HUNGARIAN UNIVERSITY OF AGRICULTURE AND LIFE SCIENCES

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Theses of the Ph.D. dissertation

ASSESSING LAND USE/COVER CHANGES AND VISUAL LANDSCAPE QUALITY IN THE LAKESHORE AREA

A CASE STUDY OF LAKE VELENCE, HUNGARY

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1. BACKGROUND AND RESEARCH OBJECTIVES

Lakeshore can be one of the most valuable area in terms of the diversity of ecological services it provides—habitat for species, recreation, harvestable resources, production and processing of organic matter, dissipation of wave energy, flood control, maintenance of water quality and dispersal corridors for flora and fauna (Strayer & Findlay, 2010). At the same time, it is also the area most exposed to the negative influences of anthropogenic stress (Furgała-Selezniow et al., 2020). The alterations to the lakeshore may result in essential changes to its characteristics (Latinopoulos et al., 2018). Excessive external intervention and human activity not only threaten the natural lake ecosystem, but also affect the natural aesthetic quality of the landscape along the waterfront.

The main objectives of this dissertation are to study the processes of land use/land cover change in the shore area of Lake Velence, and the visual landscape quality of the lakeshore. Lakeshore development and anthropogenic pressures are the main variables and drivers affecting lakeshore land cover and landscapes, specific impacts and changes will be explored in this thesis through a series of quantitative studies. This thesis will apply multiple methods to assessing land use change and visual quality in the study lakeshore area. The study integrates spatially explicit datasets, as well as other relevant variables in the field of visual landscape quality assessment. The first part of the study would present the current status of and threats to lakeshore land by mapping, analyzing and detect changes in LU/LC over a 30-year period. In the second part, public perceptions and attitudes toward the lakeshore scenes will be investigated, and a mixed methods approach will be used to evaluate the visual impact of construction and lakeshore modifications on the lakeshore landscape.

2. MATERIALS AND METHODS

In order to achieve the above research objectives. A large number of map datasets were collected for the analysis of land use and land cover change in the study. Landscape photographs were utilized as the base material for preference surveys and visual impact surveys. In addition, field surveys and field recording materials were also essential. The detailed research materials are as follows:

- **Map datasets: Topographic maps or historical maps** from the 1980s; **Orthophotography and Aerial images** from 2009 and 2019. Collection of mapping resources for research sites over time through websites (e.g., Bing Aerial Maps, Google Earth) and local authorities. **Vector cadastral maps** from Open Street Map and Copernicus land monitoring service.
- **Field work records and on-site photographs.** Visiting study sites to verify areas that are not clear on maps and where land changes are evident. Taking and collecting photographs of hot spots and core areas.
- **Official announcements and documents**. Visit relevant institutions and governmental website, obtain the information of the regional development situation and development background, especially the content of the tourism planning and the landscape condition changes over the past 30 years.
- **Research articles and regional target analysis reports.** Relevant research literatures and target analysis reports, knowledge of the study sites and previous research findings helped us to identify research questions and hypotheses.

Research approaches:

1) Multi-temporal analysis of land use and cover change

Mapping and analysis of land use/cover at different temporal points（1989, 2009 and 2019） in the study areas. Quantifying the dynamics of land use and cover utilization and changes over time through GIS-based applications

2) Accessing lakeshore landscape preferences and public perception through a photo-based

survey

To identify which landscape features and visual factors shape the visual quality of the lakeshore landscape, a preference survey was conducted using 14 different lakeshore scenes.

3) **Using a mixed methods approach to evaluate the visual impact of disturbed lakeshore landscapes.**

   To investigates how the visual landscape of the lakeshore is affected by modifications and constructions using both a landscape metrics based objective assessment and a photo-based perceptual assessment.

4) **Statistical analysis methods:** In order to test the results of the surveys and research hypotheses, statistical techniques and the following research methods will be used in the thesis: **Descriptive statistical analysis** (a measure of central tendency, a measure of range, variation and standard deviation), **Correlation analysis,** and **paired samples t-test**.

3. NEW SCIENTIFIC RESULTS

Finding 1: Developed an effective method for evaluate the relationships between the aesthetic preferences and visual landscape indicators.

