aggregation into for example indices can be further considered.

It must also be considered that currently in Chile SDI's are not part of any public strategy or agenda. Therefore, as starting point the list of indicators can be useful to start a groundswell of awareness regarding sustainable indicators and their potential use. Although some headway has been made, generally speaking there is still a lack of awareness at most levels of government and private sector as well. A lot of work still has to be done to convince institutions of the importance of indicators in general and sustainable indicators in particular.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

*"WE ARE LIVING IN AN INTERMINABLE SUCCESSION
OF ABSURDITIES IMPOSED BY THE MYOPIC LOGIC
OF SHORT-TERM THINKING."*

Jacques-Yves Cousteau, 1992

5.1 CONCLUSIONS

Land-use activities have transformed a large proportion of the nation's land surface, especially in larger cities and their surrounding areas. Rapid growth experienced in Chile in the past decades has increased economic benefits at the expense of losses in environmental quality and land resources availability.

Patterns of land use and land cover are changing in Chile. The situation shows urban sprawl, deforestation, soil erosion and pollution, and intensive agricultural activities, occupying more land areas in an attempt to increase economic well-being by increasing industrial production, housing and infrastructure development.

Land-use and land-use planning are issues recently incorporated in the Chilean public agenda and such approaches date from few years ago. Thus, in Chile, land-use can be considered as a recent concern, although the urban visage of land has long record. This situation can be observed with the strong urban connotation of land still present in the country.

The work presented in this report was conducted with the objective of achieving a closer perspective regarding land-use in Santiago, one of the Chilean most important cities. This study also concludes that the land system in Santiago is not achieving progress toward sustainable development. A necessary condition for sustainability is that processes and functions of natural land systems are supported, rather than disrupted, by feedbacks from society. Nevertheless, more research in this subject and proposed sustainable development indicators may help to the society to recognize the importance, benefits and consequences derived from the different land uses.

Natural systems assessments, such as land assessment, are an unavoidable part for land-use planning, management and decision-making. They constitute a key issue pertaining to sustainable land-use. In order to assess land-use sustainability, first at all, the processes that shape land-uses should be understood. Interdisciplinary work is required to undertake this task, bearing in mind society-nature interactions are the key processes, which historically have showed to be divergent from sustainability targets.

The pace and extent of human alterations of land resources are still not well grasped. Attempting to undertake these daunting problems requires a proper understanding of the sustainability concept, and the development of public policies to backup land use plans and programs according to an integrated standpoint. The concept of sustainability, and particularly of sustainable development, figure among the most ambiguous and controversial in the literature. After concluding field research, it can be stated that the different approaches, concept connotations and implications still remains.

On the other hand, urban sprawl and city expansion has become an environmental problematic issue. Hence, as many larger cities, Santiago has needed to expand its boundaries constantly and also the growth rhythm has been particularly high in the past 15 years. Among the facts that have enhanced this urban sprawl is the validity of the decree DL 3516 – Rustic Real Estates Law – which allows the subdivision of agricultural real estates in 5.000 square meters sets. Therefore, concerns about rural land planning exist. Policies establishment and promote programs for rural development are required in order to avoid project overlap, ineffective resources handling and unproductive land-uses. The challenge is to reach coordination between public agencies, ministries and municipalities as well.

In this context, institutions play an important role, since many land-use changes are due to ill-defined, weak institutional enforcement. There is an increasing concern about that pressure over natural resources needed to slow down and strategically long term planning is required. Consequently, there is an increasing need for well planned decision-making and

policy actions across multiple extents, considering different geographic scales, economical approaches, social dimensions, etc.

Developing and implementing regional (and national) land-use strategies that recognize both short and long term needs - thus planning pursuing land sustainability - will require cross-disciplinary research, collaboration and coordination between scientist, policy-makers and practitioners. In this context, sustainable land-use should be understood as the use of natural resources to produce goods and services in such a way that, over the long term, the natural resource base is not damaged, and that future human needs can be met.

Therefore, in order to reach sustainable land-use, the main step identified was to count with a National Policy of Land-Use and to recognize the environmental services of the territory, and with this input to reduce the gap between the market value and the real value of the land. Nevertheless, all above stated depend on political interest, will and commitment with this matter. Hence, decentralization policies play a vital role; by promoting regional development and let each region to visualize and plan their own territory, perhaps empowering even more their autonomy and supporting them with more financial resources and technical cooperation.

