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ORIGINAL ARTICLE

Utilization of City Biodiversity Index for Biodiversity Education to Improve the Urban Environment

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Abstract

The purpose of this study was to explore the use of the city biodiversity index (CBI) as a tool to improve biodiversity education for urban students. For use in educational purpose, the CBI was modified and supplemented to devise an Educational CBI, and its ability to facilitate the teaching of biodiversity topics was assessed. An Educational CBI that can be used at the high school level was successfully developed. Evaluation criteria were selected based on previous studies of the existing CBI and domestic circumstances, and the relationship between the index and biodiversity topics was revealed in detail. An examination of the relevance of the Educational CBI with the current biodiversity curriculum framework showed it to be highly relevant at the level of investigation and evaluation as a tool for measuring urban biodiversity. Furthermore, an examination of the relevance between the CBI for Education and the achievement standards of the general high school subjects of the 2022 revised curriculum indicated high relevance in environmental and science subjects. As an example, the city of Cheongju obtained 82–85 of 112 points in an evaluation using the Educational CBI, confirming the monitoring function of the index. Overall, the Educational CBI offers significant benefits as a tool for both biodiversity education and urban environmental education.

Key words: Biodiversity curriculum, Urban biodiversity index, High school, Cheongju

1. Introduction

According to the Living Planet Report published by the World Wildlife Fund (WWF, 2020), the population size of mammals, birds, fish, amphibians and reptiles has decreased by 68% from 1970 to 2016. Human activities such as land use, overfishing, climate change, environmental pollution, and introduction of alien species are cited as the causes, and the problem of biodiversity is becoming more serious day by day. In response, the international community defined biodiversity loss as a crisis in 1992 and began to make international efforts through the convention on biological diversity (CBD).

However, it is not easy for the public to experience biodiversity loss in their daily lives. About 55% of the world's population lives in urban areas, and this is expected to increase to 68% by 2050 (UN DESA, 2019). In Korea, 91.78% of the population is concentrated in urban areas that account for about 16.7% of the land (Ministry of Land, Infrastructure and Transport, 2021).

Meanwhile, how are students in the city studying biodiversity? Mainly in science classes, textbook descriptions of the concept and value of

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biodiversity, the causes of biodiversity loss, national and international conservation efforts, tigers becoming extinct due to indiscriminate hunting, bass, an alien species, disturbing the ecosystem, and growing bananas. This content is far from the lives of about 90% of students living in cities. In addition, despite the complex ethical, economic and social nature of biodiversity issues, they are mainly addressed from an ecological perspective (Menzel and Bögeholz, 2009).

Internationally developed and utilized indices for the conservation of urban biodiversity include the urban biodiversity and design (URBIO Index), the green city index (GCI), the low carbon city development index (LCCDI), and the city biodiversity index (CBI), among which the CBI intensively and comprehensively evaluates biodiversity with cities as the unit of evaluation (Rodricks, 2010). The CBI is also known as the Singapore index on cities biodiversity (SI) after the idea was first proposed in Singapore in 2008 and then developed and applied as a pilot. It was also recommended to use it in Article X/22 of the decision of the 10th Conference of the Parties to the CBD held in Nagoya in 2010 (Secretariat of the CBD, 2010). To truly increase biodiversity, it is necessary to pay attention to how human activities such as urbanization are related to biodiversity loss (Navarro-Perez and Tidball, 2012). In addition, it is necessary to stimulate students' interest in the biodiversity of the city where they live, conservation and management methods, and the relationship between various elements of the city and biodiversity. Only when we experience biodiversity in our surroundings and recognize the relevance of human activities, including ourselves, to biodiversity loss, can efforts to conserve it be fully realized. The purpose of this study is to explore ways to utilize the city biodiversity index (CBI) as a tool to provide biodiversity education to students living in cities.

2. Methods

2.1. Design of educational CBI for biodiversity education

2.1.1. CBI design for education

2.2.1.1. Design goal and method

Since CBI was originally developed as a tool to evaluate urban biodiversity, it is difficult to apply it directly to educational situations. It is necessary to devise an educational CBI modified according to domestic reality, data conditions, and learner conditions. Since the CBI idea was first proposed in 2008, indicators have been developed to adapt to the characteristics of each city, and modifications have been made to respond to the accelerating biodiversity decline. Recently, September 2021 CBD Technical Series No. 98 Handbook on the Singapore Index on Cities' Biodiversity (also known as the City Biodiversity Index) (hereinafter referred to as the CBI Manual), increasing the number of indicators from 23 to 28 (Chan et al., 2021). In this study, the 2021 CBI manual (Chan et al., 2021) and the Ministry of Environment (Shim, 2014) took the 2012 CBI version and analyzed the data according to the situation in Korea as the basis. Here, CBI evaluation data of Chungcheongbuk-do (Lee et al., 2017), Busan Metropolitan City (Yeo et al., 2017), and Gyeonggi-do (Kim et al., 2019) were referred. All index calculation methods and evaluation criteria were maintained based on the CBI manual.