To explore the relationship between the public's aesthetic preferences for lakeshores and the characteristics of lakeshore landscapes, I have developed two assessment frameworks, one based on **public participation assessment** and one on **expert assessment.**

1) Firstly, **I identified three groups of the most sensitive receptors** for the landscape preference survey：**waterfront residents, landscape planning practitioners, and outdoor enthusiasts.** And investigated the receptor's perceptions and preferences for **five representative lakeshore landscapes**[1] (with different levels of artificial intervention).

2) **Identified** a set of evaluation indicators（**vegetation coverage area, human activities , density of riparian plants, visual range, naturalness, functionality, accessibility, maintenance** ）and corresponding scoring criteria **as the fundamental framework** for **expert assessment**. The identification of landscape indicators was primarily based on consideration of **the physical state and condition of the landscape**. The landscape indicators were scoring **through field survey and spatial monitoring**.

3) After obtained the results of the public preference survey and the metrics-based expert assessment, a Pearson correlation coefficient was conducted to measure the relationship and linear correlation between the public preference judgment consensus and the lakefront visual landscape indicators.

[1] Five types of lakeshore landscape: A highly artificial shore; a semi-artificial shore with partial buildings background; a semi-natural shore without building background; a near-natural shore; a “wild”/ natural shore.

Finding 2: An optimal mixed methods approach was developed to evaluate the visual impact of the modifications on the lakeshore landscape.

Intense construction operations and developing works has continue carried on the lakeshore zone in recent years, which have had a significant visual impact on the natural lake scenery. I have developed **a mixed methods approach** for assessing the **visual landscape quality** of the lakeshore at different phases **(before construction and during construction)**. The assessment approach consists of a subjective Visual Perception Based Assessment (VPBA) method and an objective Landscape Metric Based Assessment (LMBA) method.

a) The **VPBA approach** is based primarily on the evaluation of **ground-level photographs** from two different time periods (T1 = before construction, T2 = during construction) and **involved participants**[2] in judging the visual quality of the lakeshore landscapes through a questionnaire. Negative elements in disturbed lakeshore landscapes are also identified through the public's visual perceptions and responses.

b) The **LMBA approach** has proved more accurate and effective from the previous studies. **A set of relevant indicators**[3] **and objective evaluation criteria were selected to evaluate the visual landscape quality of the disturbed lakeshore.** The landscape metrics are assessed with the help of **GIS tools** and **high-resolution aerial imagery** by measuring, recording, and calculating changes in **landscape features** and **land cover** over different time periods (from 2016 to 2021).

c) Lastly, the results of the two assessment methods were compared and combined to obtain **a combined visual impact rating (FDI)**. **Spearman's rank correlation coefficient** was computed to assess the correlations between results from visual perception-based assessment (VPBA), the results landscape metrics-based assessment (LMBA), and applied landscape indicators.

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[2] The participants included waterfront residents, planning and landscape professionals, visitors and outdoor enthusiasts.

[3] Landscape sensitivity, construction duration, and magnitude of the land cover change

Finding 3: Mapped and measured the land use/cover status of Lake Velence at different times, and LU/LC changes over different intervals.

The land use/cover maps produced for different time periods (1989, 2009 and 2019) and the quantification of data (Appendix 9) for each LU/LC type over different times illustrated the following findings:

- At Lake Velence, **Undeveloped land** (semi natural land, water area, forests, and agricultural land) is mainly located to **the west and north of the lakeshore**, while land for **tourism development** (tourism accommodation area, tourism facilities area, and recreational land) and **urban development** (settlements, bare land, transportation land) are mainly located to the **eastern and southern parts of the lakeshore**.
- Over the 30-year period, **semi-natural land** accounted for the **largest proportion** of all land types in the 0-200 m lakeshore zone. semi-natural land accounted for 44.47% of all land use types in 1989, 44.37% in 2009 and declined to 37% in 2019.

The comparative analysis study also identified **major changes in land use/cover types in the lakeshore area over three-time intervals (1898-2009 2009-2019 and 1989-2019):**

- From 1989 to 2009, the changes in this period were mainly reflected in a decrease in **water area (-6.66%) and agricultural land (-2.76%)** and an increase in **forests (4.78%) and urban area (2.69%).**
- From 2009 to 2019, land use changes on the lakeshore were markedly different from the previous period, as **semi-natural land (-7.50%)** decreased significantly in the lakeshore zone, and notable increase in **forest land (2.06%), bare land (2.01%),** and **urban land (1.33%)**.
- Overall, from 1989-2019, the main changes in the shore zone of Lake Velence show a decrease in the **water area, agricultural land and semi-natural land**. Meanwhile, **forest land, urban area and tourism-related areas** have increased significantly.

