Science Parks and Responsible Innovation

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THE AIMS OF THE PAPER

For a long time, science parks have been considered as important economic development initiatives connected to knowledge-creating institutions. They are perceived to significantly contribute to technology transfer activities and new venture formation. So, with gathering the key innovative players and facilitating innovation processes, science parks may also shape the formation of attitudes towards innovation. A new line of thinking has popped up in innovation studies which has placed responsibility into the focus of its interest. This emerging notion of Responsible Research and Innovation (RRI) deals with several oft neglected dimensions of the innovation process such as ethical, societal or environmental fields. The concept of RRI can put into practice more easily in science parks since these are spaces of innovation where a higher concentration of innovative players can be found. Thus, our study aims to theoretically examine how the concept of RRI in general can be applied in science parks

METHODOLOGY

Literature review is used to present a theoretical approach of the roles of different science park generations in terms of RRI uptake.

MOST IMPORTANT RESULTS

In first and second generation science parks universities drive the uptake of RRI while in third generation science parks, owing to the players' mutual dependence and the interactive mode of innovation, RRI efforts are initiated via common decisions and projects between different partners.

PRACTICAL/POLICY RECOMMENDATIONS

Universities connected to science parks have a crucial role in science education as an RRI key, thus their involvement may contribute to better understand innovation process and the responsible way of innovation activities. Further policy recommendations for governments is to regulate innovation processes based on the concept of RRI, e.g., a government may require open public debates on a scientific result, or may motivate universities to better engage the public or offer easily understandable scientific education/training to the public.

Keywords: science parks, responsible research and innovation, innovation, RRI

INTRODUCTION

Innovation is one of the main driving forces of the economy (Cooke et al. 2007; Edquist 2005). Several new products have affected the everyday life and opened up brand new market opportunities. Many previously insolvable problems have disappeared thanks to certain technological advancements. Nevertheless, besides the wide scale of benefits, a lot of undesired side-effects, which are also inherent parts of the innovation process, are often out of consideration (see, e.g. Lukovics et al. 2018). Additionally, several new or significantly improved products or processes that supposed to solve one problem frequently bring forth other unforeseeable negative consequences. Some actors tend to rely on moral luck (Williams 1981), believing they are not responsible for the negative consequences of innovation because the process of innovation has become so complex that these consequences could not be foreseen reasonably (Buzás & Lukovics 2015). In light of these considerations and building upon decades of attempts to take them into account, recent developments in innovation studies have placed responsibility into the focus and introduced the notion of Responsible Research and Innovation (RRI).

RRI tries to exceed the traditional limits of innovation thinking by – among others – involving stakeholder engagement or public dialogue as new elements to the innovation process. It broadens the scope of innovation process with other dimensions than economic value such as ethical, societal or environmental ones (Schomberg 2013). It shows a commitment towards the future by taking into consideration these dimensions in the present. The most popular and well-known *environmental dimension* reflects to the protection of environment and the sustainable use of natural resources. Commonly the *societal aspect* deals with the contradictory relationship between technological development and social disadvantages. Finally, the *ethical dimension* covers the conflicts between technological development and the commonly agreed value set of the society (Buzás & Lukovics 2015; de Campos et al. 2017; EC 2014; Flipse et al. 2014).

The increasing importance of knowledge, owing to its nature, has differentiated the economy (Gyurkovics & Lukovics 2014). In the proximity of knowledge creating centres, knowledge-based economic activities have become concentrated in a geographical sense. As a result, knowledge-creating organisations have been placed in focus by many economic development interventions, and of these organisations universities have aroused the keenest interest. The set of economic development interventions has also significantly grown and include means that build on universities – one of such means is science parks. Science parks are explicitly established to concentrate the most prominent innovation players in the vicinity of a university in order to utilise its results, while other initiatives, such as business incubators, technopoles and business parks, rather focus on business development than innovation.