High school students were selected as the main target learners of the CBI for Education. The meaning of biodiversity, the need for conservation, and case studies for maintenance are presented in science in the 3rd year of middle school, followed by integrated science, a common subject in the 1st year of high school, and life science Ⅰ, a general elective subject (Ministry of Education, 2022). It was judged that high school

students familiar with various humanities and social basic knowledge and abstract thinking as well as science were suitable for understanding, calculating, and evaluating the meaning of CBI indicators for education. Three current high school life science teachers reviewed whether the proposed educational CBI was suitable for high school students.

2.1.2. Biodiversity curriculum framework for the analysis of the Educational CBI

In order for CBI for education to have meaning in biodiversity education, it must be properly positioned within the framework of biodiversity education. In this study, A Biodiversity Curriculum Framework of Goals, Concepts and Skills of Biological Diversity for Secondary Education: Environmental Education Module (Peyton et al., 1995) published by UNESCO was modified and supplemented to obtain CBI indicators and analyzed.

2.2. Analysis of curriculum for utilization of CBI for education

2.2.1. Analysis target

In order to confirm whether biodiversity education can be conducted in connection with various subjects in relation to educational CBI, previous studies among the general high school subjects (group) of the 2022 revised curriculum (Seong, 2001; Gu, 2012; Park, 2020; Lee et al., 2020), achievement standards by area for the subjects in Table 1 among society (including history/ethics), science, and liberal arts subjects that showed a high level of reflection of environmental education including biodiversity were analyzed.

The reason why the achievement standard is analyzed is that it is a criterion for class activities (Ministry of Education, 2022) that combines the content that students should learn through the subject and the ability that they can or expect to be able to do after class. This is because it was judged appropriate to examine the relationship between the index and the subject. In addition, achievement standard is a term used almost synonymously with performance standard that indicates what students should learn through subjects and what students can do as a result of learning.

During the actual analysis process, in addition to the achievement standards, we noted the explanations of achievement standards as well as various learning factors; research topics and activities (examples); and matters related to teaching, learning, and evaluation methods and matters. This is because it serves as a guideline for developing textbooks and designing field classes as a wide curriculum achievement standard, so it is possible to identify related learning topics and contents expected to be covered in the curriculum of each subject (Lee et al., 2020).

Table 1. Subjects for the analysis of achievement criteria related to the CBI for education

Subject (group)	Common subjects	Optional	
		General selection	Fusion selection
Society (including history/ethics)	Integrated Society 1, Integrated Society 2	Global Citizenship and Geography, Modern Society and Ethics	
Science	Integrated Science Ⅰ, Integrated Science Ⅱ	Life Science	Climate Change and Ecology
Culture	-	Ecology and Environment	

Table 2. Criteria for each level assessing the relatedness of achievement standards for each subject to the CBI for Education and the symbols used to represent them in this paper

Symbol	●	◎	○
Relevant level	Closely related	Related	Slightly related
	content of the achievement standard for the subject is related to the CBI index	If there is no difficulty in achieving the achievement standards even if the curriculum activities are expanded and linked to the CBI index	If biodiversity education is possible depending on the level of awareness of the teacher

2.2.2. Analysis tools and methods

For the analysis framework of achievement standards by area in the curriculum and standards, each level related to educational CBI, which were created by referring to the analysis tools of Seong(2001), Gu(2012), and Park(2020), respectively were shown in Table 2.

In terms of evaluations as closely related (●), for example, it is closely related (●) to the achievement standard of integrated science [10IS2-01-02: See table 4]. It can be inferred that the evolution of living organisms occurred through the occurrence of variation and natural selection, and that biodiversity was formed through the process of evolution. The available CBI indicators for education are indicator 1, indicators 3-7, and indicators 16-28. Indicator 1 is an indicator that evaluates the ratio of natural areas within a city. Natural areas generally refer to ecosystems such as forests, grasslands, rivers, and wetlands that can be judged to have high biodiversity (i.e. ecosystem diversity). Indicators 3 to 7 are indicators that evaluate the number or change in the number of species of algae, vascular plants, and arthropods, indicating species diversity, and indicators 15 to 28 are indicators related to biodiversity conservation measures in terms of governance and management.

