Report

"A Review of Integrated Approaches for Landscape Monitoring"

Report prepared in the framework of the Work Program of the Council of Europe for the implementation of the European Landscape Convention

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Introduction

There is a consensus that landscape is a common good [1], very important for biodiversity and people's well-being and also an essential resource for tourism [2]. This makes it imperative to inform policymakers about changes in the physical quality of landscapes but also about how landscape perceptions and meanings change over time [3]. Such monitoring is an obligation for all States Parties to the European Landscape Convention of the Council of Europe.

The latter states clearly in Article 6C of the European Landscape Convention [4], that each party:

- analyses their (landscape) characteristics and the forces and pressures transforming them,
- takes note of changes.

There is a variety of landscape definitions,[1] ranging from ecologically oriented definitions [5] through definitions that highlight the geomorphological land forms of a region [6] to definitions that highlight the artistic [7] or scenic aspects of landscapes [8] and those that focus on the interaction between people, culture and the biotic and physical underpinnings of landscapes [9], [10]. Amongst all this variation, it is a merit of the European Landscape Convention that there is a sound definition of landscape, which is broadly agreed upon and highlights the natural, social, visual and experiential aspects of landscapes. The Convention defines landscape as 'an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors' ([4] (Council of Europe, European Landscape Convention, 2000, Article 1a).

Fig. 1: Landscapes are shaped by the interaction of nature and people – the Domleschg valley in Switzerland (photo: F. Wartmann)

This report is based on the European Landscape Convention's definition of landscape that highlights how landscapes consist of physical elements such as mountains, lakes, roads or villages, which are perceived by and shaped by people. Landscape is thus essentially "about the relationship between people and place" [10].

1. A number of definitions of landscape have been reported in the literature. Turner et al. (2001) give a comprehensive overview.

The Recommendation of the Committee of Ministers of the Council of Europe on the Guidelines for the implementation of the European Landscape Convention, (CM/Rec (2008)3, Appendix 1, 10; II.3.3) considers landscape observatories, centres or institutes as important structures to monitor landscape change, "and to facilitate the collection, production and exchange of information and study protocols between states and local communities". Consequently, there are several landscape observatories, centres or institutes in Europe, with most of them referring to the European Landscape Convention and describing themselves as an important implementing body of the Convention. Some of these structures are public and others have been developed by non-governmental organisations.

A typical example of a landscape observatory in the sense of the Convention is the Swiss landscape monitoring programme (Landschaftsbeobachtung Schweiz or LABES), in which the authors of this report are involved. It explicitly measures both physical and perceived landscape characteristics [11]. LABES is officially integrated into governmental monitoring activities and is constantly evaluated from a scientific point of view.

This report therefore has the following objectives.

- to provide an overview of landscape observatories and monitoring initiatives (mostly focused on Europe, with some particularly noteworthy examples from elsewhere) that aim to monitor (a) the change in the physical and cultural-historical components of landscapes and (b) the perception of landscapes by people. Special attention will be given to approaches that cover both aspects, as they are key to fulfilling the monitoring requirements of the Convention;
- to identify the prerequisites of such integrated approaches (theories, data requirements and applicability);
- to prepare a set of criteria for successful implementation for the parties of the Convention, allowing them to initiate regionally-adapted integrated monitoring programmes that overcome the dichotomy between physical and perceived landscapes.

In this report the terms "landscape monitoring programme" and landscape observatory, centres or institutes are indifferently used. It is, however, acknowledged, that the term observatory has generally a broader meaning than monitoring and implies a participatory and even action-oriented component that goes beyond the classical policy evaluation of monitoring. Furthermore, the examples and case studies covered in this report form a set of approaches carefully selected to show major types and trends and to derive recommendations, but they do not by any means include all the approaches that exist in Europe.

1. Theoretical background

Some theories and concepts on the relations between populations and landscape will be presented below, ranging from concepts of space and place (section 1.1) through landscape perception and interpretation (section 1.2) to processes of negotiating landscapes and landscape change (section 1.3).

1.1. Landscape as an integration of the concepts of space and place

The comprehensive definition of landscape in the European Landscape Convention is compatible with

the concept of space and place that has been advocated by various scholars, (e.g., [12] Hunziker, Buchecker and Hartig). The space component concerns biotic and abiotic elements of landscapes (natural and man-made) and builds an essential basis for the way people perceive and interact with landscapes [9]. The place component emphasises the individual and cultural connections of people with landscapes and particular places [13]-[17]. The interaction between these two components of (1) space as the environmental configuration and physical characteristics of landscape and (2) cultural notions and how people perceive and interact with landscape, is illustrated in

Fig. 2.

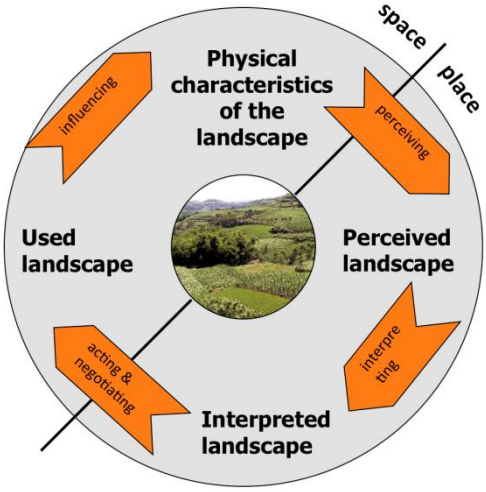

Fig. 2: The space and place concept [12]

At the top is the physical environment, which can be conceptualised as ‘space’, represented primarily by physical elements such as urban fabric, infrastructure, agricultural fields, roads and so on. These physical components are frequently overwhelmingly present in landscape monitoring [3]. They are usually well understood and are covered in the landscape ecology literature as well as through the ecosystem service framework [18]-[22]. The other half of the figure illustrates the concept of place with respect to landscape, which focuses on how people assign cultural, social or individual meanings to landscape elements and how these are shared among groups of people [9], [13]-[16], [23]. In the current ecosystem service literature, this aspect is considered to be covered by cultural ecosystem services [24], [25], where recreational values, aesthetic values or sense of place are assessed [26]-[30].

Fig. 3: Particular places and landscape elements contribute to people’s identity –

traditional building style in Marthalen, Switzerland (photo: F.Wartmann)

In environmental psychology, place meaning and place attachment are studied with respect to how they support the formation and maintenance of the identities of individuals and societal groups [31]-[35], with landscape being considered an important pillar in the identity-building process [36]. There is considerable debate in the literature about different theoretical concepts. Generally, place identity is defined as that part of our identity that relates to place [37]. More specific conceptualisations of place identity include the notion of 'place-referent continuity', the process by which people maintain the continuity of their identity via specific places that are of emotional significance to them, such as particular landscape elements or buildings and 'place-congruent continuity', as the generic and transferable characteristics of places, (e.g., mountains) that help maintain continuity [38].

The process that leads from space to place is often referred to as 'place-making', i.e., the societal construction of place. This depends on (a) how people perceive and interpret the physical environment and (b) how they socially integrate into the neighbourhood and local community. It is broadly accepted that both components are influenced by length of residency [35]. Research shows that place attachment is a key component of well-being, involving feelings of safety, belonging, control, self-esteem and meaningful life [39]. The process of assigning meanings to landscapes, where place meanings represent cognitions that individuals or groups associate with an area, has been described for various settings in the literature [40], [41]. Based on these bonds between individuals and societies and landscapes, change that results in disruptions to place and place identity can have severe impacts on individuals and local communities [42], [43].

1.2. Landscape Perception and Interpretation

In order for space to become place, as illustrated in Fig. 2, people must first perceive the landscape. Research on landscape perception is embedded in well-known theoretical concepts of perception [12], [44]-[46]. In the literature, three pillars are distinguished that are described as governing landscape perception: (1) a universal/biological/evolutionary pillar, (2) a sociocultural pillar and (3) an individual pillar. The universal/biological/evolutionary pillar is based on theories such as the savanna theory [47], [48], the prospect-refuge theory [49] and information processing theory [46]. These theories claim that a certain part of people's behaviour is universal, as it is biologically/evolutionarily determined. However, there is also empirical evidence for cultural variation in landscape preferences [50], and thus the importance of pillar 1 for landscape perception is currently being debated [51]. The research in pillar 2 suggests that landscape experience is the result of cultural influences and agreements, while pillar 3 is based on the notion that individual attitudes and preferences, but also individual factors such as preferred outdoor activities, shape the perception of landscapes [52]-[54]. Landscape elements that are perceived and interpreted in a cultural context create the unique setting or the landscape character of a given area, which is discussed in more detail in section 4.4.

Fig. 4: The preferred type of outdoor activity can influence the individual way a landscape is perceived – ski slope at Heinzenberg, Switzerland (photo: S. Gosteli)

1.3. Negotiating landscapes and landscape change

Individuals, groups or entire societies fulfil their needs and determine their demands on landscapes, which are – in the ideal case – then communicated via multiple forms of negotiation into planning action. It is observed that these negotiations go far beyond functional aspects and are increasingly centred around place meanings, involving societal discourses on lifestyles [55]. Negotiation processes differ widely, depending on the planning culture of a region. They may be top-down approaches, where planning action is delegated to technical experts trying to fulfil the demands of the population, though many countries have institutionalised forms of bottom-up participation [56]. Alternatively, there is a wide range of spontaneous self-organised planning processes, where citizens initiate planning activities individually, exemplified in cities that are said to have become unplannable [57], [58].

Fig. 5: Landscapes are continuously changing and being reshaped. Landscape monitoring aims to capture such changes and inform policy-making and planning – industrial area in Thusis (photo: F. Wartmann)

All forms of shaping the landscape – whether organised or spontaneous – lead to changes in land use, which can be oriented more towards the space aspect in Fig. 2. Numerous monitoring programmes, e.g., CORINE, are concerned with land-*use* changes. These types of monitoring are highly important for monitoring the changes in landscapes. However, due to their strict focus on land *use*, they are not covered in this report.

2. The Principles of Landscape Observatories and Landscape Monitoring

This chapter intends to provide an overview of the conceptual basis of monitoring, before focusing on monitoring as envisaged by the European Landscape Convention. Finally, we zoom in on indicator-based monitoring as a widespread approach to landscape monitoring.