In line with the growing interest in the concept of Responsible Research and Innovation, studies that seek to put RRI into practice are growing in number (see, e.g., Antiel & Flake 2017; Arnaldi et al. 2015; Forsberg et al. 2015; Fisher 2007; Lukovics et al. 2017; Stahl & Coeckelbergh 2016). Most of these studies are performed in an academic setting, and health, bio- and nanotechnology and robotics gained special attention. However, during our research we have found no analysis regarding the possibilities of integrating the concept of responsible innovation with the support of science parks. In our view science parks can be places where the practical application of RRI might be successful. They collect the main research and innovation results of a region and gather players performing innovative activities. Thus, science parks may clearly play a crucial role in the formation of attitudes towards innovation. In this way *the main aim of our study is to theoretically examine how the concept of RRI in general can be applied in science parks*.

The paper is organised as follows. Firstly, we briefly introduce the concept of RRI. After it, an overview about science parks will be provided since these initiatives might be defined as spaces of innovation where the concept of RRI can be put into practice more easily because of the higher concentration of innovative players. Finally, we examine the interrelations between the concept of RRI and science parks.

RESPONSIBLE RESEARCH AND INNOVATION

Responsible Research and Innovation has in recent years become an expression to refer to a growing interest from different actors to make research and innovation processes more ethically accountable and more responsive to society. The term is being used by scholars, as well as in policy circles,

especially in Europe. The roots of RRI are found in management, technology assessment, science and technology studies, and other areas (Inzelt & Csonka 2014; Owen et al. 2012), the concept has several definitions suggestive of its multidisciplinary origin (Buzás & Lukovics 2015; Chorus et al. 2012; Owen et al. 2012; Fisher & Rip 2013; Sutcliffe 2013). A frequently cited definition of RRI is that by philosopher and European Commission policy officer René von Schomberg: *"Responsible Research and Innovation is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society)."* (Schomberg 2011, 47). RRI is described similarly in recent official statements by the European Commission (EC 2013): *"RRI is an inclusive approach to research and innovation (R&I), to ensure that societal actors work together during the whole research and innovation process. It aims to better align both the process and outcomes of R&I with the values, needs and expectations of European society"*. Thus, RRI delegates an important role to cooperation between the actors of innovation. In responsible innovation it is not enough to provide solutions concerning the product itself; it is also important to consider the research process and issues affected by the goals (Stilgoe et al. 2013). Therefore, besides the risks and benefits of a product, and other foreseeable societal dimensions, adequately addressing issues about how to integrate existing standards, how to define and measure impacts, who is responsible when something goes wrong and who is responsible for performing checks are needed. Answers are also required concerning the purpose of the research, the transparency of motivations, the beneficiaries of the innovation and selection among existing alternatives (Stilgoe et al. 2013).

Whether a certain research and development or innovation project (including its processes) accords with the principles of responsible innovation or not, the four dimensions of responsible innovation needs to be analyzed (Buzás & Lukovics 2015; Carbajo & Cabeza 2018; Owen et al. 2013; Stilgoe et al. 2013). *Anticipation* refers to the need for researchers and developers to constantly think about both known and yet unknown, but potential adverse effects, with questions like "What if?" in mind. *Reflexivity* examines the assumptions that limit technical experts' ability to identify and anticipate possible repercussions of their decisions, objectives, and motivations. *Inclusion* refers to genuinely listening not only to the opinion of direct stakeholders, but to that of diverse and wider publics. *Responsiveness* has to do with taking actions that take into account during R&D&I processes the values, concerns and opinions of diverse stakeholders regarding hazards and risks by adjusting the course of research, development and commercialization accordingly. In addition to these procedural principles that can help both scientific and industrial actors identify and integrate stakeholder values into their technical processes, the European Commission has also listed six key elements of responsible innovation (RRI keys) (EC 2014), which overlap to some extent with the aforementioned dimensions (see Table 1).

Table 1: Connection between RRI dimensions and RRI 6 keys

RRI dimensions	RRI 6 keys
Anticipation	Ethics
Reflexivity	Gender equality Governance
Inclusion	Public engagement in innovation Scientific education Open access
Responsiveness	Gender equality Ethics Governance

Source: own construction

The first key is *public engagement in innovation* which ensures wider acceptance of outputs and more effective ways to tackle the urgent societal challenges. *Gender equality,* as the second RRI key, aims to improve the opportunities of women and the under-representation of women researchers. *Scientific education* – the third RRI key – aims at broadening the knowledge of future researchers and other societal actors, so that they would be able to participate more actively in the innovation processes and they would be able to express their opinion in public engagement. The fifth key, *ethics* respects and adherences to shared values of the European Union (basic human rights and ethical standards). The fifth RRI-key, *open access* seeks to ensure the availability of research results to everyone. All these are put under control with the sixth key: *governance* ensures both the formal regulatory environment and the informal interactions among innovation actors.