Finding 4： Identified specific changes in land use/cover in the subdivided Lakeshore zones.

By analysing and visualizing the land use/cover of the three subdivided lakeshore zones (0-30m shore zone, 30-100m shore zone, and 100-200m shore zone) over the period 1989 to 2019.

- The changes in water area and recreational land use are mainly in the 0-30m lakeshore zone and the 30-100m lakeshore zone. Meanwhile, woodlands and urban areas show a significant increase in the 100-200m lakeshore zone.
- All three subdivided Lakeshore zones show significant reductions in semi-natural land between 2009 and 2019, with -7%, -5.6% and -7.7% respectively.

By analyzing the transition process for each land use/cover category over three time periods, the results show that some LU/LC types show **a linear trend of increasing or decreasing**.

a) A significant **linear growth** in the **recreational land, tourism facilities area and bare land** in the **0-30m lakeshore zone** from 1989 to 2019.

b) In the **30-100m** lakeshore zone, there is **no significant change** in the proportion of LU/LC classes, except for a slight increase in tourist accommodation area, urban area and forests.

c) Land use/cover classes in the 100-200m lakeshore zone have changed more dramatically over the last 30 years than in the first two lake zones., with the results show a **clear linear decrease in semi-natural and agricultural land** and a **linear increase** in u**rban land and forest land** from 1989 to 2019.

Finding 5: Identification of land use and land cover changes in the two largest natural lakeshore areas in Hungary.

By mapping and analyzing the land use/land cover of the two largest natural lakeshore areas in Hungary (Lake Balaton and Lake Velence) from 1989-2019, the annual rate of LU/LC change and the area change rate of each LU/LC type in the two lakeshore areas over a 30-year period were determined.

The following similarities in LU/LC change were detected in the two lakeshore areas:

1) Both Lakeshore areas have seen similar changes in the major LU/LC categories[4] over the last 30 years. This is reflected in the **increase** in **tourism development and urban development areas**, and the **decrease** in **undeveloped areas**.

2) The main threat to the shore areas of Lake Velence and Lake Balaton is the increase of **tourism development lands (including recreational lands, tourist accommodation areas and touristic facilities)** and these expansions are mainly **at the expense of semi-natural lands.**

A combined analysis of LU/LC from the two lakeshore areas showed:

a) The area of **all types of land use/land cover** in the lakeshore area are **statistically significantly different in both 1989 and 2019** ($p \leqslant 0.01$)[5].

b) Of all the land use/cover classes, **forest land** has seen the most prominent growth in the two lakeshore areas. However, **agricultural land** and **semi-natural land** decreased sharply.

[4] Undeveloped land, tourism development land, urban development area.
[5] According to the results of the Wilcoxon signed-rank test. Significance level at 0.05.

Finding 6: Identification of growth land use pressures in the near-shore area.

Ports, marinas, and piers were well developed in Lake Balaton and Lake Velence since the 1980s. The last decade has also observed the continued development and expansion of water tourism facilities and water-based tourism (fishing, boating, yachting and sailing) in the two lakes. Based on fine-scale spatial monitoring of the nearshore area (1989 and 2019) and official information released on investments and constructions in the Hungarian Lake region. **The changes and developments in the nearshore areas can be identified as follows:**

1) In Lake Velence, the proportion of natural shoreline has declined from 55% in 1989, to 42% in 2019. The lost natural shoreline has been replaced by concrete shore walls and artificial sandy beaches.

2) The number of marinas on **Lake Valence** has **remained almost the same** and has not changed noticeably in size over the last three decades, but the number of marinas on **Lake Balaton** has increased sharply **from 18 in 1989 to 49 in 2019**.

3) Over all, a total of 59 marinas and 27 boat ports have been built on the shores of Lakes Velence and Baleton by 2019. **Seven of which have a capacity of over 200 berths**. The marinas are evenly distributed over the entire shore zone of Lake Balaton and the southern shore of Lake Velence from Velence to Agárd.