If there is no difficulty in achieving the achievement standard even after expanding the curriculum and linking it with the CBI index, it was evaluated as related (◎).

2.3. Actual application of CBI for education

Urban biodiversity in Cheongju was evaluated as of 2021 using CBI for education. In 2017, Chungcheongbuk-do evaluated Cheongju-si CBI results and compared them to find implications for biodiversity education. The reason why Cheongju City was selected as a CBI-applied city for education is that Chungcheongbuk-do conducted a CBI evaluation for Cheongju in 2017, and the monitoring function of CBI can be confirmed through comparison with this evaluation. In addition, the 2021 urban ecological status map has been completed and basic data are in place. In addition, Cheongju Wonheung, which is considered a successful case of public conflict resolution (Park and Kwon, 2016), is a city with experience in resolving conflicts by creating a toad ecological park. It is characterized by a local government that is interested in. A statistical nonparametric test was performed on the differences between the 2017 and 2021 Cheongju city biodiversity index scores using the wilcox test. Non-parametric tests were performed using RStudio 2024. 04.2.+764.

3. Results

3.1. Design of educational CBI for biodiversity education

3.1.1. CBI draft for education

In order to utilize it for biodiversity education,

the 2021 CBI was modified and supplemented to devise a educational CBI. Efforts to maintain the indicators of the existing 2021 CBI, but the CBI of the Ministry of Environment (Shim et al., 2014), Chungcheongbuk-do (Lee et al., 2017), Busan Metropolitan City (Yeo et al., 2017), and Gyeonggi-do (Kim and Jang, 2019) Referring to the research, evaluation basis data were selected according to domestic circumstances. Considering that the subject of evaluation is a high school student, the data used for calculating the indicators were selected and used.

Like the 2021 CBI, the CBI for Education consists of two parts: A City overview and 28 indicators measuring native biodiversity, ecosystem services, and governance and management.

3.1.2. City overview

It describes general information about the city, providing background information that is not included in the index but is relevant to biodiversity. Among them, gross regional domestic product (GRDP) is the sum of the final product values newly created within a certain region during a certain period, that is, how much added value is generated by economic activity within each city or province. Economy It is an indicator. It can be seen as GDP by city and province, which comprehensively shows the reality of the regional economy through regional income statistics (Statistics Korea, 2022). It is an item that can indirectly know the pressure on biodiversity along with major economic activities.

3.1.3. CBI indicators and evaluation methods for education

The relationship between each CBI index for education and biodiversity, and the evaluation method were summarized. The specific calculation methods and evaluation criteria were indicated in Chan et al.' studies (2021).

3.1.4. Analysis of educational CBI from the perspective of biodiversity education

Table 3 shows the location of CBI for education in the biodiversity curriculum framework.

As a tool for measuring urban biodiversity, all CBI indicators for education are Ⅲ. It is related to monitoring at the level of investigation and evaluation (A) and knowledge and skills (B). Through monitoring (Ⅲ-A), long-term trends in biodiversity in the region can be observed and the future of biodiversity can be predicted. By comparing evaluation results over time, city values and points of improvement can be found, which can lead to new policy proposals. In order to evaluate urban biodiversity, knowledge and skills (III-B) that identify indicators and information, investigate, and synthesize information are required, and knowledge and skills can be trained in the evaluation process through feedback.

Among the educational CBI indicators, indicators 1 and 7 in table 3 evaluate ecosystem diversity (Ⅰ-A), and indicators 3 to 7 evaluate species diversity (Ⅰ-A). In particular, the ecosystem diversity realized in cities is important because diverse habitats support species diversity, genetic diversity, molecular diversity, and are involved in maintaining functional diversity. Indicator 7 identifies not only quantitative efforts to increase the area restored, but also qualitative efforts to restore different habitat types, by identifying the number of restored habitat types compared to those existing within the city, thereby further emphasizing the concept of ecosystem diversity.

