Experience of place: colour and lighting design methods in the process of inclusive housing projects.

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ABSTRACT

The periods of confinement that we have experienced have highlighted the proven impact of the quality of living spaces on their occupants. While the health crisis has been at the heart of many debates in recent years, it has only served to highlight the issues at stake and to accelerate research into the quality of life in collective housing. The notion of quality of life often translates into the ambition to build responsible buildings, responding to issues of air quality, water quality, energy saving (etc.), however, the design of visual environments must be considered in the same way as the other intrinsic characteristics of the dwelling as elements contributing to meeting the expectations of inhabitants in terms of health and quality of life for all.
Our research has revealed that the architecture of collective housing often suffers from a lack of care when it comes to the design of their interior spaces. This can have detrimental effects on users. We hypothesised that a transdisciplinary approach (physicist/colour designer) based on optimising ambient factors could improve the quality of use of these spaces. The objective was to demonstrate scientifically how the spaces in which we live influence our quality of life. The results obtained offer two levels of analysis. The first, theoretical, contributes to the advancement of the issue of environmental perception. The second, practical, presents a research-creation protocol that can help designers to create more sensitive and inclusive communal spaces by optimising the factors of colour, light and materials. In conclusion, the interpretation of the results obtained from the projects validated the undeniable effectiveness of this multidisciplinary protocol.

KEYWORDS Light design, Colour design, Visual comfort, Property developer, Collective housing.

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1. Introduction

1.1 *Issues addressed*

Currently, 31.6% of the French population lives in a collective dwelling, i.e. nearly 21 million people (Henri Albertini *et al.*, 2018). At the same time, around 12 million French people are affected by a disability, including 1.5 million with a visual impairment and 850,000 with reduced mobility, due to various pathologies, life accidents or age (Mormiche, 2001). Similarly, the increase in life expectancy is indeed a warning factor that should challenge us in our approach to designing an inclusive space, because in 2050, metropolitan France will have between 58 and 70 million inhabitants, by which time more than a third of the population will be over 60 years of age, which will require numerous adjustments to our daily living environment (Brutel, 2002). Moreover, in recent years, home care has been preferred to institutional care, especially for people with a slight loss of autonomy (Kubiak, 2012), so for all these people, the positive and safe perception of the daily environment must become an important issue for designers of collective housing. Thus, it is essential to take into account the parameters of colour, light and materials in this type of environment, as factors of atmosphere and comfort of use. These elements have led us to question how professionals of collective housing take into account the characterisation of the CLM (colour-light-materials) approach in the design of inclusive common spaces, where plural human needs must be at the centre of the reflections.

1.2 *Reassessment of standards*

For many years, the authorities have placed man and his pluralitý at the heart of many laws that come to life within new architectural projects. However, these laws are very often set up and governed by recurrent and unwavering norms, averages and conformities; yet, if we stick to the strict observance of these, as man does not respond to any average it is obvious that many gaps remain. Furthermore, in the literature on environmental factors, the subjective part in the assessment of environmental factors is often mentioned, but there are very few indicators that refer to this. Mudri (Mudri, 2002) states that in studies using interviews and observations, the dimensions of the personalitý and disabilities of the subjects have generally not been studied in detail and the subjects are therefore considered 'average'. As a result, it goes without saying that strict adherence to these rules and averages does not guarantee the success of an architectural project, particularly in visual ambience design.

2. Transdisciplinary approach

2.1 *Research context: transdisciplinarity as a lever for social innovation.*

Today, we note that more and more designers in the field of architecture are becoming aware that the quality of life in collective housing requires the emergence of interdisciplinary designs and are committed to placing human concerns at the heart of the issues. Therefore, our study presents a design method combining collaborative and evolving expertise for the benefit of tomorrow's inclusive housing. Attentive to emerging demands, the company Sobrim, an expert in Basque real estate development, took the initiative in 2018 to create a multidisciplinary centre of expertise. Its ambition is to go beyond the strict field of property development, as the methodology applied to this new approach, known as Haranam (SOBRIM - HARANAM), is experimental, global, transversal and multidisciplinary. It is based on a synergy of work between experts from different fields. During dedicated days, doctors, physicists, doctoral students, building and human science experts are invited to discuss the complexity of the issues at stake in order to come up with concrete solutions and specifications that meet the expectations of tomorrow's housing.