How to put RRI into practice is in the focus of current researches (see, e.g., Bajmócy & Pataki 2019; Lukovics et al. 2018), but less attention is paid to science parks though they are key actors of innovation processes. Regarding science parks, the most important actors are governments, private companies and universities. Governments, national or local, promote the public interest and general welfare, and in this context, they have a responsibility to help ensure that the actions of these actors have social benefits, conform to standards of ethics, include stakeholder engagement, anticipation and reflection, and employs multi-stakeholder governance. They also have an interest to promote the economy, which involves not placing unnecessary burdens or restrictions on private industry. Private companies usually have a profit motive, but many aims to make a positive contribution to society as well, and it is increasingly in the interest of companies to be seen by clients and other stakeholders as responsible corporate citizens that help solve problems in society rather than causing them. Universities are actors that science parks rely on for scientific knowledge and innovative ideas. Most universities are publicly funded, and as such have a responsibility to contribute to the public interest, mostly through the production of new knowledge and ideas.

Our study therefore will focus on current strategies of governments and private companies to give shape to RRI in the operations of science parks. We will focus on the role of government in developing laws, regulations, frameworks, and incentives for RRI in science parks, and on the role of private companies in these parks. To the extent that the management of science parks is separate from both government and the private companies that participate in them, we will also study their actions and responsibilities.

SCIENCE PARKS

There is no uniform concept description of 'science parks' in professional literature. What initiatives are labelled by science and development policies with this term changes from country to country. Extremely different development policy means are often also put under the 'science park' umbrella term, making even more difficult to provide a clear and precise definition (EC 2007). For example, the French technopole approach is frequently labelled as science park however it is a far bigger initiative. Mostly it comprises a complete settlement with research institutions, industrial and residential sites (Oh 1995). Business parks, on the other hand, are sometimes also referred as science parks but mainly these parks just provide high quality infrastructure without having close connection to a research centre or a university (EC 2007).

Due to the large number of definitions and the difficulties around offering an accurate description, this study does not select any particular definition. Instead, we compared the most often used definitions and identified their points of intersection (Gyurkovics & Lukovics 2014). Based on the definitions examined, four elements could be distinguished that are present – explicitly or implicitly – in all of the definitions: the importance of geographical proximity and the (physical) environment; partnerships with knowledge-creating institutions, universities; encouragement of knowledge/technology transfer; encouragement of the creation of new businesses (incubation services). The importance of geographical proximity and partnership with knowledge-creating institutions refer to the necessity for firms to be physically close to knowledge creating institutions and other firms in order to exploit the positive effects of knowledge spillovers (Colombo & Delmastro 2002). Proximity to research centres or universities provides firms located in a park easier access to scientific expertise and research results which facilitates their innovative activities. Jaffe (1989) and Acs and his co-authors (1992) find that spillovers from university research supported the innovative activity of local firms (Colombo & Delmastro 2002). Facilitating knowledge and technology flow between knowledge creating and knowledge

exploiting institutions are the third decisive element of science parks since these parks can support both the demand and supply side of knowledge flows. In one hand sophisticated users of developed technologies are concentrated in the park's domain which can lower the search cost of universities and research institutions (Link 2009). On the other hand, knowledge creating institutions provides highly trained and specialised workforce for firms which incite them to (re)locate to the parks' premises. Finally, the incubation element refers to the overarching goal to promote the establishment of new knowledge/technology intensive businesses.

Using these as a starting point and building on the research results of Capello and Morrison (2009), four functions could be defined which a science park can fulfil in its region's economic system. These functions are the followings: (i) *technology transfer function,* i.e. mediating advanced technologies and supporting their dissemination, (ii) *knowledge creating function,* i.e. the encouragement of the innovation activity, (iii) *„seedbed" function,* which plays a decisive role in the creation of a special environment, and (iv) *incubation function,* i.e. the encouragement of the creation of new technology-intensive businesses. Which of these functions is more dominant is strongly determined by the profile of the given science park and the identity and motivations of its owners. The above-mentioned authors highlight the fact that *science parks, as understood in the traditional sense* (i.e. a real estate development in a given geographical region, where enterprises, research centres and universities are gathered), *can fulfil all of these functions at a high level, with the exception of technology transfer* (Capello & Morrison 2009).