4) Most of the new marinas and **expanded marinas** are concentrated in the **Keszthely region** in the west of Lake Balaton, and the northeast **Balatonfűzfő region.**

5) From 1989 to 2019, a total of **22.88 hectares** of nearshore **water area in Lake Balaton was infilled**, which was mainly **converted to recreational land or marinas**. In Lake Velence, approximately **57.72 hectares** of water area in the nearshore zone was filled in and **31.77 hectares were retreated**. The new filled areas of Lake Velence are basically occupied **by meadows and wildlife habitats**.

Finding 7: Public preference for different types of lakeshore landscapes and lakeshore embankments

According to the extent of human influences and different intervention levels, **five representative types of Lakeshore landscape**[6] (from a highly artificial lakeshore landscape transition into a "wild" lakeshore) were selected for evaluation**.** Additionally, there are **nine types** of **lakeshore embankment**[7] that were selected for the preference assessment. Based on the results of the evaluation from the receptors[8], I draw the following conclusions:

a) The **most popular lakeshore landscape** scenes are the **semi-artificial lakeshore** (41%), followed by the **artificial lakeshore** (26%) and the **near-natural lakeshore** (25%). Both **highly artificial and semi-natural lakeshore landscapes** are **unpopular** and received the most negative aesthetic ratings, with 37% chose the "wild" lakeshore, 37% chose the semi-natural lakeshore and 20% chose the artificial lakeshore as the least preferred.

b) The most popular **lakeshore revetment types** are: The **natural beach** with curved wooden groyne (P3), and the **rip/rap bank slope** with open grassland (P5), and the **rock slope revetment** with unobstructed pavement (P7).

c) By comparing the results and responses to the aesthetic ratings of the four lakeshore landscape groups it can be concluded that **experts and the waterfront residents differ in their concerns and preferences for the lakeshore**. However, there is **no statistically significant difference** in the aesthetic evaluation of the lakeshore by the public and experts in this study ($p > 0.05$)[9].

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[6] Five types of lakeshore landscape included: an artificial shore; a semi-artificial shore; a semi-natural shore with fences; a near-natural shore with the unobstructed pavement; a natural shore.

[7] Embankment types: P1 a concrete revetment with partly sand slope, P2 a shore with timber piles, P3 a natural beach with wooden groyne; P4 a shore entire edge provided metal railings, P5 a rip/rap bank slope with openly grassland, P6 a shore restricted by aquatic plants and wooden fences on both sides of the pavement; P7 a rock slope revetment with unobstructed pavement, P8 a rock slope revetment with obstructed pavement, P9 a concrete revetment without sloping breakwater.

[8] N=62 valid perceived responses.

[9] Fisher's exact test was used to determine if there was a significant association between experts and residents (significance level≤0.05)

Finding 8: Identification of correlations between lakeshore landscape preferences and visual indicators.

In order to discover the influence of visual indicators [10]on the public's judgement of aesthetic preferences, a correlation test between the perceived scores of the study sites and visual landscape indicators was analyzed by means of Pearson correlation coefficients.

Based on the results, I have identified:

a) **The aesthetic judgements** are significant **positive correlated** with **accessibility** ($r=0.82$, $p<0.01$), **visual range** ($r=0.81$, $p<0.01$), and **maintenance state** ($r=0.79$, $p<0.01$).

b) However, the aesthetic values by cognitive judgements are **negatively correlated** with **naturalness** ($r=-0.46$, $p<0.01$), **aquatic plants** ($r=-0.79$, $p<0.01$) and **vegetation coverage** ($r=-0.4$, $p<0.01$).

In this study, **naturalness, aquatic plant cover** and **vegetation cover** had a significant negative effect on the aesthetic preference of the studied lakeshore landscape. **This finding is inconsistent with the outcomes of most previous related articles.** The main reason why the lakeshore vegetation cover is not conducive to visual aesthetics is that the density and height of the aquatic plants cause a partial closure of the visual zone and obstruct the visual axis.

Finding 9: Outcomes of a lakeshore visual impact assessment based on a mixed methods approach

Six pilot sites[11] along the lake were selected as samples for visual impact assessment.

1) According to the **LMBA method**, during the construction phase, the greatest visual impact on the lakeshore landscape was at **the stockpile site** (S5), followed by **Site 2** (tailings pond) and **Site 6** (promenade construction site).

[10] Visual factors included vegetation coverage area, human activities, density of riparian plants, visual range, naturalness, functionality, accessibility, and maintenance.