The ecological importance of biodiversity (Ⅰ-C), the most repetitive emphasis in science subjects is ecosystem stability. Through the educational CBI, material cycles (indicator 10) and ecosystem services (indicators 10 to 13) can be learned with examples. In particular, in the era of climate crisis, we experience frequent environmental disasters such as heavy rain and

Table 3. Relation between the biodiversity curriculum framework and CBI indicators for education

Target level	Concept	The details	CBI indicator number (CBI indicator)
Ⅰ. Ecological basis	A. Meaning of biodiversity	Species diversity, genetic diversity, ecosystem diversity	1 (Percentage of natural areas), 3 (Native biodiversity in urban areas), 4 (Changes in the number of native vascular plant species), 5 (Changes in the number of native bird species), 6 (Changes in the number of native arthropod species), 7 (Habitat restoration)
	B. Presence of Biodiversity	The state of global and regional biodiversity	
	C. Ecological importance of biodiversity	Evolution and adaptation, ecosystem stability, energy flow and material cycles, ecosystem services	10 (Control the amount of water),11 (Climate control),12 (Recreational services),13 (Health and wellness)
	D. Factors that reduce biodiversity	Sudden changes in environmental conditions (natural factors, anthropogenic factors)	1,2 (Connectivity measurement or ecological network),9 (Rate of invasive alien species)
Ⅱ. Conceptual awareness of biodiversity issues and values	A. Biodiversity issues	Spatial (local, global) time (present, future, past)	
	B. Nature of the biodiversity problem	values or beliefs of stakeholders, issues of all citizens, Insufficiency of Scientific Solutions	
	C. Biodiversity Conservation Values	Values and benefits of biodiversity conservation (regional, global)	
	D. Biodiversity issues and human activities	The relationship between human activities (religious, economic, political and social) and biodiversity issues	
	E. Individual roles	The role of individual action in the creation and resolution of biodiversity problems	
	F. Science and Technology	for biodiversity management and protection scientific and technological means	7,15 (Institutional capacity), 28 (Citizen science)
	G. Sociopolitical	Sociopolitical processes and institutions that manage biodiversity issues and problems	7,8 (Percentage of protected areas), 14 (urban agriculture), 15,16 (Budget allocated to biodiversity), 18 (Natural capital valuation status), 19 (Current status of green space and river management plan), 20 (Biodiversity-related response to climate change), 21 (Policies, regulations and incentives for green infrastructure),22 (Cooperation between government agencies), 23 (Engagement and partnership), 24 (Engagement and partnership), 25 (Number of biodiversity projects implemented by the city each year), 26 (Education), 27 (Recognition)
	H. Measures	Regional, national and global measures being implemented and planned to manage biodiversity resources	17 (Policies, rules and regulations)
Ⅲ. Investigation and evaluation	A. Monitoring	Monitor and predict trends in nature and society	entire
	B. Knowledge and skills	Knowledge and skills required to investigate biodiversity issues and synthesize the collected information	entire
	C. Analytical Capabilities	A key component of the problem of biodiversity (Stakeholders, current state of science and technology, values and beliefs, etc.) Analytical ability	
	D. Assessment Ability	Ability to evaluate solutions (scientific information, stakeholder values and beliefs, political, social, economic and natural resources available)	
	E. Ability to Clarify Values	Identify and clarify one's own and others' values and priorities related to biodiversity issues	
Ⅳ. Action function	A. Ability to participate	Ability to participate effectively in the process of evaluating and selecting biodiversity problems and solutions	
	B. Decision-making ability	Ability to identify, evaluate and select effective solutions to biodiversity challenges	
	C. Ability to execute	Ability to effectively implement selected actions to address biodiversity challenges	

heat waves. The higher the impervious area of a city (indicator 10), the lower the amount of inflow into the groundwater, which, coupled with the increased consumption of groundwater, affects the water circulation. It also means that a separate system should be prepared for heavy rain and sewage overflow (Vermonden et al., 2012). In relation to heat waves, shade formed by green spaces, especially shrubs (indicator 12), reduces the urban heat island effect. Despite its importance, ecosystem services are not explicitly covered in educational content including textbooks (Rodríguez-Loinaz and Palacios-Agundez, 2022), and CBI for education is an opportunity to introduce the concept of ecosystem services and confirm its value in urban environments.

3.2. Analysis of curriculum for utilization of CBI for education

Table 4 shows the results of analyzing the relationship between the 2022 revised high school curriculum achievement standards and educational CBI indicators.

For each subject, 5 Ecology and environment, 4 integrated science, 4 integrated society Ⅰ, 1 integrated society Ⅱ, 2 climate change and ecology, 1 global citizenship and geography, 1 politics and law, Relations with the CBI indicators for education were confirmed in the achievement criteria of 2 in Modern society and Ethics, and 1 in Life Science.