Through their functions described above, science parks, being spaces of innovation, may do a lot for the translation of the responsible innovation concept into practice. They collect a region's main research and innovation results, gather players needing similar knowledge elements, stimulate two-way knowledge flows (Link 2009) and enhance university students' chances for local employment, i.e. the local utilisation of special expertise. It seems from the above that the primary roles of science parks are the collection of players (supporting the creation of knowledge intensive businesses and attracting such organisations to the given region) and the facilitation of innovation processes (stimulating businesses' innovation activities). However, the creation of new and the channelling of existing knowledge depends first and foremost on the members of science parks and, among them, primarily on universities. In summary, the concept of responsible research and innovation can be carried over to the operation of science parks and, through them, going forward, into the wider region's attitude, with the assistance of universities.

The results of studies on connections between universities and science parks scatter over a very wide range (Vedovello 1997; Hansson et al. 2005). However, none of the studies on this topic states that these connections could be ignored. Moreover, *it is exactly the network of relations with universities that determines the successfulness of science parks in a great extent.* As their innovation approach gets more sophisticated ("science push" being replaced by "interactive"), the efficient operation of these connections is even more strongly needed. At the same time, the nature of these relations should be clearly understood: in most cases, the main attraction to businesses is highly qualified human resources (Andersson et al. 2009) or informal relations, rather than contracted research projects or technology transfer contracts (Vedovello 1997).

Colombo and Delmastro (2002) and Löfsten and Lindelöf (2001) found that firms located in a science park are more likely to have connections to local universities or other firms than firms outside the park. It is also noted that knowledge sharing, which is necessary for the process of innovation, is faster among firms in close geographical proximity (eg. in a science park) (Chan & Lau 2005). Siegel, Westhead and Wright (2003) assessed the impact of university science parks on research productivity in the UK. They found that firms located inside a park have higher research productivity than firms outside of a science park. In their study on Spain, Díez-Vial and Fernández-Olmos (2015) also found that firms cooperating with universities and/or research institutions inside a science park would have a higher innovation performance (in case of product innovation). They also emphasize that even though firms that establish research cooperation with universities would have a higher innovation performance, but belonging to a science park would intensify these benefits.

In most cases, the creators and owners of science parks are universities (IASP 2012). In the beginning, the dominance of universities so much influenced the operation of science parks that the purpose of the first park generations was only to broaden universities' economic opportunities (Gyurkovics & Lukovics 2014). Later on *science parks has been established as an integral part of their larger region*. A more detailed overview of the history of the generations of science parks – based on Annerstedt (2006) – may help us understand the relations between science parks and universities (Table 2).

Table 2: Comparison of the three generations of science parks

Aspects	First generation	Second generation	Third generation
Aim	broaden universities' economic opportunities	support the creation and growth of innovation oriented businesses	improve the welfare of the local community
Mechanism of operation	economic utilisation of the university's research results	create technologies suitable for economic utilisation encourage university students to become entrepreneurs	support A-I-G relations and interactions offer a broad portfolio of innovation services develop the region's entrepreneurial culture
Location	in the immediate proximity of the university but not in the city centre	not in the city centre	in bustling city centres
Started by	mainly universities	primarily business organisations, the minority by universities	universities, businesses and local (municipal) government together
Management	organisation created by the university	organisation created by the private sector, the public sector has a smaller influence	a business jointly owned by the three sectors With a professional management team
Innovation approach	science push	market pull	interactive, feedback-based

Note: A-I-G = "academic-industrial-governmental"
Source: edited by the authors, based on Annerstedt (2006)

The creation of *first generation parks* was clearly inspired by the success achieved by Stanford University (Annerstedt 2006). This science park type is characterised by being located in the immediate proximity of universities. It gives home to a variety of incubation and business services and has access to external sources of financing. Park management is exclusively in the hand of university, through some foundation or self-owned enterprise. The key goals of first generation science parks are to broaden universities' economic opportunities and to support university-related business activities and communities (Gyurkovics & Lukovics 2014).