2.1. Monitoring in general

Monitoring in the very strict and classical sense should be part of any comprehensive national or international environmental policy evaluation procedure that ultimately leads to adaptive management. Adaptive management is the incremental improvement of environmental status by continuously reducing the differences between output and environmental policy goals [59]. Fig. 6 illustrates this adaptive management process in the so-called MER cycle (**m**onitoring, **e**valuation, **r**eporting). The cycle starts with strategic planning goals or environmental policy objectives (upper left), followed by activities. These activities manifest themselves in a certain output or effect/outcome, e.g., a change in land use. Subsequently, the outputs and/or outcomes are measured by means of monitoring (upper right) and compared with the intended targets (lower centre). Reporting provides decision makers with the information they need to make any necessary changes to strategic planning or environmental policy. In accordance with European Environmental Agency [60], various evaluation and evidence collection methods should be applied, in order to base the reporting on as much knowledge as possible. This includes, e.g., cost-benefit analyses, environmental monitoring or literature reviews and indicator analysis or modelling. This MER approach fits well for relatively technocratic approaches in fields such as air pollution or water purification.

Fig. 6: The monitoring-evaluation-reporting (MER) cycle. Modified [61]

However, in the context of policies or projects dealing with landscapes and landscape change, the classic MER cycle might fall short, because:

> "the ultimate goals [of landscape development] are often not easily defined. These goals will be long term and influenced by many forces that may be outside the control of those driving the landscape process [59]."

Consequently, Sayer et al. [59] outline a "theory of change" to trace the relationship between an intervention and its ultimate impact and importantly, they explicitly address the need to negotiate stakeholder demands and planning goals with a management coalition. The latter sets goals that are reviewed using suitable indicators. The biggest refinement of Sayer's 'theory of change' is therefore the participatory character of both the planning negotiation and monitoring activities of the MER cycle.

2.2 Landscape Observatories envisaged by the European Landscape Convention

Currently, considerable efforts can be observed in the landscape research community to develop monitoring tools that fit a holistic definition of landscape and are really concerned with landscape and not exclusively with land use. This is indeed necessary, because land-use/land-cover monitoring programmes such as CORINE detect how the composition of the landscape is changing, but they do not allow us to assess how these changes affect how landscapes are perceived. Commonly, landscape monitoring relies heavily on land-use/land-cover monitoring and the corresponding data are usually accessible for the derivation of indicators [3]. However, ideally, landscape monitoring programmes should derive indicators that measure specific landscape properties.

As exemplified in the recommendation R (2008) 3, landscape observatories are envisaged as the primary means of "taking note of change". These landscape observatories, centres or institutes can be set up at various levels – local, regional, national or international – employing interlocking observation systems and providing the opportunity for ongoing exchanges. With these bodies, it should be possible to:

- describe the condition of landscapes at a given time,
- exchange information on policies and experiences concerning protection, management and planning, public participation and implementation at different levels,
- use and, if necessary, compile historical documents on landscapes which could be useful for understanding how the landscapes concerned have developed (archives, text, photographs, etc.),
- draw up quantitative and qualitative indicators to assess the effectiveness of landscape policies,
- furnish data leading to an understanding of trends and to forecasts or forward-looking scenarios (recommendation R (2008) 3).

As stated under ii) and discussed later in this report, many observatories have – in addition to the task of being information platforms – also an active transdisciplinary role. In this role they initiate or facilitate participation or the landscape-related actions of inhabitants. As well as the landscape observatories, centres or institutes, the European Landscape Convention also recommends programmes that are mostly centred around specific topics or are initiated for a limited time.

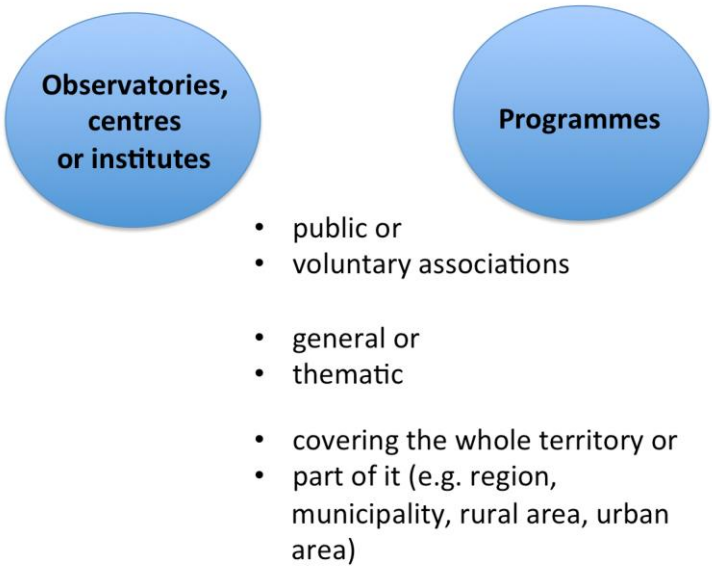

Fig. 7: To "take note of changes" and fulfil the landscape monitoring recommendation R (2008) 3, it is necessary to distinguish between observatories, centres, institutes and programmes. Their institutional embedding, themes and spatial coverage vary greatly (information from Mrs M Déjeant-Pons, written communication).

2.3 Indicator-Based Monitoring

Indicators are at the heart of many monitoring activities [3]. Indicators are simple and reliable ways to measure complex processes [62]. One can distinguish between 'umbrella' indicators, which aggregate many processes into one measure and specific indicators, which are representative for one process only. For instance, an indicator about light pollution is merely an 'umbrella' indicator, measuring many processes such as urbanisation, land abandonment or remoteness, without being able to distinguish between the processes, whereas an indicator about 'publicly accessible rivers' is a specific indicator, measuring the recreation potential of an important landscape element [11]. Generally, an indicator produces quantified information to help actors in interventions to communicate, negotiate and make decisions (European Commission 1999 in [63]). It is commonly accepted that indicators play a major role in policy evaluations and there is a substantial literature on indicator selection [64].

Fig. 8: Landscape indicators can produce impartial information that helps stakeholders to discuss and make decisions about landscape interventions (revitalisation of a river in Fribourg, Switzerland). (photo: S.Gosteli)

Excellent overviews are given by, e.g., Hasund [64] and Sand, Miller and Ode [65]. Many indicator-based analyses select indicators according to the driving force-pressure-state-impact-response framework DPSIR, used by the European Environmental Agency [66], [67]. As a rule of thumb, indicators should be comprehensive without being exhaustive or redundant. A large number of indicators should therefore always be checked for redundancy. Further requirements for indicators are that they:

- are measurable and sensitive to external change [68];
- exhibit a potential for long-term measurement [3];
- are representative for a process and a specific geographical region [62], [69];
- are embedded in financially feasible frameworks to reduce the risk of incomplete temporal and spatial coverage due to potential financial cuts [3].

Importantly, there are also equally valid landscape observatories that are *not* based on strict spatio-temporal indicator sets but rather on data assembled in an ad hoc way.

2.4 The Role of Landscape Atlases and Landscape Character Assessments in landscape monitoring

Any landscape monitoring, whether it is under the umbrella of an observatory, a centre, an institute or a programme, is dependent on a broad knowledge and description of the landscape types in the region or territory covered. This knowledge must be assembled prior to any identification of, e.g., landscape indicators or methods of monitoring. There is a broad tradition in geography of describing landscapes from both a cultural and a natural point of view. Paul Vidal de la Blache (1845-1918) and Carl Otwin Sauer (1889-1975) are excellent representatives of the discipline of "regional geography" that lays the foundations for scientifically sound landscape descriptions. More recently, i.e., after 1950, French and German geographers, such as Georges Bertrand, Thierry Brossard, Carl Troll and Wolfgang Haber, emphasised the use of "landscape" in the context of spatial planning and the protection of cultural landscapes.

In the 1990s the UK Countryside Agency launched several activities to establish the methodology of landscape character assessment, an attempt to describe landscapes with similar properties for the sake of planning and protecting the cultural and natural heritage. In 2002, the Countryside Agency and Scottish Natural Heritage published a remarkable tool – later referred to as a landscape character assessment (LCA) – to "help us to understand and articulate the character of the landscape. It helps us identify the features that give a locality its 'sense of place' and pinpoints what makes it different from neighbouring areas" [70]. This tool of LCA has been re-evaluated numerous times and forms an excellent instrument for a broad and holistic but still reproducible description of landscapes in specific regions [71]. In 2005, an effort was made by the Fifth European Union Framework Programme on Energy, Environment and Sustainable Development, to obtain an overview of LCA activities in Europe. The corresponding report [72] was for a long time one of the best references. This report was followed by an excellent handbook on landscape character assessment [73]. It describes how LCAs are applied in numerous countries, such as the UK and Ireland but also Sweden, Croatia, Cyprus, Turkey or Portugal, where a core knowledge is built for use in later landscape monitoring.

Work has also been carried out within the framework of the Ministry of the Environment of France, which is the basis of the Landscape Atlas methodology. This method makes it possible to identify landscape units, areas of various sizes, but with similar characteristics in terms of landscape. The landscape atlases have a stronger link to landscape architecture and spatial planning than the LCAs. More and more landscape atlases incorporate a strong bottom-up landscape perception component [74]. The methodology of landscape atlases developed in many departments of France. In Belgium, Wallonia and Flanders have also developed Landscape Atlases [75]. An excellent methodological overview is given in [76], stressing the need for updating the landscape atlases every 10 years. This would then indeed be a form of landscape monitoring similar to the Countryside Quality Counts (CQC) programme reported here. However, as reported in [74], there seems to be a delay in both production and updating due to the time-consuming nature of the process. Nevertheless, landscape atlases could be a main input for many landscape monitoring initiatives described in this report.

3. Presentation of selected landscape observatories and monitoring initiatives

In order to present the current state of the art of landscape monitoring, a selection of existing monitoring initiatives are presented based on the following resources: (1) previous overviews such as that of Cassatella and Peano [3], which is probably the most comprehensive review of indicator-based approaches at the European and regional level, (2) a survey of European landscape observatories [77], (3) a search in the Web of Science database with the keywords "landscape", "observatory", "monitoring", "indicators" and "perceive", (4) Internet searches, (5) personal communications and (6) information given in the public list of the European Landscape Convention online [78]. The list of monitoring initiatives (Table 1) is not complete but rather is a representative sample, which is well suited to extracting major trends in the current monitoring debate. It must be noted that the precursors of many monitoring initiatives are landscape character assessments or atlases. Quite frequently they represent some kind of monitoring, as some of them are repeated over time and thus describe the landscape at different points in time. Nevertheless, most of them were not designed as monitoring programmes in the strict sense of the term. Excellent atlas and landscape character studies have been reported in France and Belgium, (e.g., in the atlas de paysage of France and Belgium, etc.) but also in the UK, Serbia, Andorra, Andalusia and Galicia. In our report, all

purely land-cover/land-use-related monitoring schemes are excluded but we are well aware that these play an important role in delivering physical and land-use-related basic data for landscape assessments. The great effort by monitoring activities such as CORINE or the Harmonised European Land Monitoring (HELM) programme is, however, recognised. Without these monitoring initiatives neither quantitative statements about the physical and land-use-related landscape resources nor spatial extrapolations of empirically derived landscape preferences, e.g., in the form of preference maps, would be possible.