The study proposed here questions the way in which doctoral research in CLM is taking up these new design methods. The answers and methodologies provided are anchored in a research-creation approach, addressing an interdisciplinary design protocol, conducted in the real estate development sector. To this end, we will present a case study and a design protocol in terms of colours (colour counter-types), lighting (characterisation of light) and soundings (characterisation of feelings), with the aim of accompanying designers in a process of designing interior visual environments and chains of movement that are truly adapted to the conscious and unconscious needs of their inhabitants.

2.2 *Research-creation and creation-research in colour, light and matter.*

In the literature of cognitive sciences and psychology, there is little research on the role of colour in its relationship to space and in particular in the spatial orientation of people. However, we know that a visual environment adapted (Damelincourt *et al.*, 2010) to the pathologies of people with disabilities has positive effects, but must respect a certain number of criteria such as an appropriate amount of light, contrast and spatial distribution. Various design factors can enhance or hinder the human response, and weaken environmental visual cues.

We therefore hypothesised that colour in the architectural environment of multi-family dwellings could support spatial location and orientation, particularly for people who are disoriented, less responsive to conventional signage systems (Bay and Fayolle, 2020) or have certain age-related visual impairments, (see Figure 1).

Fig. 1 . Illustration of age-related visual pathologies. Résidence Opalescence, Bayonne, SOBRIM, Ambre Building, floor n°2.

In doing so, this empirical approach will hopefully lead to a reflection on colour in collective housing environments. Inherited from hygienic and standardised norms, we note, even today, that few works integrating colour are the object of a voluntary approach. The choice of colours and materials often depends on the tastes of the project manager and the usual validation of the client, but what seems to be a secondary issue is in reality a key point in the evaluation of the success of an architectural project. The results of this study will allow the development of a creative protocol that will help the developer to design visual environments that are adapted to the needs of all inhabitants.

The main results expected from this study are:

1.To improve the analysis and interpretation protocol for defining comfortable visual environments.

2.To develop tools to simulate the lighting environment in the design phase of the programme.

3.Facilitate the integration of the results of this study by professionals.

3. Methodology of analysis and creation

3.1 *Colour-material, colour-light*

The protocol presented is based on a combination of chromatic expertise (colorimetry) concerning the choice of materials, textures and finishes, with an emphasis on colour for its plastic character; and lighting (light characterisation) concerning the quantity and colourfulness of light, with particular emphasis on different colour temperatures. This study focuses mainly on the chains of movement, i.e. the common spaces and the interior horizontal circulations. Indeed, the visual atmosphere of these spaces must create a feeling of welcome, visual comfort and safety for all users, of all ages, day and night. The method used will therefore serve to create coherence and harmony between the exterior landscape treatments and the interior colour and light treatments in order to create an intuitive and inclusive chain of movement.

The protocol and analyses presented were carried out between April 2019 and June 2022 on the site of the "Opalescence" residence in Bayonne built by the property developer SOBRIM (Basque Country, France).

The method was divided into three stages: capture, creation and feedback:

3.2 *Step 1: Recordings*

The first phase consisted of collecting photographs of the construction site over a period of 8 consecutive hours, the inventory of the existing situation being an essential phase before any project. Equipped with cameras, this preliminary analysis was accompanied by a walk around the site.

Photographs cannot faithfully reproduce the colours of a palette. However, they are essential graphic documents for memorising, visualising and disseminating information (Lenclos and Lenclos, 2016). Most colour studies use photographic investigations to support colour surveys. In our case, photography was used in two approaches, one aimed at establishing an inventory of the surrounding

urban colours and forms, the other a colour and light diagnosis to judge the appearance of the site under cyclical light conditions. This step was a means of transcribing and analysing the experience of a space.
The second step was to reference the colours of the site using countertypes. In our study, the colour survey consisted of observing the colours of the environment and the architectural elements surrounding the project and comparing them to reference colour samples. Here we used the colours of the NCS colour chart. The Natural Color System is a universal system used for standardised colour communication, based on an intuitive coding system designed for human vision. This reference system allows us to communicate colours universally in different fields of application. This representation has also allowed us to translate these colour readings into values using the CIE XYZ L.a.b system, taking into account the logarithmic response of the eye, but also the specific characteristics of coloured surfaces with their luminance index.