There is also an obvious need for good inventory data and statistics about land-use and land-use change at local, regional and national level. This information may constitute inputs for indicators at different geographical scales. Indicators, whether they are economic, social or environmental, constitute important tools, because many social, economic and environmental processes are not directly visible on the scales on which political decisions are taken, and indicators can provide this view when a proper set of indicators is available. Nevertheless, lack of data for some indicators can be an important signal in itself. In this way, an effective framework for SDI serves as a check template to be revisited from time-to-time in a test of current priorities.

For this report, in order to draw conclusion about land development trends - if they point to sustainability targets - plenty of data to fill and complete the indicators proposed will be needed. Nevertheless, the main outcome of this paper is, in broad terms, to bring into focus some issues that may deserve special attention at present and over the next years. Moreover, it is obvious that the availability of all that information for filling all the proposed indicators on a regular basis of time periods is not realistic, unless sustainable land use becomes part of a major public policy and the indicators are part of it.

Regarding the SDI proposed, although they are presented separately, many linkages can be drawn between them and single economical or social indicators. In this context, stakeholder participation is vital in order to construct sustainable development indicators and also to assess sustainability of land-use plans and programs, since involvement of the wider stakeholder community can provide and active learning arena for all those involved. The very nature of this issue requires it: land-use occurs in local places, where people reside, thus strategies to ameliorate the detrimental effects of land-use could use a common frame of reference for concerted actions. On the other hand, planning needs to be sensitive to the cultural values influencing natural landscapes in order to maintain traditional features of culture and society and also to avoid conflicts. For instance, urban–rural relationships play an important role in dynamics of land use. Resources from the countryside are crucial for all inhabitants, largely concentrated in cities. Growing cities and urban sprawl may jeopardize the countryside as it has been experienced in Santiago in the past decades. More concern should have decision-makers, besides considering the role of institutions should have looking forward sustainable of land systems.

Conflicts can be identified between natural and cultural assets on the one hand and industrialization and intensive forestry on the other; while agroecosystems specialization, intensification in agriculture as well as abandonment may conflict with amenity values of cultural landscapes. There is lack of conscience about the impact of continuing growing cities with no integral planning strategies. Nevertheless, there are new attempts to tackle these issues through some strategies which points out to identify relationships between all elements within the land system and their interactions, functions and services. These

strategies would consider land not only as rural or urban but also buffer or contact zones, vulnerable areas, among other characteristics of the land.

On a different topic, it can be concluded that public participation is a key element to successfully develop public policies and programs. Several lessons learnt from history have taught that biased land planning has led to several problems, which have been clearly hard to fix or to revert. Some of these problems have not been absent of controversies, social discontent and conflicts counting some cases with violence. The biggest achievement of participation process should then consist in generating commitments in further planning processes. Although full representation may not always be feasible or necessary, it is recommended that all interested stakeholders should be represented. The big challenge for reaching (or start approaching) sustainable land-use is to connect worlds currently apart, the politic-administrative system and planners' sphere with a world called local "everyday life space". Interviews conclusions reached agreement in that if planned and well performed, public participation can contribute to the design of policies better fitted according to the needs and priorities of those concerned.

Finally, according to the proposed conceptual model of this paper, land is understood as a system composed by three main aspects: Land characteristics, land ownership and land management. This complex system calls for developing a method to find a suitable set of indicators able to fulfill certain requirements and purposes, keeping in mind that the set of indicators must be relatively compact if it is to be of any value. The purpose of the SDI proposed accomplish with being able to report progress towards sustainable development, since all dimensions of sustainable development of the MAIN tetra model are considered. The information obtained from indicators can be used for contributing to planning and policy creation, support land use policy priorities, encourage debate and spark interest in sustainability issues.

5.2 RECOMMENDATIONS

The intended outcomes of further planning policies for land-use should point out to direct the majority of growth into the urban areas, and to limit growth in rural and natural resource areas; and also to promote rural development. Limiting residential expansion in rural and natural areas can be positive in order to preserve agricultural and natural resources, and maintain rural community character as much as possible.

In this context, some of the land-use proposed indicators intent to monitor land development trends in Santiago that support or undermine these outcomes. The goal should be to see if eventually, trends established will help decision-makers evaluate the success of their planning policies or programs in achieving their desired outcomes.