Second generation science parks can also be considered as some sort of "extension" of universities, but they are not necessarily located in the immediate proximity or operate under their exclusive supervision (Annerstedt 2006). Rather than the economic utilisation of the university's research results, the key driving force in second generation parks' operation is to create innovation oriented businesses and to support their growth. Management tasks are mostly performed by some privately owned business organisation, the academic and local governmental sectors being involved only in certain cases (Gyurkovics & Lukovics 2014).

The *third generation of science parks* exists in bustling urban regions. They are the manifestation of cooperation between economic, academic and government players (Annerstedt 2006, Gyurkovics & Lukovics 2014). The declared aim of these parks is to improve the welfare of the local community, through supporting efficient cooperation between these players. However, a well operating third generation park also offers a broad portfolio of innovation related services, contribute to the development of their regions' entrepreneurial culture and establish two-way communication between the creators and users of knowledge and technologies.

In summary, first-generation parks, which were exclusively built upon universities' needs and research results, were replaced by third-generation parks, which were more tightly knitted to the opportunities and needs of their region (Gyurkovics & Lukovics 2014). The initial "science push" approach was replaced by the

interactive innovation model. Accordingly, focus is no longer on aggressively pushing the results of universities into economic utilisation: now innovation activities that are based on two-way knowledge and information flow between the players are the key mechanisms.

RRI EFFORTS IN SCIENCE PARKS

Science parks, being an institutional form of collecting and producing innovation results, can play a crucial role in dissemination and practical application of the theory of responsible research and innovation. By its nature, science parks are governed by many equally important stakeholders. However, it is very important to identify who are the leaders of RRI efforts, and what kind of motivations of innovators exists.

As being one of the most influential actors in a science park, a university might lead the RRI efforts in most cases (Gyurkovics & Lukovics 2014). However, science park development always requires a multi-stakeholder approach, so businesses and government might also support RRI efforts in the park. This might be also supported by the change occurred in the innovation approach. While in the linear innovation process relations between players are practically one-way and are usually dominated by one of the two parties, the interactive innovation approach enables the timely detection and management of any negative impacts of innovations, through feedbacks. Owing to the players' mutual dependence and continuous communication, RRI efforts may be initiated not only by the academic sector but by a wide range of players connected to the science park. Still science parks might encounter the concept of responsible innovation primarily through the university's scientific base: universities can have a significant influence on science parks' members not only in the field of technology innovations but also in the dissemination of novel concepts. Although universities do not have the resource to establish and operate a science park. Funding a science park is mostly in the hands of the government or business investors while a professional management team should be trusted with the operation of the park. Universities have crucial role in science education as an RRI key, too. Its improvement may contribute to better understand innovation process and the responsible way of innovation activities.

The *motivations* of a park's members to learn and adapt the concept of RRI might depend on the aims of the science park which are defined by its owners. However it is very rare that only one type of actors establishes and operates a science park, so conflicting motivations of different stakeholders are present (Kleinheincz 1999). The motivation of national government is to improve the level of applied research in the national economy and to create more jobs. Besides job creation, regional and local governments endeavour to improve the attractiveness of their region for businesses and investors. Academic actors try to utilise their research results and to ensure better job opportunities for their students. Finally, business actors make effort to expand their research and development capacity by cooperating with research centres and to acquire highly skilled workforce. Nevertheless, the role of government should be mentioned, since a government may regulate innovation processes based on the concept of RRI, and e.g., a government may require open public debates on a scientific result, or may motivate universities to better engage the public or offer easily understandable scientific education/training to the public. Altogether, the rules of a science park are in the hand of a government, and the obligatory rules (coming outside of a science park) may lead a science park to adopt RRI principles.