The observatories are presented in geographical order from north to south, starting in the UK, through Northern, Eastern and Central Europe to Southern Europe. Three observatories from outside Europe are included (Peru, New Zealand and Australia), together with three monitoring initiatives of protected areas such as national parks or landscape protection zones.

Table 1: Selection of landscape observatories and monitoring initiatives. The name of the monitoring initiative is given in bold, and – if not self-explanatory or too long – also the abbreviation used in Fig. 13 and Fig. 15

United Kingdom

Countryside Quality Counts (abbreviation in this report: CQC England)

In 2002 the Countryside Agency and Scottish Natural Heritage published a remarkable tool – later referred to as a landscape character assessment (LCA) - to 'help us to understand and articulate the character of the landscape. It helps us identify the features that give a locality its 'sense of place' and pinpoints what makes it different from neighbouring areas'[70]. LCAs have been applied in numerous circumstances in England, Scotland and elsewhere. LCAs help to involve communities and people in defining and describing their landscapes via well-established official tools. The core of the LCA is a relatively value-free characterisation of landscape character types with maps, perceptual qualities, photographs and land-use/land-cover data, which is assembled by peers or local representatives involved in landscape issues. Each landscape character assessment has a clearly defined scope. An LCA often results in maps delineating the homogenous landscape character areas. The monitoring instrument of the Countryside Quality Counts (CQC) scheme is a logical continuation of LCAs with a temporal component. Based on the national landscape character areas (NCAs), the project assessed the changes in landscape character for England for the two periods 1990-1998 and 1999-2003, based on extensive studies of data, maps and photographs and on expert interviews. For the first assessment of change (1990-1998) a series of eight regional consultations were undertaken in the autumn of 2003. Local knowledge was sought from various expert stakeholders who were asked to consider the adequacy and accuracy of the statements of change found in the original landscape character descriptions. They were then asked to review the associated statistical and geographical information and reach a conclusion on the significance of the change for landscape character as represented by these data. It was through the consultation exercise that the judgment of change and its significance was partly determined. For the first assessment, landscape character areas were classified as experiencing:

- marked change inconsistent with character;

- some change inconsistent with character;
- limited or no change consistent with character.

The second assessment of change expanded the evidence base and placed even greater emphasis on consultation with local stakeholders (particularly the professional landscape community), thereby greatly increasing the robustness and acceptability of the context.

Web Resources: [70]

Landscape Character Study, Cornwall (abbreviation in this report: Cornwall)

The landscape character study in Cornwall was carried out in 2005-2007 and funded by Cornwall County Council (and others). Strictly speaking it is an updated landscape assessment and not landscape monitoring per se. However, as it has been carried out twice (once in 1994 and once in 2007) it can be seen as landscape monitoring. The goal of the assessment is to guide the development of landscape policies and strategies. Therefore, for each landscape area (40 character areas) a report is available on the Internet, describing ecological and social aspects of the landscape and its development (biodiversity, geology, land use, settlements, historic features and aesthetics) [79].

Fig. 9: Historic traces in the landscape are a part of the landscape characters in Cornwall – old Cornish farm by Mathias Liebing on www.flickr.com (licensed as CC BY-NC 2.0)

Web Resources: [79], [80]

Norway

Landscape Monitoring (abbreviation in this report: Norway)

3Q is the national monitoring programme of Norway established in 1998 and organised by the Norwegian Institute of Bioeconomy Research (NIBIO). It is based on 1,000 randomly selected 1 x 1 km squares containing farmland. It analyses the entire agricultural landscape and is designed to measure the effects of policies. To this end, the land use, biological diversity, cultural heritage and accessibility are surveyed using indicators. Methods include GIS analysis of aerial photographs and other data, landscape photography, field registration of biological diversity and cultural heritage

sites, questionnaires and interview surveys and analysis of documents and statistical data. The programme is scientifically evaluated and aims at linking physical landscape appearance with the perception of landscapes through the use of landscape metrics and photos presented to locals and students. Dramstad et al. [81] found "significant positive correlations between preferences and spatial metrics, including number of land types, number of patches and land type diversity. In addition, preference scores were high where water was present within the mapped image area, even if the water itself was not visible in the images." In addition to the landscape perception aspect, Norway also runs a scientific historical photo documentation scheme on landscape changes (see [82]).

Web Resources: [82]-[84]

Finland

Finnish Landscape Observatory (abbreviation in this report: Finland)

The Landscape Observatory of Finland is a recent activity led by Aalto University. The concept of the landscape observatory is based on the European Landscape Convention and follows the recommendations of the Committee of Ministers of the Council of Europe. With a comprehensive narrative (social and economic) view of the landscape, a proactive system of landscape planning should be reached. The Landscape Observatory of Finland is still in its early stages and the types of data that will be collected are not yet fully defined, but the aim will be to establish an indicator-driven monitoring system with representative data for the whole of Finland. Finland has an excellent environmental monitoring system (SYKE, [85]). However, landscape is not covered in their monitoring priorities. There is already an excellent overview of Finish landscape areas run by environment.fi ([86]), together with outstanding photo documentation ([85]). Activities planned for the landscape observatory thus seem an ideal complement to existing environmental monitoring.

Web Resources: [87]-[90]

Sweden

NILS (abbreviation in this report: Sweden)

The Environmental Monitoring and Assessment of Sweden, EMA, is led by the Swedish University of Agricultural Sciences and is funded by the Swedish Government. It is organised into 10 different programmes (forest, agricultural landscape, lakes and watercourses, costal and sea areas, built environment, climate, biodiversity, eutrophication, acidification and non-toxic environment) [91].

Fig. 10: Agricultural landscapes are a focus landscape type for the NILS project in Sweden – "Beautiful Skåne Countryside" by Robin on www.flickr.com (licensed as CC BY-NC 2.0)

For analysing the agricultural landscape sector, for example, the national inventory of landscapes in Sweden's NILS was launched in 2003. NILS is conducted as a sample-based stratified inventory in which aerial photographs are interpreted and combined with a field inventory. Within five years, all of the 631 sample units were surveyed [92].

Web Resources: [91], [93]

Estonia

Monitoring the Rural Landscape (abbreviation in this report: Estonia)

Landscape monitoring is part of the agri-environmental programme of Estonia. It focuses on agricultural landscapes. Changes in land use/land cover as well as human impacts are studied by measuring the spatial structure of the landscape, taking aerial photos and evaluating biodiversity-relevant indicators, (e.g., number and diversity of earthworms in the soil). Therefore, this indicator-based monitoring programme has a strong cultural-biological focus. The perception and social components are less pronounced but clearly stated in the aims. There is an aspect of visual landscape perception in this monitoring, in that the appearance of the monitored farms as well as agri-ecological compensation areas have been chosen as an indicator of landscape attractiveness for people.

Web Resources: [94]-[97]

The Netherlands

Landscape Observatory (abbreviation in this report: the Netherlands)

The national landscape observatory in the Netherlands is an ongoing landscape monitoring programme organised by LandschappenNL, the Ministry of Education, Culture and Science and local universities. It has a strong outreach component, but at the same time has sound scientific support. The monitoring is based on a landscape quality assessment [98] which includes indicators,

visual assessments and expert opinions on a variety of landscape aspects, including cultural history. People's perception of the landscape is not assessed with questionnaires, but expert assessments are used instead.

Web Resources: [98]-[100]

Belgium

Landscape Atlases of Belgium

Significant work has been done by the Public Service of Wallonia and the Flemish organization for Immovable Heritage for the creation of landscape atlases.

See International Landsacpe Observatory of the Council of Europe (Information System):
www.coe.int/en/web/landscape/landscape-observatory

Citizen Observatory of the landscape *(Observatoire citoyen du paysage)*, Belgium, Wallonia (abbreviation in this report: Wallonia)

The Citizen Observatory of the landscape *(Observatoire citoyen du paysage)* is a landscape monitoring initiative in Belgium in the Wallonia region. It is led by the Inter-Environment Federation Wallonia, in cooperation with the Wallonia and local nature parks [101]. For evaluating the changes in the landscape, stakeholders (citizens and associations) are asked to take photos from the same site annually, compare the old with the new and evaluate the landscapes [102]. The Observatoire has a subjective approach, focusing more on social and less on ecological aspects.

Web Resources: [101]-[103]

France

Landscape Atlases of France

Important work on landscape atlases has been conducted by the Ministry of Solidarity and Ecological Transition. More and more landscape atlases incorporate a strong bottom-up landscape perception component [74]. The methodology of landscape atlases has been developed in many departments of France [75]. An methodological overview is given in [76], stressing the need for updating the landscape atlases every 10 years. This would then indeed be a form of landscape monitoring similar to the Countryside Quality Counts (CQC) programme reported here. However, as reported in [74], there seems to be a delay in both production and updating due to the time-consuming nature of the process. Landscape atlases are important tools for landscape monitoring.

See International Landsacpe Observatory of the Council of Europe (Information System)
www.coe.int/en/web/landscape/landscape-observatory

National Photographic Landscape Observatory of France *(Observatoire photographique national du paysage)*, France (abbreviation in this report: France)

The National Landscape Photographic Observatory of France was established in 1992 by the Ministry of the Environment. It contains currently 20 local observatories (one for monitoring each territory). In each local observatory, an artist takes 40 photographs from the same site annually. These photographs are then compared with previous ones. The artistic aspect of the observatory is important [104].

Web Resources:[104]–[106]

Belgium and France

Semois Valley, Belgium and France (abbreviation in this report: Semois)

The landscape monitoring of the Semois valley in France and Belgium is part of the European Territorial Cooperation programme (Interreg III). It was initiated as a cross-border restoration programme for the watercourse and resulted in a landscape-scale collaboration. To identify the landscape evolution, photos of the same site were taken through the seasons and old photographs and postcards studied and compared with the current situation. In addition, random photographs were taken on a route through the Semois valley. The survey took agriculture, the forest, the river and housing and other infrastructure, (e.g., roads) into account.