3.3 *Step 2: Creation*

The first phase consisted of a study of the existing light, the environment, the chromatic and architectural identity of the site. Each environment has a unique identity, of which colour and light are part. The mission of the CLM research engineer must necessarily include a diagnosis of the existing environment. This stage defines the way in which we will approach the existing environment and certain elements in relation to the project, but also in relation to the wishes of the developer in terms of the expected aesthetic and functional ambitions. In this phase, we have taken into account the so-called "permanent" and "cyclical" colours. The "permanent" colours are the basis of any chromatic study. They constitute the stable elements of the place, having a durable character, such as the building materials. They are opposed to "cyclical" colours, which are unstable and subject to innumerable temporal, meteorological and light variations, such as the colour of patinas, plants, the sky (etc.).
The second phase consisted of recommending atmospheres adapted to the place, using chromatic ranges, materials and lighting systems that favour the safety and visual comfort of all inhabitants. This method consisted of experimentally constructing chromatic ranges by means of the view, proceeding by variation and multiplication of optical combinations until a visual impression was obtained that conformed to the aesthetic expectations of the project. To design these colour schemes, we used the NCS colours previously surveyed on the site, which we then matched with the paint and material manufacturers' colour charts used for the project. Thus, a visual atmosphere was designed around the spirit of the place, the chosen shades are sublimated by the contribution of contrast around several soft and assertive tones inspired by nature and harmonizing perfectly with the vegetation present on the site. These prescriptions have led to the creation of three chromatic palettes specific to each building in the project, (see figure 2).

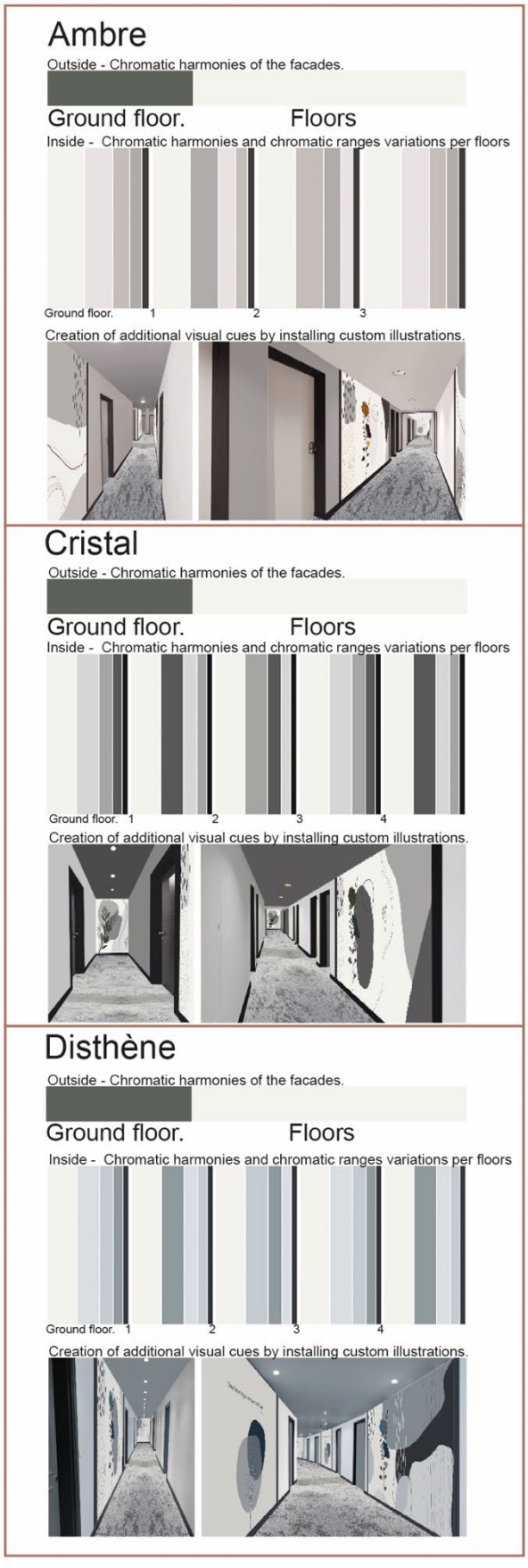


Fig. 2 . Chromatic environment creation.