As one can see none of the most common owners is interested in defining aims that facilitates ethical acceptability, social desirability or even sustainability if these approaches hamper their motivations. It could be integrated to their mission if the national science policy specifies it or other financial aid is provided but these external incentives rarely lead to long term success. However, a science park which aims to be well integrated in its region and set the aim of improving the welfare of the local community, which cannot be limited to merely improving the financial standards of life, might facilitate internal motivations at its residents (Gyurkovics & Lukovics 2014). That is, no strict regulations incite residents of a science park to integrate RRI approach to their normal operation but being in a special environment where other actors do business in line with this approach might facilitate this uptake internally. In this case, aspects other than financial matters (e.g. the improvement of efficiency resulting from innovations should not lead to a drastic decrease in employment or, if so, the company should have a predefined plan to handle such a situation) might get taken into account in the course of innovation processes, as

the players' internal motivation. Offering training programs in the topic and showing best practices for residents to facilitate RRI uptake might help to build their inner motivation. And finally, an additional motivation can be the fact that RRI may be a positive differentiating factor for the innovator in terms of doing business which can even result in reduced costs, and this financial advantage or just the distinctive image might also promote the diffusion of the concept within the park.

Since universities are perceived to be crucial actors in science park formation and operation it might be useful to study the dominant type of universities in a science park (Gyurkovics & Lukovics 2014, Brey et al. 2016). In the beginning, parks functioned as the point of collection of universities' research results – as a kind of extension of the university structure – and that required entrepreneurial activities also on behalf of universities. Consequently, promoting RRI was also a part of universities' entrepreneurial activity portfolio (in certain cases, this is integrated into the selection policy of the science park created by the university). However, as their aim has been extended by the improvement of the welfare of the local community, the engaged university model, in which both the park's players and the university work for the development of their wider territory, might prevail. And this engaged approach might broaden the set of intervention tools.

We can establish that this logic is in no conflict with the framework system of all three generations of science parks or the different university models. The differences between these generations can be identified in the leaders of RRI efforts, the motivations of innovators and the dominant third-mission operating mechanism of the universities involved (Table 3).

Table 3: Manifestation of RRI efforts in different generations of science parks

Aspects	First generation science parks	Second generation science parks	Third generation science parks
Leader in RRI efforts	university	university	university, management businesses, government
Innovators, motivation for the practical application of the RRI concept	meeting university expectations	meeting university expectations	general attitude, internal motivation, meeting university and partner expectations, positive image

Source: edited by the authors based on Gyurkovics & Lukovics (2014)

In first and second generation parks, RRI efforts are led by the university (Gyurkovics & Lukovics 2014, Brey et al. 2016). These parks do not yet have the multidimensional initiative and leadership which can already be observed in third generation parks. As a result, the first two generations of science parks can encounter the concept of responsible innovation primarily through the university's scientific base. Consequently, the motivations of a park's innovators to adapt the concept of RRI are not internal but external ones supported mainly by governmental funds. By contrast, third generation science parks, which are a more deeply integrated to their region, set the aim of improving the welfare of the local community. In this scenario, aspects other than financial matters (e.g. the improvement of efficiency resulting from innovations should not lead to a drastic decrease in employment or, if so, the company should have a predefined plan to handle such a situation) can get taken into account in the course of innovation processes, as the players' internal motivation. This is also supported by the change occurring in the third generation's innovation approach. While in the linear innovation process relations between players are practically one-way ones and are usually dominated by one of the two parties, the interactive innovation approach enables the timely detection and management of any negative impacts of innovations, through feedbacks. Owing to the players' mutual dependence and continuous communication, RRI efforts are initiated not only by the academic sector but by a wide range of players connected to the science park.

SUMMARY

This paper aimed to theoretically apply the concept of Responsible Research and Innovation (RRI) to science parks. After an introduction of the notion of RRI, a review was provided of science parks, their evolution, aims, organization, management and approach to innovation. Next, it was studied how different generation of science parks currently incorporate RRI in their operations.

An analysis was then made of the main RRI issues parks facing, and it was studied how such issues could be faced by them in the different generations of science parks. A distinction was made between classes of RRI issues, those of a general nature, those pertaining to the construction and operation of the material infrastructure of the park, and those pertaining to the regulation and operation of individual businesses in the parks. It could be said that in first and second generation science parks universities drive the uptake of RRI while in third generation science parks, owing to the players' mutual dependence and the interactive mode of innovation, RRI efforts are initiated via common decisions and projects between different partners. Since science parks are the seedbeds of innovators these responsibilities entail that RRI issues might be addressed in the mission of science parks, that local stakeholder interests and environmental consequences are taken into account in the construction and operation of science parks, that the special role of universities as providing publicly funded knowledge and ideas is expected, and that for individual businesses in the parks attention is paid to guidelines, support, information and advice.

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