[11] Six lakeshores that underwent different modifications: S1=a pavement renewal site, S2=a new tailing pond field, S3= a site under reconstruction for embankment and walkway, S4=demolition site, S5=stockpile field, S6=new promenade construction site.

2) Results for the **VPBA approach** showed that perceived aesthetic scores and median scores were **significantly lower**[12] at all survey sites **during construction (T2)** than perceived aesthetic scores in the **previous landscape (T1).** The site that received the highest visual impact rating was **the material stockpile site** (S5), followed by the **reconstruction of the embankment** (S3) and **the new tailings storage site** (S2).

3) Combining the results of the two assessment methods, the **final composite degree of visual impact (FDI)** shows that **Sites 2 and 5** received a visual impact level rating of **D**, meaning **significant negative visual impact**, and **Sites 3 and 6** were rated **C (moderate negative visual impact)**.

Visual impact factors on the lakeshore during the construction phase were identified through assessment and responses from receptors. The visual stimulation of the lakeshore construction and renovation on the receptors is mainly reflected in the **incongruous object intrusion scenes** (piles of construction materials and heavy equipment) and **textural contrasts** (e.g., granular foundation paving, turf scars from crushing operations), and **cluttered scenes.** All of which reduce the aesthetic and visual amenity of the lakefront landscape and disrupted the connection between the receptors and the lakefront landscape. A summary of public reactions and votes on negative landscape elements shows that:

1) The three most **prominent factors** contributing to the **negative visual impact** of construction were **damaged vegetation** at around 22%, followed by **stockpile of construction materials (soil, grave, rocks, sand)** at 18.4% and **unpaved or bare ground** at around 17.4%.

2) In general, nearly 39.4% of the negative visual impacts on the lakeshore landscape were associated with **land cover change (LC)** and 34.5% were **visually volumetric intrusion elements (IE)**. High contrast material elements (EM) and other peripheral elements (SE) account-ed for 15.5% and 11.9% of the total impact categories respectively.

[12] A Wilcoxon signed rank test showed statistically significant differences in visual quality before and during construction ($Z=-12.277$, p-value < 0.01)

Finding 10: Identified the strengths of using mixed methods for visual impact assessment.

The case of the Velence Lakeshore study shows that the results of the two evaluation methods (LMBA method and VPBA method) **do not conflict, but rather complement and cross-reference each other.** This mixed methods template may be helpful in monitoring and assessing the visual quality and visual impact of other lakes with similar development contexts.

After testing different assessment methods, the following conclusions were drawn.:

- The **LMBA method** can be used as a **simple** and **cost-effective systematic assessment tool** for **preliminary estimates** of the impact of development or modification on the lakeshore landscape. Such **remote sensing and geoprocessing methods** allow for **accurate physical measurements** and regular monitoring of changes in land cover and landscape patterns through GIS software and temporal-spatial datasets. **In practical terms,** it is more **reliable and efficient**.
- The application of a **visual perception assessment survey** can collect and r**eflect receptors' intuitive sense responses and judgements** on landscape change and visual stimuli. It also helps researcher to **identify the main visual stimulus** to the receptors of construction activities and sites.
- Planners cannot solely rely on **aerial images or spatial landscape information** to evaluate the visual impact of construction and modifications. **Site surveys and ground-level photographs** are still indispensable tools for assessing visual disturbance.

A mixed methods approach helps to **obtain information from multiple perspectives** and provides **different criteria** for assessing the visual impact of interventions and modifications on the lakeshore landscape. The results of the two assessment methods are combined to obtain a comprehensive evaluation of the final impact value (FDI), which can provide a reference basis for subsequent governance and mitigation measures.

4. CONCLUSIONS AND RECOMMENDATIONS

The lakeshore area provides essential functions for economic, cultural and recreational uses as well as human settlement. Besides, as an ecological transition zone between land and water, the lakeshore area is important for the habitat of flora and fauna as well as for biodiversity. However, human intervention and various socio-economic drivers directly influence changes in land cover and visual landscape quality in the lakeshore area. The results of the study shown a marked change in land use/cover type in the Lake Velence area over the last three decades. The expansion of built-up areas and large infrastructure has altered the lakeshore land cover and contributed to the hardening of the shoreline, also threatening the natural character and habitats of the lakeshore. The results of the lakeshore landscape preference survey and visual impact assessment show that most people consider some level of development to be acceptable, mainly in relation to the maintenance, appearance, and function of the landscape. However, lakeshore development activities and changes in land cover have had a significant impact on the visual quality of the lakeshore landscape.