Inside, the chromatic combinations are composed of five shades, but established on a dominant trichromy (Déribéré, 2014), varying at each level, thus avoiding any visual disturbances caused by a discordant polychromy, and relieving the space of a certain visual monotony recurrent in this type of place. Particular attention was paid to chromatic contrast and luminance values, as contrast sensitivity generally decreases with age and can be even more disturbed when visual pathology is added. For example, a contrast of 70% has been maintained between the various important media so that they can be perceived by a visually impaired person, whose sensitivity to contrast is still operative.

Here, light colours are used for large surfaces and dark colours for small surfaces or accessories in order to allow better discrimination of the elements. The creation of these differentiated harmonies has therefore allowed us to design circulation spaces with chromatic variations for each level, favouring intuitive orientation as well as an efficient and comfortable reading of the chain of movement for all inhabitants. This colour scheme was accompanied by numerous contrasting visual markers, designed for the occasion. The 77 illustrations installed in the residence not only serve as landmarks, but also have the advantage of dynamising and reducing the perception of large landings and long corridors which can be perceived as anxiety-provoking.

Thus, this evidence-based approach to colour and contrast integrated into the design of the environment improves visual awareness of the environment. This approach, which is aimed at older people, visually impaired people and people with dementia, is in line with inclusive design guidelines and supports orientation and wayfinding, as well as the safe performance of daily activities.

Finally, these harmonies were also accompanied by a lighting design. This was studied so that the quantity and quality of light would meet the needs of all inhabitants, as at 55 years of age the amount of light required is 300% higher than at 25 years of age, for an equivalent level of visual performance, (Association française de l'éclairage, 2020). For this reason, we recommended an average of 300 lux at floor level, homogeneous throughout the buildings, using direct and indirect LED lighting with a colour temperature of 3000 Kelvin. Finally, the choice of materials was studied in order to recommend finishes ranging from matte to satin in the entrance halls according to their natural light contribution in order to adapt to each exposure and thus not generate glare or darkness.

Finally, the third phase was the creation of a technical execution file for the project management. This file is based architect and includes normative descriptions as well as graphic documents such as colouring diagrams on plans, lighting system layout diagrams, cross-sections, a details and signage booklet, as well as a material library to ensure the proper implementation and monitoring of the project.

3.4. *Step 3: Feedback*

Finally, following the completion of the works and the installation of the inhabitants, we repeated a series of measurements inside the various common areas. These measurements provided additional information on the relevance and effectiveness of the recommendations made prior to the project. This last observation phase consisted of characterising the light and colour present in the buildings. To do this, we carried out several series of measurements along the movement chain.

First of all, we repeated a referencing of the environment inside the common areas with the help of photographs and chromatic counter-types. These chromatic collections were used to draw up a cartography. Establishing a chromatic representation of a place through a cartography allowed us to produce a qualitative and quantitative restitution of the colours collected in situ, in order to draw up a visual synthesis and to validate the efficiency of the contrasts.

Secondly, we carried out a series of measurements to characterise the lighting environment of the site. The evaluation was carried out at three different times of the day (morning at 10:00, early afternoon at 14:00, late afternoon at 17:30) to measure the light amplitude. In addition, in order to analyse the light distribution of the area, the area was divided into several zones of the site (strategic point of the movement chain).

This series of measurements was carried out using a CRI Luxmeter-Chromameter (Minolta CL-70 F), allowing us to collect all the values composing the light such as its colour temperature; its illuminance; its light spectrum and its colour rendering index, (see figure 3).