Web Resources: [107], *in French:* [108]

Switzerland

Swiss Landscape Monitoring Programme (abbreviation in this report: Switzerland, LABES)

The Swiss landscape monitoring programme LABES (abbreviation originates from the German "Landschaftsbeobachtung Schweiz") is one of the first national landscape observatories (total area ca 40,000 km^2) where landscape perception is systematically monitored with representative surveys. The monitoring consists of roughly 30 indicators that are embedded in the DPSIR framework, (i.e., driving force-pressure-state-impact-response). Approximately 25% of the indicators measure perception properties, including the information content of the landscape [46] and indicators including fascination, landscape beauty and authenticity. Respondents are instructed to base their statements on the landscape and places in their current home municipality rather than on pictures of specific landscapes. An innovative indicator of the physical space concerns light emissions, which is a straightforward proxy for urbanisation and human activities. The monitoring also measures landscape fragmentation and urban sprawl, as well as areas without buildings or infrastructure. Currently, around half the indicators are available as a time series. A rigid quality control process showed that the indicators are geographically representative for Switzerland and a core set of indispensable indicators was determined [11]. The programme is constantly evaluated scientifically.

Web Resources: [109], *in German:* [110] – *See appendix to this Report.*

Switzerland, Regional Nature Park Chasseral, Switzerland (abbreviation in this report: Chasseral)
- See Appendix to this Report.

For the photographic landscape observatory in the protected area of Doubs and Chasseral (Jura) photographs are taken by volunteers. The survey focuses on everyday landscapes and is part of the environmental awareness and education activities of the regional park.

Web Resources: [126], [127]

Italy

Landscape Observatories of Italy

Italy has several landscape observatories at various spatial levels (

Fig. *11*). They all refer to the European Landscape Convention. Many of them use indicators to express the changes over time. The National Observatory of Rural Landscape is strongly linked to surveying agricultural practices and traditional knowledge considered to be of particular value for Italy [111].

Fig. 11: Landscape in Piemonte. Image: 'Barolo Landscape' by x1klima on Flickr (licensed as CC BY-ND 2.0)

Here the monitoring activities of the Piemonte region (abbreviation in this report: Piemonte) are highlighted as an excellent example of the fact that scientifically sound monitoring need not exclude a strong bottom-up component and involvement of the people. On the one hand there are seven local observatories which cover important areas of Piemonte [113]. On the other hand there is a well-elaborated and well-documented indicator-based monitoring approach that bridges all aspects of landscapes from biological aspects to perceptions [3].

Web Resources: [112]-[115]

Portugal

Tagus River (abbreviation in this report: Tagus)

The landscape observatory of the Tagus river collaborates with NOVA – the New University of

Lisbon – and with the University Autonoma de Madrid. It characterises the landscape in the context of awareness and education as well as the cultural and socioterritorial dynamics of the Tagus landscape. Therefore, a knowledge repository of the river landscapes is established as well as a photo observatory to monitor the landscape and to publish proof photographs and "photographs suggested by the public to show various aspects of recognised interest" [116]. Public participation plays a major role in this landscape observatory.

Fig. 12: The Tagus river flows through Spain and Portugal, which requires collaboration between two countries for landscape monitoring along the stream. Tagus River viewed from Santarém. Image: 'IMG_0821_2_3_tonemapped' by Paolo on www.flickr.com (licensed as CCBY-NC-ND 2.0)

Web Resources: [116], in Portugese: [117]

Spain

Landsacpe Monitoring

Important works carried out by the Ministry of Culture (Institute of Cultural Heritage) of Spain, intended to present the works carried out on the whole territory of Spain for the follow-up of the landscapes are in progress: Andalusia, Aragon, Cantabria, Castilla-La Mancha, Castile and Leon, Catalonia, Community of Madrid, Community of Navarre, Community of Valencia, Extremadura, Galicia, Balearic Islands, Canary Islands, La Rioja, Basque Country, Principality of Asturias, Region of Murcia.

See International Landscape Observatory of the Council of Europe Information System: www.coe.int/en/web/landscape/landscape-observatory

Landscape Observatory of the Canary Islands, Spain [133]

Landscape Observatory of Catalonia, Spain (abbreviation in this report: Catalonia)

The Landscape Observatory of Catalonia was established in 2004 by the Regional Government of Catalonia. The aim is to promote a better knowledge of the local landscape in Catalan society [118]. Apart from studying and monitoring the landscape, an important aspect is awareness-raising among

all members of society for better landscape management and planning [119].

To evaluate the landscape, various indicators, (e.g., landscape diversity, landscape fragmentation, economic value) are used, while taking social and economic aspects of landscapes into account [120]. The evaluated landscapes are described in landscape catalogues. In addition, a report on the state of the landscape is generated every four years [119].

Landscape inventory in Galicia, Spain [121]

Web Resources: [118], [122]

Cyprus, Greece, Jordan and Lebanon

Eastern Mediterranean Landscape Observatory, EMLO (abbreviation in this report: EMLO)

The Eastern Mediterranean Landscape Observatory, EMLO, has partners form Cyprus, Greece, Jordan and Lebanon. It is led by the Laona Foundation for the Conservation and Regeneration of Cypriot Countryside in Cyprus, in partnership with MEDSCAPES. The aim is to increase landscape sensitivity and knowledge, to protect the landscape heritage and to monitor and document the landscape change to support the adoption of government land instruments. The monitoring has a strong outreach component [123].

Web Resources: [123]

Germany

National Park Berchtesgaden (abbreviated in this report: Berchtesgaden)

The Berchtesgaden National Park in Germany conducts landscape monitoring to identify and interpret landscape developments. Repeated surveys are carried out, focusing almost entirely on ecological aspects. Social aspects play a subordinate role because Berchtesgaden is an IUCN Cat. II protected area. The monitoring is concentrated on the core zone, where little or no human interaction takes place. In order to be able to compare the results nationally, Berchtesgaden National Park is keen to push the idea of a standardised ‘core data set’ of indicators that are nationally and internationally comparable.

Web Resources: [124], [125]

Peru

Terrace Landscape Observatory (abbreviation in this report: Peru)

In Peru the Terrace Landscape Observatory was established in 2014. It is a strongly bottom-up and participatory project with the aim of improving the quality of life of the inhabitants of the terraced landscapes in Peru. Monitoring is a minor activity; the major focus is on water management, sanitation of drinking water, improving agricultural practices and market strategies and empowering

the (female) rural population. [59].
Web Resources: [128]

New Zealand

Rotorua District (abbreviation in this report: Rotorua)

Rotorua is a 2,614.9 km^2 district on the North Island of New Zealand with an estimated permanent population of 58,800. It is the country's 10^{th} largest urban area. Rotorua is a major destination for both domestic and international tourists, with the tourism industry being by far the largest industry in the district. Given its small size, the Rotorua district has a remarkably broad indicator-driven environmental monitoring scheme, where physical landscape aspects such as land-use/land-cover changes or biodiversity are monitored but also landscape amenity values and resource consents by indigenous groups of people (*tangata whenua*). This indicator-driven system has a cycle of one to five years. Each indicator is evaluated on the basis of whether the good or service it stands for is stable or decreasing/increasing in quality or quantity. Indicators such as water quality, air quality and rural and urban land, as well as cultural heritage and tourism, are used to support a sustainable environment, economy and infrastructure. In addition, for a specific area known as the Lakes A Zone, landscape change is reported in detail by taking photographs every two years from 24 viewpoints. The photographs are then compared by experts to identify visual changes, which are recorded, and their impacts and threats quantified. The Rotorua district monitoring scheme is an indicator-based approach, taking social and economic aspects into account.

Web Resources: [129], [130]

Australia

Great Barrier Reef, SELTMP (abbreviation in this report: Barrier Reef)

The landscape monitoring programme of the Great Barrier Reef in Australia is a social and economic long-term monitoring programme called SELTMP that was funded in 2011 by the Australian Government. It is led by researchers from the local university and the Commonwealth Scientific and Industrial Research Organisation. In addition, the Great Barrier Reef Marine Park Authority, local organisations, community groups and industries are involved in this project.

The aim is to inform reef managers about the current status and historical and possible future trends of the local industries, communities and park users. It should provide social and economic information for effective management and planning. Therefore, stakeholders, (e.g., tourists, fishers, residents) are questioned about their affinity, experiences and values regarding the reef, focusing more on social and economic aspects than on ecological aspects.

Web Resources: [131], [132]

European island landscapes

ESLAND project aimed to consider, including the unique identities and values they have [134].

4 Proposing a typology of landscape monitoring

4.1 Assessment criteria

Based on the review of experiences previously presented, a catalogue of six criteria to systematically characterise and classify the approaches was developed. For each criterion, two strongly contrasting views or poles have been delineated that describe a gradient along which each monitoring programme was then classified (Table 2).

Table 2: The criteria according to which the monitoring was evaluated. Two contrasting poles are given for each criterion. Each monitoring activity was evaluated along the gradient formed by the two perspectives given in this example.

Criterion	**Pole 1**		**Pole 2**
(1) Type of landscape assessment	Indicator-driven		Comprehensive narrative landscape assessment focusing on case studies described with characteristics that differ from case to case
(2) Replicability and scientific ambitions	Science-driven (biology, geography, sociology)		Art-driven (photographs, drawings, architectural objects)
(3) Spatial coverage and representativeness	Statistically representative for a region		Case studies without statistical representativeness
(4) Compliance with ELC landscape definition	Integrated (covering all aspects of the ELC landscape definition)		Sectoral (covering selected aspects of the ELC landscape definition)
(5) Legal framework	Endorsed by an official national or provincial body		Endorsed by NGOs or citizens' movements
(6) Protection status of the covered area	Fully protected area		Protected areas form a mosaic in a matrix of unprotected land

The orientation of the poles is neither positive nor negative; they represent distinct manifestations of the same criterion. This means that the assessment of which poles a landscape monitoring activity belongs to does not assess the *quality* of this monitoring activity but is rather an attempt at proposing a typology of different monitoring approaches. Using these six criteria, it has been possible to place the monitoring approaches to the best of our knowledge along the gradients. This analysis is

sometimes a challenge, because each approach is in some way unique and difficult to reduce to these six categories. Nonetheless, the proposed typology helps our understanding by systematising different approaches according to defined criteria. Given our classification of the different monitoring approaches according to the criteria in Table 2, we present rankings of the different monitoring schemes according to those criteria, to show graphically how the approaches in one group differ in detail (Fig. 13 and Fig. 15). The boundaries between these broad groups are not sharp. As is the case for any grouping or classification, the use of sharp boundaries in a continuum is based on partly subjective group affiliations. The following groups of approaches may be considered (for details see sections 4.2 to 4.5):

- indicator-driven approaches;
- comprehensive narratives, partially art- and action-driven approaches;
- landscape character assessments (LCAs) with a monitoring component;
- approaches for protected areas (based on criterion (6) only).