In summary, the main recommendations regarding land use and visual landscape quality of the lakeshore comprise:

- Sustainable land management and planning considerations
- Regular monitoring of land cover changes and opening up map and spatial image resources for researchers
- Establishment of specific regulations for the lakefront area and zoning of the lakefront management and protection areas
- Special protection of unique landscape elements and visual areas of scenic beauty in the lakeshore area
- Minimizing visual impacts through a combination of measures and maintaining the appearance of landscape

5. LIST OF PUBLICATIONS

Published journal articles:

- **Cai, Xuecheng**, & Boromisza,. Z., 2020. Public perceptions and aesthetic preferences of lakeshore landscape: the example of Lake Velence (Hungary). *Landscape &Amp; Environment,* 14(2), p.31–42. https://doi.org/10.21120/LE/14/2/3
- Furgała-Selezniow, G., Jankun-Woźnicka, M., Woźnicki, P., **Cai, Xuecheng,** Erdei, T. and Boromisza, Z., 2022. Trends in Lakeshore Zone Development: A Comparison of Polish and Hungarian Lakes over 30-Year Period. *International Journal of Environmental Research and Public Health*, 19(4), p.2141. https://doi.org/10.3390/ijerph19042141 , ISSN:1660-4601.Impact factor: 3.39 (SSCI Q1)
- Cai Z., **Cai Xuecheng,** Ren T.，2022. Communication strategies for minority cultures under the context of "One Belt, One Road". *Journal of Guizhou Institute of Socialism*, 2022, (1) P. 64-69，DOI:10.3969/j.issn.1673-9310.2022.01.012.

Published conference paper:

- **Cai, Xuecheng,** 2021. Waterfront Development and Regeneration: A Review of Issues and Opportunities. *Proceedings of the 8th VUA Scientific Conference, "Challenges of Nowadays in the Light of Sustainability"*: p.205-210, ISBN 978-963-269-968-4
- **Cai Xuecheng**, 2022. Evaluation of visual landscape quality in waterfront areas: methodology and indicators, *Proceedings of the Lippay-Ormos-Vas Scientific conference*. p.139-147, ISBN 9786150137384
- **Cai Xuecheng**, 2021. Tourism development and land use dynamics in the shore zone of Lake Velence, *Proceedings of the 5th International Scientific Conference on Rural Development, "Reality In Europe".* P.23-32. ISBN 978-963-269-995-0
- Boromisza, Zsombor; Gergely, Attila; Jákli, Eszter; and **Xuecheng Cai** , 2019. "Landscape, Ecological and Visual Impacts of a Stream Restoration in Hungary," *Proceedings of the Fábos Conference on Landscape and Greenway Planning*: Vol. 6 : Iss. 1, Article 4. pp. 1-11. DOI: https://doi.org/10.7275/gaqk-th93
- NÁDASY LÁSZLÓ, BOROMISZA ZSOMBOR, JÁKLI ESZTER, **XUECHENG CAI** (2019). Ökoturisztikai infrastruktúra beruházások tájbaillesztésének vizsgálata. In. Fazekas I., Lázár I.: Tájak működése és arculata. MTA DTB Földtudományi Szakbizottság. Debrecen. pp. 163-167. ISBN: 978-963-7064-39-5

Conference abstracts:

- **Cai Xuecheng**, Zsombor Boromisza, 2022. Land use pressure in the lake shore area:a case

study from Lake Balaton. *The 7th Fábos Conference on Landscape and Greenway Planning*. *Book of Abstracts.* p31

- **Cai Xuecheng**. 2021 ASSESSMENT OF VISUAL QUALITIES AND IMPACTS IN LANDSCAPE BY PERCEPTION ATTRIBUTES AND PREFERENCE .6th Conference on Horticulture and Landscape Architecture in Transylvania. Acta Biologica Marisiensis Volume 4. Supplement 1, P.26. ISSN: 2668 – 5124

- **Cai Xuecheng**, Rural Tourism in the Context of Pandemic and New Normal: Opportunities and challenges. ECLAS conference 2021 "stop and thinking". eISBN 978-91-85735-99-0. p.81
- **Cai Xuecheng**. 2021 Assess waterfront land use dynamic transformation and vegetation change by using GIS. Digital Landscape Architecture Conference DLA, MAY 2021