Example of readings to characterise the interior light
«Ambre» building, ground floor :

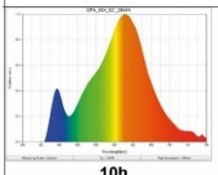
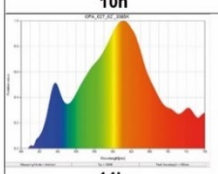
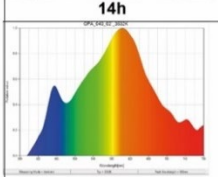
EVOLUTION OF LIGHT SPECTRA INDOORS.	HOURS	MEASURES TAKEN			
		INDOOR LIGHTING SURVEYS		OUTDOOR LIGHT SURVEYS	
		lux	Kelvin	lux	Kelvin
 10h	10h	303 lux	2838 K	8090 lux	6155 K
 14h	14h	473 lux	2898 K	43300 lux	5864 k
 17h	17h	547 lux	2780 K	13600 lux	6500 K

Fig. 3 . Collection of values composing the light of common spaces.

Secondly, we used a video luminance meter, which allowed us to collect the values that make up the light comfort of these spaces, such as luminance, unified glare ratio (UGR), daylight glare index (DGI) and visual comfort probability. In order to analyse the light distribution of the different spaces that make up the residence, the surveys were divided into several zones, consisting of strategic points in the movement chain specifically lit with natural or artificial light. We then chose three periods of the day to carry out the measurements.

This distribution in time makes it possible to analyse the evolution of the amount of light during the day, mainly in the halls and the sharing lounge (common space intended for the creation of sharing workshops between the inhabitants). Also, in order to compare the values between artificial and natural light, we also carried out measurements of the external light, simultaneously with the internal light. These photometric collections were used to draw up a measurement table showing the quantities of light and colour temperatures perceived during the day in different areas of the residence.

Finally, we plotted these data on the Kruithof curve in order to deduce whether the visual environments were considered comfortable or not for the observers, (see figure 4).

Synthesising this information allowed us to produce a qualitative and quantitative restitution of the light present in situ, in order to draw up a visual synthesis and to validate the efficiency and possible nuisances during the day.

Finally, a survey was carried out among the inhabitants in May 2022. The survey was administered by paper questionnaire; residents were asked to share their age, physical condition and the name of their building. The questionnaire consisted firstly of measuring the general satisfaction with the care given to the (interior) environment of the residence and secondly of describing in detail their long-term visual impression of the common spaces. They then assessed their comfort over the course of the month for three specific periods of the day: in the morning, from 8:00 am to 12:00 pm; at noon, from 12:00 pm to 2:00 pm; and in the afternoon, from 2:00 pm to 6:00 pm in different spaces of their residence. For each of these intervals, residents were asked to rate their visual comfort in one of four categories: imperceptible, noticeable, disturbing or intolerable.

Thus, the visual comfort and general appreciation ratings of the residents were compared to the measurements carried out in situ in order to correlate the metric data collected with the visual atmosphere felt.

4. Result

The different phases of surveys and analyses contributed to demonstrate in a quantitative and normative way how the place could be perceived by the inhabitants (INSEE, 2017).