4.2 Indicator-driven approaches

The first group identified is landscape monitoring activities that are indicator-driven and aim at representativeness. This group is the largest of the four, comprising the monitoring programmes from the Netherlands, Piemonte, Switzerland (LABES), Norway, Rotorua New Zealand, Estonia, Finland, the Eastern Mediterranean Landscape Observatory EMLO, Sweden and Catalonia, and the Countryside Quality Counts programme from England, all of which have been described in more detail in Table 1. As exemplified in Fig. 13, this group has quite similar characteristics for the first four criteria. Most monitoring schemes belonging to this class try to mirror all aspects of landscapes by means of indicators, which are statistically representative for the region under consideration and accompanied by scientific evaluations of the data. The requirements for indicators stated in section 2.3 are not repeated, but it seems important to note that indicators are not simply scientific data but are time series of data that approximate complex processes with the simplest possible measurements. All monitoring systems discussed in this group meet this requirement. This does not mean that the other monitoring systems do not use scientific data but that their use is frequently ad hoc and not in the form of strict indicators. Remote sensing is used in many of these approaches as a way of measuring the physical aspects of the landscape.

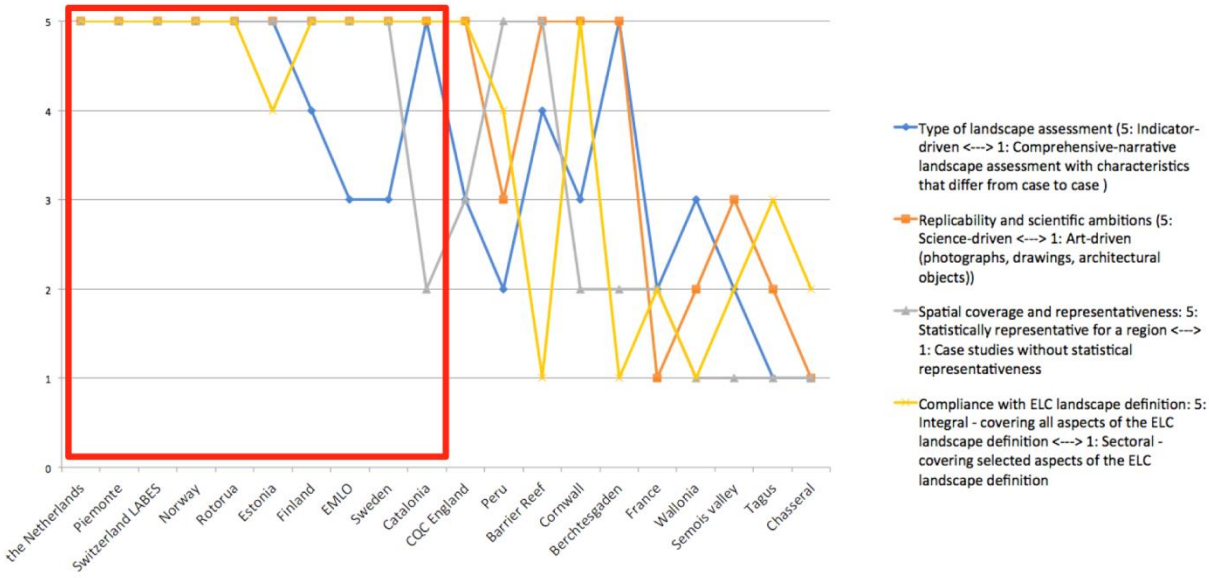

Fig. 13: Ranking of the investigated approaches according to four criteria (see Table 2)

A number of these monitoring systems come from experiments conducted for rural territories (e.g., Italy's Observatory of the Rural Landscape, Q3 in Norway and the Swedish and Estonian programmes). The reasons are obvious: there are generally good statistics on agricultural land, facilitating monitoring of biodiversity-relevant aspects but also cultural aspects of landscape. However, due to this bias towards agricultural areas, these landscape monitoring schemes tend to neglect urban landscapes. There is a danger that such monitoring schemes may remain locked in stereotypical assumptions that rural areas are always 'the landscape per se' and that urban and peri-urban landscapes have a distinct lower landscape quality. Whilst this assumption may hold true in many cases, it should nonetheless be substantiated with representative surveys among the population, such as the Countryside Quality Counts scheme in the UK [135] or the Swiss landscape monitoring scheme, which assesses the aesthetics of the landscape in people's home community through a representative survey in the population [11]. Assessments including the population directly should be preferred over the entirely expert-based assessments which are still found in many programmes.

The indicator-driven approaches have many advantages but also some disadvantages. One of the main advantages is that the different aspects of the landscape such as habitat occurrence, patterning of the landscape or perception, are measured quantitatively and recorded independently. This enables separate policy recommendations to be made based on the same monitoring scheme. The disadvantage of these approaches is that it is difficult to arrive at a comprehensive synthesis regarding how landscapes are developing. A case in point is Switzerland's landscape monitoring programme LABES. Despite the fact that this pioneering monitoring system measures many aspects of the physical and perceived landscape, it has clear deficiencies in assessing changes to the overall character of Swiss landscapes.

Another challenge for indicator-based approaches is that they are relatively expensive to maintain, including documenting the data, continually evaluating the use of the latest technologies, collecting and analysing representative survey data and ensuring consistent time series. Therefore indicator-based monitoring programmes should be endorsed by an official national or provincial body. It is therefore not surprising that some of the approaches studied here have deficits with regard to keeping

the programme running over several years and documenting it well with information available in written reports or online. Leaving indicator-based monitoring entirely in the hands of non-governmental organisations carries the risk of inconsistent data production or project termination.

Fig. 14 The landscapes of Rotorua in New Zealand are monitored through an integrated approach comprising physical and social indicators (photo: Pia Bereuter)

It can be noted that the Integrated Landscape Monitoring Program in Rotorua District, New Zealand, presents a particularly interesting approach. This program is based on physical and social indicators and follows the implementation of an instrument that safeguards the claims and needs of the indigenous population in the landscape (*tangata whenua*). This explicit monitoring of legal instruments for landscape management has been found in this monitoring approach only and would be worth considering in other approaches. Importantly, all indicators are accessible and well documented on the Web, making this an exemplary case of a holistic landscape monitoring programme.

4.3 Comprehensive marratives, partially art-driven and action-driven approaches

The aim of the approaches in this group is to monitor landscape development of smaller or larger regions by means of landscape descriptions that do not strictly follow indicators but are comprehensive narratives of the landscape. Most use photographs, some almost exclusively. There is frequently a strong link to art. Some use photographs uploaded and interpreted by the public and some rely on professional photographs. There is often a strong bottom-up and participatory component. The most important aim of the descriptions is not representativeness. Rather, a description is provided of the typical landscape characteristics as seen by the public or by experts. Six approaches are included in this group that are similar in terms of the evaluation of the criterion type of assessment (non-indicator) and a more art-driven approach. These include the monitoring of the protected area of Chasseral (Switzerland) and the landscape monitoring systems of France (the Photo monitoring not the Landscape Atlases), Wallonia, Tagus, Peru and the Semois valley.

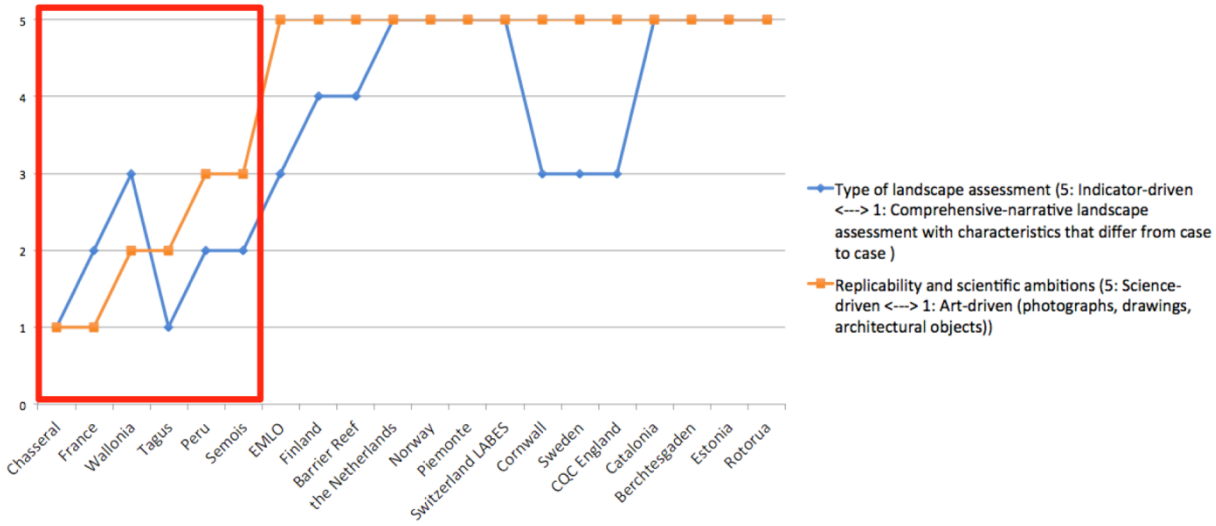

Fig. 15: Ranking of the investigated approaches according to the criterion type of assessment and replicability

Advantages of these monitoring systems include the rapid characterisation of the important landscape features of a region and the fact that there is often no tedious search for data or long time series (except for the professional photo time series). Furthermore, through the bottom-up approach these monitoring systems integrate the views of the population and are well suited to implementation by associations.

The disadvantages include the fact that landscape development and changes are difficult to substantiate on a quantitative basis, which is often demanded by decision makers, and sectoral recommendations are difficult to make. Another drawback is the strong focus on the visual aspects of landscape through the use of photographs, potentially neglecting other important values.

4.4 Landscape Character Assessments (LCAs) with a Monitoring Component

The basic idea in this group is to repeat landscape character assessments (LCAs, see [136]) at given time steps and compare the changes through time. The most prominent example is the pioneering work of the Countryside Quality Counts (CQC) initiative from England. This aims at monitoring landscape quality through time in roughly 160 joint character areas in England [137], [138]. The monitoring analyses what physical changes in the landscape occur in each landscape character area, whether those changes matter and whether the overall character of the landscape has changed. This change is compared to the vision statement of a broad panel of stakeholders, which summarises how the character area should develop in the future. This group occupies an intermediate position between the purely indicator-driven (section 4.2) and the comprehensive narrative approaches (section 4.3). The two approaches that fit this profile are the CQC England and the Landscape Character Study, Cornwall.