Also, if properly managed and with good and enough information, indicators can lead to supervise the good use of land resources, to appropriately locate productive activities, and to increase infrastructural and urban facilities for a more equitable development, as well as a more successful fight against poverty and marginalization, all currents unsolved problems in Santiago.

5.3 FURTHER STUDIES

There are possibilities to consider which may warrant additional strategies for further study upon the conclusion of this research. Once the SDI has been filled with the required information, further assessments and key messages are targeted mainly at policy makers, who could use the outcomes to inform progress, correct or update their policies. Researchers and experts can use the indicators as a tool for their own work by using the framework and methodologies to do their own analysis. They can also look at the methodology and set critically, give feedback and contributing to future research.

Land use sustainability needs to be measured in some extent; by considering land as a system with own features, owned by someone and managed through certain constraints. In order to conduct this assessment, information is required. Most information sources rely on public agencies databases and researches.

At academic level, there are also information sources, although that can be considered private information and obtaining might be difficult. In conclusion, it is interesting to develop further studies in this matter, gather all relevant information to fill the proposed indicators, observe the results and link them with economical, social, and/or environmental indicators. Also it can be necessary to check consistency and adequacy of the indicators as well.

CHAPTER VI

REFERENCES

"IT IS NOT HARD TO LEARN MORE.

WHAT IS HARD IS TO UNLEARN

WHEN YOU DISCOVER YOURSELF WRONG"

Martin H. Fischer, 1937

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APPENDIXES

APPENDIX I: STAKEHOLDER SELECTION AND INTERVIEW GUIDELINES

The interview involved five different groups of actors that deal with land-use in some extent.

- Public sector
- Private sector
- Politic sector
- Academic sector
- Civil society

A) Stakeholder selection

Considering the levels of involvement, participation and decision-making for land-use, the proposed groups of actors are:

Sector	Proposed Stakeholder
Public sector	Ministry of Agriculture Ministry of Housing and Urbanism Environmental agency Farming and agriculture agency Urban Observatory
Private sector	Consulting Firm Engineering or Architecture firm
Politic sector	Local governments - Municipalities Regional Counselors
Academic sector	Urban Studies School – Catholic University Agrarian Investigation Group
Civil society	Environmental NGOs Agriculture Research Groups

B) Interview Guidelines

The questions point out to identify the interviewee, his/her work position, role and responsibilities; major advantages/drawbacks/difficulties/challenges for current and future use of the land, level of understanding about SD, prospects and progresses of developing sustainable land-use, and main conflicts and discrepancies that might exist between stakeholders.

Interviewee identification

- Name
- Organization
- Description of education
- Work position
- Tasks and responsibilities
- Time have working in the organization
- Planning time to stay in the organization

1. Land-use decision-making

- a) What kind of studies/criteria are utilized before determine the future use of the land?
- b) Who participate in it? Who takes the decisions?
- c) What are the main advantages and drawbacks of this process?
- d) What limitations and acquiesces have you feel in your position, in terms of improving land-use and land-use change?
- e) What are the needs and challenges that must be faced in this matter?

2. SDI and Land-use

- a) What do you understand of SD? Is there a policy in your organization about SD?
- b) Are the policies, procedures and/or legislation related to land-use and land-use change appropriated and suitable for sustainability goals?
- c) Do you think land can be managed in a sustainable way? How would that be?
- d) What do you believe are the key drivers moving us towards sustainable development for land-use? What steps if any have you / your organization taken in this direction?
- e) What role would have SDI in Land-use? Are SDI applied for Land-use? Why are or are they not applied?
- f) Would it be recommendable to utilize SDI for Land-use? Why?
- g) How could SDI for Land-use be applied in the future?

3. Land-use problems, conflicts and power analysis

- a) Are the actual goals of the current administration seeking to reach sustainable development for land-use?
- b) With whom do you think it is important to work along in order to move forward sustainable development for land-use?
- c) Who has the power of changing or improving things?
- d) In your opinion what are the key barriers preventing organizations/decision-makers/industry moving towards sustainable development for land-use?
- e) How can these problems be avoided or solved?
- f) At present what are your major concerns about going down this issue?

4. Additional Information

- a. Who else would you recommend I contact?
- b. Is there any document I should read?
- c. Are there other sites I should visit?