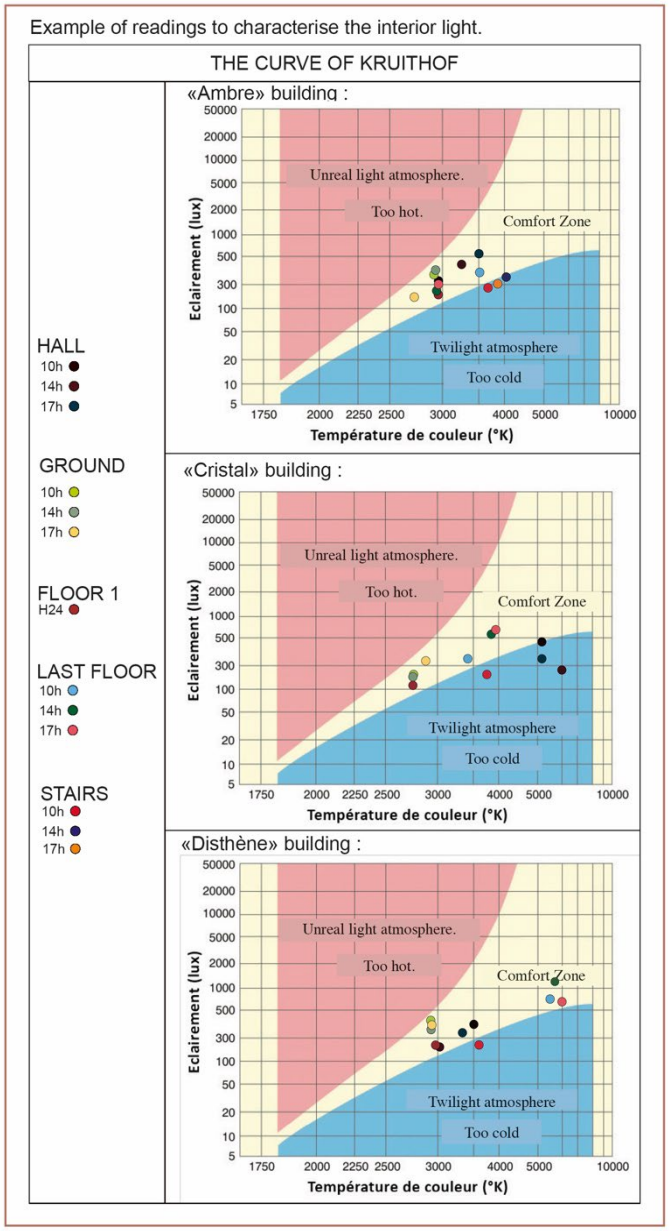


Fig. 4 . Visual comfort control with the Kruithof curve.

The interpretation of the results obtained at the time of delivery enabled us to validate the efficiency of the recommendations established thanks to the analysis protocol carried out before the project, beyond the consideration of the standards in force, this one calling upon an experimental construction method (Pfeiffer, 1966), taking into account several factors intrinsic to the project and which will be reiterated on the projects to come:

- The analysis of the characterisation of colour and light on the site.
- The spirit and visual coherence of the project location.
- An efficient chain of movement.
- The comfort of use and appreciation of the spaces for all inhabitants.

We can conclude that this research-creation protocol and the expertise carried out around the chromatic and luminous

characterisation within the circulation spaces was validated by the feedback established in the last phase. Indeed, the measurements taken in situ correlated with the feelings of the inhabitants validated the hypothesis that this approach generates more visual reference points and comfort of use for all the inhabitants. Moreover, these results were compared to other data collected on a sample of the developer's previous real estate projects that did not benefit from this creation protocol and did not have such good results; this confirmed the fact that this new design approach is now a health and social necessity.

5. Discussion

The issue of lighting and colour in collective housing is quite complex, as designers' preferences vary greatly according to both objective and quantifiable conditions (economy, standardisation of practices, specific needs related to disabled people, etc.) and socio-cultural and subjective conditions (preference for a particular colour scheme, type of luminaire, type of covering, etc.).
As a result, and in the absence of standards directly related to these semi-private spaces, architects tend to use very neutral or even monotonous colours and materials, and struggle to install sufficiently efficient, comfortable and aesthetic lighting in common spaces. With this study, we are beginning to awaken designers to the challenges of colour and light. Because together, beyond their simple aesthetic contribution, they make circulation safe and efficient while allowing the inhabitants to plunge into singular universes where the atmosphere becomes a factor of well-being and cohesion.

6. Conclusion

In the coming years, a larger comparative study will complete the research-creation protocol studied in this article. This comparative study will take into account the values obtained in a large sample of old residences and those that are being built from this protocol, and will be completed by an interview with the inhabitants asking them about their perception of the place and based on a
scale of sensations. This study will allow the property developer to ensure the efficiency of its approaches and to continue to design in a systematic and sustainable way visual environments better adapted to human physiological needs by proving the validity of qualitative approaches in terms of the design of light and colour within its property programmes.

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8. Conflict of interest declaration

No conflict of interest.

9. Funding source declaration

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10. Short biography of the authors

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