4.5 Approaches for protected areas

Monitoring approaches for protected areas have in common the fact that their geographic extent is very clearly defined and that there is a management body in place that is immediately interested in results and in the maintenance of the monitoring programme. However, approaches may differ

considerably between different protected areas. A protected area monitoring scheme experiment will be presented below.

Fig. 16: The Great Barrier Reef is a protected area where the aim of monitoring is to inform reef managers – image 'The Great Barrier Reef – 189' by Kyle Taylor on www.flickr.com (licensed as creative commons CC BY 2.0)

The Berchtesgaden National Park is a protected area according to Category II (National Park) of the International Union for Conservation of Nature (IUCN) and it limits its monitoring almost exclusively to biological-ecological and physical aspects of the protected landscape.
The Great Barrier Reef is an IUCN Category V (Protected Landscape/Seascape) area, where the aim of monitoring is to inform reef managers about the current status and historical and possible future trends of the local industries, communities and park users. It should provide social and economic information for effective management and planning. Therefore, the attitudes of stakeholders, (e.g., tourists, fishers, residents) towards the reef are also monitored. The Chasseral protected area observatory is a bottom-up initiative, and was included therefore in the group of comprehensive narrative and art-based monitoring programmes, as the emphasis is on photographs taken by the population to promote place attachment and place-making.

5. Key factors for successful implementation

Landscape monitoring is a challenging task, as it covers many dimensions ranging from the ecological to the social and cultural. Therefore, expertise for landscape monitoring is needed from a range of disciplines including geology, ecology, geography, economy, sociology, psychology and history.

Considering the previous review of approaches, as well as the expertise acquired by the authors of this report with the Swiss landscape monitoring program over more than eight years, it is possible to list some key factors for successful implementation. integrated landscape monitoring schemes.

5.1 Use the monitoring type that is appropriate for the local situation

The following recommendations are given in accordance with the typology presented above,

The recommendations mentioned below are made according to the typology devised in chapter 5, namely, indicator-driven approaches, comprehensive narratives and partially art- and action-driven approaches, landscape character assessments and approaches for protected areas. They describe the situations in which they will have the greatest potential for success.

Indicator-driven approaches with representative scientific data

This approach is only recommended in cases of good availability of landscape-relevant data, which can be generated, e.g., from topographic maps or remote sensing data. An update cycle of two to five years should be guaranteed, otherwise the indicator-based approach is never up to date, due to the time delay. Indicator-based approaches need a sound conceptual model so that it is clear what each indicator measures. When collecting perception-based indicators, including aesthetic landscape perception and place attachment indicators, representative surveys should be preferentially conducted rather than expert-based assessments. These surveys are relatively expensive and may require a great deal of commitment from, and persuasion of, respective stakeholders. This may particularly be the case where governmental agencies are strongly oriented towards biodiversity monitoring and technological aspects.

However, the financial investment required for the surveys includes the costs involved when hiring large pools of experts, as is known from the assessment of landscape character (LCA). Furthermore, indicator-driven monitoring activities do not require a mandatory a priori classification of character areas. As a rule, a rough regionalisation may be sufficient, depending on the purposes of the monitoring. The fact that a priori landscape character areas do not have to be delineated makes indicator-based monitoring relatively inexpensive and flexible compared to LCAs. While a range of indicators allows for making policy-specific recommendations for a range of policies, it is difficult to generate a comprehensive overview of landscape relevant trends, as would be possible through landscape character assessments. Once all indicators have been recorded, the set of indicators can be relatively easily reduced through statistical analysis and expert judgments. The Swiss programme, for example, is evaluated every 10 years. Each indicator is checked to assess whether it is still needed and whether it adds to the overall landscape characterisation. This is beneficial because, in times of limited financial resources, the indicator-based approach can still be implemented as a sort of ‘mini version’ of a more comprehensive monitoring programme, enabling the maintenance of crucial time series and change detection, whereas LCA-based approaches may encounter more difficulties with reduced financial resources.

Comprehensive narratives, partially art- and action-driven approaches

These monitoring programmes are very well suited to arriving quickly at publicly effective statements about certain developments in the landscape. Since the approach does not claim to be representative, effective policy areas can be selected and depicted with great attention to detail and through a bottom-up approach. Since generally only photo time series are created, the approaches run the risk of not being taken seriously by politicians, since no ‘hard’ measurable facts are presented. These approaches are well suited to private sponsors or NGOs, as they offer great potential for mobilisation of the public with regard to landscape-relevant topics. These approaches also have potential to be integrated into larger monitoring programmes as a more bottom-up component that involves the population more directly than, e.g., the use of surveys or panels. Where

maintenance of time series is a necessity, burdening volunteers with this responsibility may not be viable in the long term, although there are several examples of highly successful environmental and cultural monitoring schemes that are based entirely on volunteers [139]-[142].

Landscape character assessments (LCAs) with a monitoring component

The comprehensive landscape description is the unique selling point of LCA-based monitoring activities and it ensures – in contrast to indicator-based monitoring schemes – that landscape is always seen in a holistic way and not through the sectoral view of many indicators. However, LCA requires a great deal of previous knowledge and preparatory work to delineate the homogeneous landscape character areas and a large pool of experts to cover the many aspects of the character regions. LCA-based monitoring activities require many well-coordinated steps (defining the development goals for a region, reviewing the old status with data and expert opinions, reviewing the new status and monitoring the achievement of goals for each region). Society must, as is the case in England, have an affinity for cultural landscape protection and thus assign a high value to landscape aspects. However, significant changes in landscape character are sometimes difficult to detect, because the character contains a multitude of aspects that are all interrelated. It may therefore take a long time and large changes for landscape character to change significantly, by which time taking corrective action may be challenging.

Approaches for protected areas

For protected areas there is usually an agreement or a decree, signed by a governmental organisation or an NGO designated by a public authority, with financial support and the obligation to monitor the development of the area. Under these circumstances, those in charge of monitoring usually choose the indicator-based approach with representative data collection. This can be seen in most monitoring schemes for protected areas. An indicator approach is also recommended because the size of the area under protection is usually manageable and does not – in most cases – cover entire regions. It could be quite risky to operate a narrative approach with only a few selected topics, as the protection status of an area must usually be periodically evaluated with representative parameters and reporting perspectives might easily change over the years. However, as seen in the case of the Chasseral, integration with a strongly place-based component that integrates the public's view is well suited to implementation in protected areas and can provide views from those who visit and live in a protected area to complement the indicator-based monitoring often required by funding bodies.

5.2 Endorse the monitoring

If monitoring is endorsed by an official governmental organisation or a committed non governmental organisation designated by a public authority, it is usually less likely to be discontinued. If it is only endorsed by citizen groups there may be a higher risk of the programme being discontinued, even though several citizen-based environmental programmes have been running for decades. Endorsement by an official body facilitates access to policy-relevant administrative bodies and thus helps in implementing the European Landscape Convention, as the Parties to the Convention are states. In our selection of 20 approaches, approximately 65% have official status as part of a national

report, (e.g., Switzerland LABES, the Netherlands), a provincial/regional report, (e.g., Wallonia) or a report organised by an NGO (Peru, EMLO).

5.3. Seek public participation and encourage citizen science

Public participation boosts motivation, stimulates self-responsibility and helps to reduce mistrust. It contributes to confidence-building, acceptance and identification with the landscape monitoring system. This is especially important for action-oriented bottom-up initiatives. However, participation should not be placed solely on the shoulders of volunteers, as enthusiasm may or may not cease after a few years, depending on the community of volunteers and their dedication. Furthermore, volunteer work is often strongly dependent on individuals, with success or failure hinging on the contribution or blockade of individuals. However, key people as drivers are essential and highly beneficial to the process, especially in the initial phases of a landscape observatory, but also for ensuring continuity and maintaining a high quality of overall volunteer-based monitoring. Approaches based on volunteers are increasingly being used in many different fields and have become known as citizen science. Citizen science is already used in some monitoring activities, (e.g., the photo observatories), and it has a large potential that should be utilised even more, whether in the form of uploaded photographs or texts highlighting the perceived landscape character of a region.

5.4. Inform stakeholders and the public

Monitoring activities are usually not among the most attractive topics discussed by politicians or scientists. Thus, it is important that stakeholders are kept informed, that contacts with the media are maintained and that suitable political events are chosen for press releases. In each monitoring programme there will be data that the public responds well to. In the Swiss monitoring programme, for example, the survey results on landscape perception were extremely well received. It was demonstrated, for example, that the population in the peri-urban areas perceives the landscape least positively, and that both the urban centres and rural areas are perceived much more positively. The media response to the publication of the light emission data was also positive. It was embedded in the message that the population should be able to see the stars in the night sky, because this is an important dimension of the night landscape.

Fig. 17: Peri-urban landscape in Pfäffikon SZ, Switzerland – it was shown by surveys that the people living in peri-urban areas perceive this type of landscape the least positively (photo: S. Gosteli)

5.5 Willingness to accept a lay view in landscape assessment

This crucial point applies strongly to all indicator-based monitoring schemes. They have the tendency to use expert opinions and judgments and neglect the view of the broader public. This tendency is most obvious when it comes to judging landscape beauty and cultural meanings. In this aspect, comprehensive narrative monitoring activities on a participatory basis have a clear advantage, as they integrate the view of the broad public in their monitoring concept. Integrating this view can be a success factor when public decisions are at stake, for instance regional or local public votes on the protection status of land. Monitoring of the public perception of landscapes would strengthen many public debates on protected areas in Europe and would facilitate coalition-building.

5.6 Seek collaboration with research institutes

Scientific support is extremely important. It promotes credibility and thus the chances that recommendations are implemented. It is, however, necessary to beware of solely expert-driven landscape assessments. Experts often see their specialist field differently and their judgement can

deviate considerably from that of the population, even if the experts may claim to know and represent the view of the population.

5.7 Promote rapid availability of data

Most indicator-based monitoring schemes use official land-use data, some of which are already dated. The credibility would significantly increase if up-to-date data could be provided, e.g., from satellites with high temporal and spatial resolution. For instance, Sentinel-2 satellite data with multiple scenes per vegetation season could meet this requirement. These have been available since the end of 2015 and could be used, for example, to measure the dynamics of land use.

5.8 Be consistent with internationally-recognised landscape theories and concepts

If a landscape monitoring programme has a clear theoretical foundation, it is usually better accepted in the scientific community and, thus, in the realm of policy and administration, and indicators or descriptive data are better selected and prioritised. For this reason, the introductory chapters of this report present some basic theories that could help landscape monitoring programmes to establish a theoretical foundation. For indicator-driven approaches, indicators should be promoted that clearly link to broader landscape concepts. Indicator-driven monitoring activities are at particular risk of proposing indicators simply 'because they can be measured' without rigid control of what aspects of the landscape they should measure and in which broader theoretical framework of landscape research they are situated.