APPENDIX II: INTERVIEWEES GENERAL CHARACTERISTICS

Sector	Name	Organization	Description of education	Work position	Tasks and responsibilities	Time have working in the organization	Planning time to stay in the organization
Public sector	Sergio León	Ministry of Housing and Urbanism – Urban Observatory Division MINVU	Geographer BSc in Rural Environmental Studies Master in Human Settlements and Environment	Urban Observatory Division Manager	Coordinator of the Observatory, gathering and updating of information, pre-analysis research	16 years	Indefinite
	Juan Fernández	Environmental Agency CONAMA	Bachelor in Education and Politic Sciences	Manager of the Education and Participation Division	Environmental Certificate Schools and Citizen Participation at the EIAS	16 years	Indefinite
	Mario Ahumada	Ministry of Agriculture - Agriculture and Livestock Service MINAG - SAG	Agronomist Master in Environmental and Sustainable Development	GIS Department Manager	Project Coordinator	10 years	Indefinite
	Jaime Iturriaga	Environmental Agency CONAMA	Geographer Master in Environment and Sustainable Development	Technical Coordinator National Strategy for Integrated Watershed Management	Coordinator of the National Strategy for Integrated Watershed Management	17 years	Indefinite
	Ana Huaico	Municipality of Maria Pinto	Geographer Expert in Renewable Energies	Director of Local Development Municipal Unit	Territorial Planning, Productive development, Environment studies and tourism	3 years	Indefinite
	Pablo Badenier	Ministry of Public Works – Secretary of Environmental and Territorial Affairs MOP – SEMAT	Marine Biologist Master in Public Policy	Executive Secretary of Environmental and Territorial Affairs	Environmental Impact of Public Infrastructure Works and Territorial Planning Infrastructure	8 months	2 more years
	Gladys Villamán	Municipality of El Bosque	Environmental Engineer	Local environmental and GIS Department	GIS analysis	3 months	Indefinite

Sector	Name	Organization	Description of education	Work position	Tasks and responsibilities	Time have working in the organization	Planning time to stay in the organization
Private sector	Enrique Vial	Independent Consultant	Architect MIT Master of City Planning	Independent Consultant	Consulting Services in Territorial Planning Instruments	20 years	Indefinite
	José Villalobos	ECOSYNERGY	Industrial Engineering	Sales Marketing Advertising	Consulting Services in Odour Control Technologies - Offensive Odour Removal Measures-	4 years	Indefinite
	Felipe Marchant	Independent Consultant	Environmental Engineer	Risk Prevention Expert	Solid waste management and risk prevention assessment	5 years	Indefinite
	Mauricio González	Independent Consultant	Civil Engineer MSc	Independent Consultant	Consulting Services in Local Management and Solid waste management	2 years	Indefinite
	Erick Toledo	BESALCO S.A	Civil Works Engineer	Civil Engineer	Execution of structural civil engineering projects and works	5 years	Indefinite
	Marcela Fernández	Independent Consultant	Lawyer Master in Law Sciences Stanford University Citizen Participation Expert	Independent Consultant Services	International Environmental Law, College Professor, Environmental Policies	16 years	Indefinite
Politic sector	Rafael Asenjo	Centre of Studies for the Development - CED	Lawyer	Independent Consultant	Consulting Services in Environmental Policies and Laws	7 years	Indefinite

Sector	Name	Organization	Description of education	Work position	Tasks and responsibilities	Time have working in the organization	Planning time to stay in the organization
Academic sector	Pablo Honeyman	OTERRA Academic Research Institute – University Mayor	Forestry Engineer	Research Department Coordinator	Consulting and research and development projects	5 years	Indefinite
	Rodrigo Arrué	University Andrés Bello	Geographer Master in Human Settlements and Environment	Professor	Coordinator of the “National System of Environmental Certification of Schools”	2 years	3 more years
	Patricio Gross	Catholic University of Chile Senior Professor and Independent Consultant	Architect	Senior Professor and Independent Consultant - Former President of the Chilean Architecture College	Professor, Associate Consultant and Manager of Aepsilon Consulting Firm Planning Instruments	35 years	Indefinite
Civil society	Giovanna Medina	CAS Corporación Ambiental del Sur	Architect Master in Human Settlements and Environment	Associate Consultant	Database analysis and Local Management Programmes	2 years	Indefinite
	Pedro Lira	Agrarian Investigation Group GIA	Geographer	Associate Consultant	Consulting Services Academic Professor	27 years	Indefinite
	Ximena Vera	Social Nets Analysis Society of Chile ARSCHILE	Sociologist	Associate Consultant	Consulting Services	4 years	Indefinite