5.9 Use novel social science methods and emerging forms of data to gain information on people's place attachment

Due to recent advances in social science survey methods and the availability of crowd-sourced data, two important trends for modern landscape monitoring can be observed: (a) the breakthrough in the field of representative online panel surveys, which will enable the use of complex survey methods and visualisation techniques and (b) the immense possibilities of the analysis of so-called user-generated data (social media data), to capture the statements, commentaries and pictures of residents concerning landscapes and to evaluate cultural landscape values such as sense of place, place attachment, aesthetic appreciation and recreation [28], [143]-[147]. Instead of collecting people's knowledge or attitudes directly, which has the disadvantage of being 'reported' and therefore often biased, crowd-sourced data lead to inferring people's knowledge from their behaviour through digital traces [148]. A simple example of the use of crowd-sourced data is the map comparison shown in Fig. 18. The upper map in Fig. 18 shows the results of the Swiss landscape monitoring indicator "landscape beauty of the municipality", as expressed by a Switzerland-wide representative number of people, aggregated by districts. The lower map is taken from a query on Instagram and shows the number of user-uploaded images using the hashtag "landscape" (#landscape). There is quite a large agreement between the two maps, highlighting that alpine areas are perceived as more beautiful by residents (as assessed in the survey), and are also photographed more on social media (as evidenced through Instagram images). There are also areas where the two methods yield different results, which makes it interesting to investigate such methods in more detail. The example shows that social media have the potential to validly reproduce results from traditional surveys but also to generate a great deal of new information. It still needs to be assessed whether the new methodological possibilities can be combined with traditional surveys, (e.g., in a mixed-method approach) or should be run in

parallel. The Swiss landscape monitoring programme LABES will undergo a rigid methodological evaluation to answer these questions.

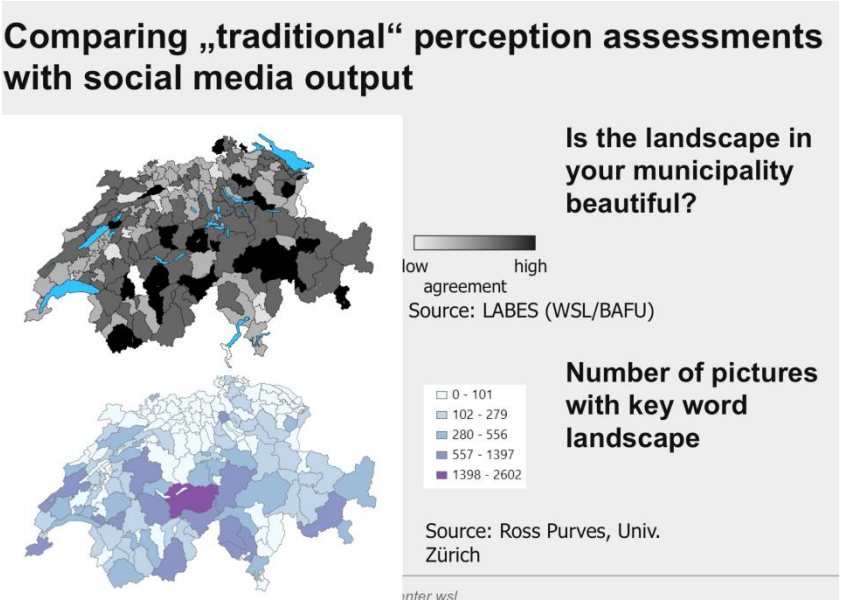

Fig. 18: Comparing perception assessments originating from representative surveys with crowd-sourced data

6. Future challenges for landscape monitoring

Most of the landscape monitoring schemes presented here are able to respond to the current processes shaping landscapes. However, landscape monitoring should also be able to cover any future processes, the effects of which may only be seen in a few years or even decades. If one takes into account the enormous impact of globalisation, climate change and migration, the development in communication technologies and the global decoupling of capital (land) and people, landscape monitoring must continuously strive to identify how these processes will impact on societies and their relationship with landscapes. It appears that the topics mentioned in sections 6.1 to 6.4 are generally under-represented in approaches to landscape monitoring and should be considered for inclusion in existing monitoring instruments.

6.1 Light and soundscapes

Very few landscape monitoring activities deal with light and soundscapes. The night landscape is often completely neglected, thereby omitting an important aspect of the environment for the ecology, human health and culture [149]-[151]. Light emissions increasingly brighten the night sky. A strong increase has been observed worldwide over the last 20-30 years [152].

Fig. 19: The sound of water flowing from a fountain is an example of a pleasant *element of a soundscape – fountain in Zurich, Switzerland* (photo: S. Gosteli)

Excessive nocturnal brightness can affect the habitats of nocturnal animals, with sometimes fatal consequences for insect and animal populations. For example, light pollution can disturb the orientation of flying animals such as birds or bats [153]-[156], but marine mammals such as turtles also become disoriented through artificial night lights [157]-[159]. The loss of the night landscape also poses problems for humans. Star observation becomes almost impossible for astronomers and the fact that 60% of Europeans cannot see the Milky Way or can only see it to a limited extent, is a cultural loss [152]. Too much light at night can also be harmful to health. The "internal clock" regulates various bodily functions and is closely linked to the daily change from light to dark. The hormone melatonin, for example, is only produced in dark phases. If production is disrupted, sleep disturbances or changes in the immune system can occur [160]. An economic study estimates the damage caused by light pollution in the USA alone at USD seven billion per year [161].

Fig. 20: *Artificial light emissions change the night landscape – bright night sky in Zurich, Switzerland – image "Lights of the plain at sunset II" by Tambako The Jaguar* on ww.flickr.com (licensed as creative commons CC BY-NC 2.0)

Besides these negative aspects of artificial night lighting, there is a trend in many societies towards using light in an artistic way that enhances people's experiences of landscapes at night [162], where

a sustainable use of light can improve the experience of a night landscape and generate bonding to a place.

Regarding soundscapes, very few monitoring systems observe the sounds of the landscape. The Okinawa Environmental Observation Network (OKEON) is a good example. It would be desirable to operationalise soundscape ecological research [163] in large-scale monitoring of the soundscape that would enable us to link visual and biological properties of landscapes with sound aspects and add this important component [164], [165]. Furthermore, there is promising research demonstrating how aural aspects of landscapes can be extracted from user-generated texts in the UK, providing a citizen-based assessment of sounds in the landscape [166].

6.2 Systematic place-making and place attachment monitoring

Many of the comprehensive narrative and partially art- and action-driven approaches are based on concepts of place attachment, place-making and sense of place. These projects are often positioned as initiators to promote sense of place by means of participatory processes. However, because there is a demand for quantitative indicators from policymakers, there is a need to integrate qualitative assessments of place attachment with measuring systems that allow those aspects to be taken into account, otherwise there is a risk of them being overlooked in favour of more easily quantifiable indicators such as recreation. The approaches of the Tagus river (Portugal), the Chasseral (Switzerland) or the Observatoire Citoyen du Paysage (Belgium) programmes are interesting. It would be desirable if these approaches developed systematic place attachment indicators [167] to measure place attachment through time. Such systematic approaches could be complemented with qualitative and art-based approaches for a more holistic assessment of this important aspect of people-landscape relationships.

6.3 Indicators measuring the role of landscapes in integrating migrants

Studies show that the longer people reside in a place, the stronger their place attachment becomes ([34], [35]), but there is also evidence for place attachment developing more immediately [168]. With globalised workplaces and voluntary and forced migration in our global societies, people increasingly need places they can feel connected to and can access easily and quickly, irrespective of their sociodemographic and cultural backgrounds. None of the reviewed approaches has taken into account the inclusive character of landscapes, although a recent review sheds light on the role of landscapes in promoting inclusion [169]. Enabling inclusive experiences in landscapes and creating landscapes that enable such inclusion is paramount in our changing societies.

6.4 Indicators measuring the success of legal instruments

Few monitoring activities explicitly look at the legal instruments of landscape protection and landscape management. Today – at least in democratic states – many court rulings or approval procedures are publicly and digitally accessible and could be recorded over the time periods under which, or in the context within which, certain laws or incentives have an effect. The example from New Zealand (Rotorua) in which it is counted how often resource consents by indigenous groups of people (*tangata whenua*) are given, is very illustrative.

Conclusion

Landscapes are changing rapidly. States Parties to the European Landscape Convention undertake to identify the landscapes throughout their territory, to analyse their characteristics and the forces and pressures transforming them and to take note of their changes. Grounded in the integrated landscape definition of the Convention, these activities must take into account both the physical aspects of landscape and how landscapes are perceived by people.

A wide variety of landscape monitoring approaches can be observed; some have been presented in a synthesis that also includes particularly notable examples from different points of the globe. These approaches were grouped into different categories (indicator-driven approaches, comprehensive narratives and landscape character assessments…). Based on experience with the Swiss landscape monitoring programme, a set of key factors for the successful implementation of a monitoring programme was identified. Ensuring the endorsement of the monitoring by official (governmental) bodies is essential to secure the long-term implementation of a monitoring scheme, as well as to secure the rapid availability of data needed for the monitoring to be effective and timely in informing policy and decision-making. Public participation and generating information from the bottom up about how people perceive landscape (change), rather than solely conducting expert assessments, is also of major importance. Novel methods, such as art-based and action-oriented approaches have been successfully used and have considerable potential. Societal trends, such as the use of social media to post experiences and impressions of landscapes and places, enable us to assess landscape perception and people-place relations cost-effectively at large spatial scales, which was previously unfeasible.

Importantly, landscape monitoring activities need to be constantly adapted to capture relevant aspects of landscape change. It appears important to monitor changes in nightscapes, which are affected by artificial night lighting, and to develop and apply indicators measuring changes to soundscapes. Furthermore, in our changing societies there is also a need to reflect how landscapes can become inclusive places that enable people from different cultural and socio-economic backgrounds to connect with and relate to the landscape.

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Appendix

The experiences from the Swiss Landscape Monitoring Programme,

an indicator-driven monitoring programme of physical and perceived landscapes

The Swiss landscape monitoring programme (Landschaftsbeobachtung Schweiz or LABES) is a national monitoring programme that measures physical landscape properties as well as their perception by the local population. It meets many of the desired criteria and success factors listed in this report, such as representativeness, linking physical and experienced landscape properties and official endorsement by a government agency.

Although tested and applied in Switzerland, a country with high landscape awareness in the population, the LABES concept, or at least some part of it, could be applied in other countries. There may however be limits to the transferability of its concepts, which would be very interesting to examine.

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*

The systematic monitoring is based on the following landscape concepts.

- pattern and process paradigms in landscape ecology [5];
- disturbance theories in ecology;
- ecosystem services;
- perception theories (evolutionary and culturally-driven concepts);
- theories of place attachment;
- theories of the restorative environment;

- the centre-periphery concept in spatial planning;
- the driving force-pressure-state-impact-response framework DPSIR [67].

A.1 Indicators of the Swiss Landscape Monitoring

The full set of LABES indicators consists of: (1) indicators that can be derived from land cover data, satellite images, census statistics and digital maps and (2) indicators that are derived from surveying respondents' perceptions and place attachment in the resident community. Each indicator is used to measure a specific aspect of the Swiss landscape and is justified by one or more of the theoretical concepts listed above. Depending on the source, the indicators cover one to a maximum of five time intervals over a maximum of approximately 70 years. All indicators cover the whole of Switzerland or are a representative sample of the object of interest. More details about the temporal aspects are presented below:

- around 50% of the indicators (mainly physical and land-use indicators) cover a time range from the 1970s to the present, with two to four time intervals.
- around 20% of the indicators cover a time range from the 1990s to the present, with two to four time intervals.
- selected indicators cover longer time periods (1930s to the present for urban sprawl) or have an annual resolution (light emissions).
- perception and place attachment indicators (around 30% of the indicators) had their first assessment in 2011, with the next assessment planned for 2020.

Most of the indicators for the physical landscape and land use (Table A1) are self-explanatory. The perception/place attachment indicators have been gathered into a standardised questionnaire that was sent out to a representative sample of 8,700 households in three languages (German/French/Italian).[2] A total of 2,814 questionnaires were returned, which amounts to a return rate of 35%.
All respondents were instructed to base their statements on the landscape and places of their current home municipality. In addition, respondents were asked to indicate how important each landscape assessment concept, (e.g., legibility or aesthetic beauty) is to them with respect to their home municipality. The statements had been previously tested for scale reliability and validity in an extensive pretest. The assessment is fully based on people's mental images of places in their home municipality and not based on photographs, video sequences or hand-drawn sketches. This conceptual decision to work without visualisations is worth discussing here. The merits of using visualisations in planning and design have been documented in the literature [170], [171]. They have great potential for use in local planning where the photographs or videos match the local context. For a national survey, however, this would mean that a high number of locally adapted questionnaires, with hundreds of local visualisations, would have to be generated. This is by no means financially feasible and would add unpredictable noise to the data. It was therefore decided to use perception

2. The selection of households followed the concept of stratified random sampling, each canton of Switzerland (equivalent to a federal state) representing a stratum with at least 300 questionnaires sent out. With this sampling strategy, we reached a relatively even spatial distribution of respondents at the national level. Within each canton, however, the random selection procedure selects respondents based on the population density; hence, the resulting spatial pattern resembles the pattern of towns and villages. The stratified random sampling follows the principles of the federal state, i.e., giving equal weight to each canton and at the same time, giving enough weight to the densely populated areas. For the analysis, answers were weighted according to the unit of interest (nation, canton, or district).

parameters that are independent of visualisations.

Table A1: The full set of landscape indicators, corresponding to DPSIR (D = driver, P = pressure, S = state, I = impact, R = response), spatial resolution and data sources.

Physical properties and land-use related characteristics		**DPSIR**	**Spatial resolution**	**Data sources***
	general			
SETTLE	Settlement area	P	100 m grid	a
QUAL_RESIDENTIAL	Landscape quality in the residential area	I	Municipality	
IMPERV	Impervious area	P	100 m grid	a, d
LOW_INT	Area with low management intensity	P	100 m grid	a, e, g
NO_INF FEW_INF	Area without buildings and infrastructure Area with a few buildings and infrastructure	S	500 m grid	c1
FRAG_LARGE_RD FRAG_SMALL_RD	Landscape fragmentation (2 classes of road widths)	S	Polygon District (m_{eff})	c1, g
URB_PERM	Urban permeation, urban sprawl	S	District	c1, c2, c3, f2, f3
CENT_PRIV CENT_PUBLIC	Travel time to central services (public & private transportation)			
LIGHT_E	Light emissions	I	1 km grid	d
	Recreational use			
RECR RECR_DIST RECR_DIST_POP	Accessibility of near-by recreation areas (independent of distance to settlements; distance-weighted; distance & population weighed)	S	25 m grid	b, c1, h
HIKE	Availability of hiking trails	S	Line feature	c1, i
ACCESS_RIV	Rivers with public access	S	500 m grid	c1, h
FEW_INF_RECR	Area with a low density of buildings and infrastructure suitable for recreation	P	100 m grid	a
	Agricultural and forestry use			
AGRI_CHANGE	Change in agricultural area	P	100 m grid	a, f1
AGRI_DIV	Diversity of agricultural use	P	Municipality	f1
FOREST_CH	Change in forested area	P		b

ANGE				
FOREST_EDGE	Length of forest edge	P		b
LOW_INT_FOREST	Area of low-intensity forest use	P	1.4 km (NFI-) grid	e
ALP_PAST	Alpine pastures	P	100 m grid	a
	Landscape perception			
CPLX COHE MYST LEGI	Perceived landscape structure (information content) Complexity, Coherence, Mystery, Legibility	S	Municipality	h
PLACE	Place attachment	I	Municipality	h
DIST CONT	Distinctiveness of the landscape (character and reference to the past)	I	Municipality	h
AUTH	Authenticity	I	Municipality	h
FASC	Fascination	I	Municipality	h
BEAU	Perceived landscape beauty	I	Municipality	h
	Legal aspects of landscape conservation			
CONSERV_AREA	Federal landscape- and nature conservation areas	R	Polygon feature	g
REGIONAL_PARKS	Regional parks of national importance	R	Polygon feature	

* Data sources:
a = Arealstatistik (BFS, 2005)
b = digital topographic map 2011 (VBS, 2013)
c1, c2, c3 = digital topographic map 2007 (Swisstopo, 2007), map 1:100’000, map Dufour 1:100’000
d = remote sensing (DMSP, 1994-2009)
e = National Forest Inventory (SZF, 2011)
f1, f2, f3 = agricultural census (Landwirtschaftliche Betriebsstrukturerhebung), census of enterprises, population census
g = national inventories
h = public questionnaire
i = Federal offices
k = map ecomorphology water

A.2 Use of the indicators

The use of the indicators presents advantages and disadvantages, as described below.

Advantages

LABES is a systematic national landscape monitoring programme with a set of tested indicators that are able to measure both the physical and sociocultural aspects of landscape quality. Most of the benchmarks mentioned in this report could be met with the current selection, i.e., the set proved to be comprehensive and representative for Switzerland and yielding a national coverage of physical

landscape properties and their changes. In parallel, how local residents perceive the landscape in their municipality in terms of its beauty, fascination or authenticity is monitored, which may be considered an important milestone in landscape monitoring. Analysis of the data showed that this indicator set is capable of picking up a dominant urban-rural gradient in the data, as described by, e.g., Wu et al. [172] or Dietzel [173]. In Switzerland, the urban-rural gradient is caused by a highly mobile and leisure-oriented urban society, with an increasing per capita consumption of space for housing and transportation and at the same time, a desire for high-quality recreation areas around settlements and authentic and 'natural' landscapes in the countryside. Research is ongoing to develop landscape models that link physical landscape properties with landscape appreciation values.

Data availability

Due to the fact that the data are predominantly derived from land-use surveys, topographical maps or census products, data availability for the last decades and the future is ensured. If possible, data stemming from non-repeated surveys or data collection efforts should be used with caution, as repeated measurements are absolutely essential for a reliable assessment. This problem was experienced with, e.g., the eco-morphological assessment of rivers and streams, which will probably not be updated in the near future due to financial constraints.

As far as data availability for the questionnaires about landscape perception is concerned, the Swiss landscape monitoring programme has gathered only the first time step to date. As this data set is so far the only one, and because it is collected exclusively for this landscape monitoring programme, it is expected that the survey will be repeated every eight to 10 years, albeit with higher target numbers of respondents, to reach the spatial detail required for downscaling of the indicators (see below).

Periodically revised indicator set

The quality of this monitoring activity is maintained by periodically reviewing the topics and indicators and the concepts/methods used. A review will take place between 2018 and 2019, so that a new time step can be worked out in 2020. Thematically, there are emerging landscape topics that have not been covered by the current indicator set. These include the topic of sustainable energy production, which will considerably influence the visual aspects of landscapes, (e.g., wind energy, power-line grids), or the topic of landscape and health, which is only partially covered by the indicators on recreation. New methods will include analysis of novel emerging data sources, such as social media, to establish complementary information about place attachment and landscape perception. Other novel data sources include spatially and temporally high-resolution satellite data for capturing intra-annual land-use dynamics for agricultural land.

Disadvantages

For the advocates of comprehensive narrative monitoring, LABES is too little driven by art- and action-oriented approaches and does not include any qualitative descriptors of landscape. Furthermore, it has the problem that a synthetic view of the landscape from the perspective of many individual indicators is difficult to achieve. LABES does not focus (for the time being) on citizen science and is not expected to use data from social media until 2020.

Still awaiting selection of a core set of indicators

LABES comprises a selection of indicators that is based on literature surveys, statistical considerations and expert knowledge. It became obvious that 30-40 indicators are the upper limit of what national surveys are capable of maintaining (due to costs, expertise, data maintenance, etc.). Thus, it would be important to prioritise the indicator set using so-called 'umbrella' indicators that are able to capture many aspects of the development of landscapes, together with indicators that allow specific assessments. In a correlation analysis, it was shown that the monitoring could be done at reduced costs with roughly two thirds of the full set of indicators [11]. This is not to say that the full set is not needed, but in the event of strong financial cuts the reduced set is a minimum set which contains a high, yet reduced, informational content and which could assure the maintenance of an absolute minimum of indicators allowing time-series analysis of landscape change in Switzerland. One of these indispensable indicators is the indicator of light emissions. Due to the high spatial and temporal resolution of the data and the high correlation with many land-use and perception indicators, it is one of the umbrella indicators with the highest relevance. It has been shown, for example, how light emissions in Switzerland have risen in the past, and how the area of complete darkness has diminished, particularly on the Swiss Plateau and in the Jura Mountains. This is consistent with the information from other indicators, (e.g., areas free of buildings and infrastructure) and marks a considerable loss of 'naturalness' in Switzerland.

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