Particularly closely related (●) subjects were ecology and environment, and integrated science. In particular, the main contents of the achievement standards [12 EE 04-02] (Ecology and environment), and [10 IS 2-01-02] (Integrated Science) are related to more than 20 CBI indicators. However, since these achievement standards deal with the meaning and value of biodiversity and biodiversity conservation measures, they could show high relevance.

The achievement criterion that showed the highest correlation with educational CBI was the ecology and environment [12 EE 04 – 02]. Although the number of related indicators itself is similar to that of integrated science [10 IS 2-02-02], it is much more explicit in identifying the relationship between biodiversity issues and social systems and requesting participation in conservation activities. Looking at the description of the achievement standard, Understand the role and interaction of organisms in the ecosystem from the natural science and social science aspects through cases such as reckless capture, introduction of alien species, and habitat destruction, and the economic, social, and cultural values of organisms. By recognizing this, students participate directly or indirectly in biodiversity conservation and its activities, and through discussions, they can infer the impact of biodiversity loss on ecosystems and social systems. We pursue a multifaceted understanding related to biodiversity, including the natural and social scientific aspects of causes and effects, the value of organisms, and conservation and participation in biodiversity.

At this time, it is important to think about not only international agreements and international organization data, but also what efforts we can make in our lives. Considering that CBI is an evaluation criterion proposed based on an international treaty called the convention on biological diversity (CBD), and an indicator that aims to improve and maintain urban biodiversity through management in terms of city government and governance, it is a global It is a good material to look at local efforts at the intermediate level between effort and effort in individual daily life. As a common subject that all high school students must study, integrated science [10 IS 2-01-02] is particularly important in biodiversity education.

Among the CBI indicators for education, climate control (indicator 11), recreation (indicator 12),

Table 4. Results of the analysis of the level of relevance between high school subject achievement standards and CBI for education

Subject	Achievement standard	CBI indicator relevance	
		Number	Degree
Integrated society 1	[10 IS1-02-02]* Explore the need to create a high-quality settlement environment, economic stability, democratic development, and moral practice as a condition for realizing a happy life.	12, 13	◎
Integrated society 1	[10 IS1-03-03] Investigate the various efforts of the government, civil society, and companies to solve environmental problems, and seek ways to implement them as an ecological citizen.	entire	◎
Integrated society 1	[10 IS1-05-01] We investigate changes in living space and lifestyle due to industrialization and urbanization, and propose solutions to problems associated with them.	1, 10	◎
Integrated society 1	[10 IS1-05-03] Explore aspects and problems caused by spatial changes using the area where you live as an example, and seek and implement ways to change the local community as a member of the community.	entire	◎
Integrated society 2	[10 IS2-05-02] Identifies the distribution and consumption of energy resources on a global level, and explores institutional measures and individual efforts for climate change response and sustainable development.	entire	◎
Global citizenship and geography	[12 GG 04-02] It explains the types and examples of major environmental problems in the world, and critically examines current lifestyles in light of ecological transformation.	entire	◎
Modern society and ethics	[12 ME 02-03] You can compare and explain Eastern and Western perspectives on nature, investigate the cases and severity of today's environmental problems, and suggest ethical solutions to them.	-	○
Modern society and ethics	[12 ME 05-02] It is possible to criticize ethical issues related to eating and drinking, conflicts between moral good and the pursuit of profit arising from economic life, and issues in consumer culture from an ethical perspective.	-	○
Integrated science 2	[10IS2-01-01] It can be inferred that the global environment has been constantly changing through the geological era, and biodiversity has been affected by these environmental changes.	-	○
Integrated science 2	[10IS2-01-02] It can be inferred that the evolution of living organisms occurred through the occurrence of variation and natural selection, and that biodiversity was formed through the process of evolution.	1, 3~7, 15~28	●
Integrated science 2	[10IS2-02-01] Able to understand ecosystem components and explain the interrelationships between living organisms and the environment.	11-14	◎
Integrated science 2	[10IS2-02-02] You can understand the process of maintaining ecosystem equilibrium around food relationships and ecological pyramids, and collaboratively communicate about the effects environmental changes can have on ecosystems.	entire	◎
Life Science	[12 LS 01-06] You can explain the importance of ecosystem components by understanding the structure of an ecosystem and deducing the circulation of materials and the flow of energy.	11-14	◎
Climate change and ecology	[12 CE 03-02] You can understand desertification, large-scale forest fires, and regional droughts and floods that are accelerating due to climate change, and discuss human efforts to overcome them.	20	○
Climate change and ecology	[12 CE 03-04] Learn about the international community's efforts to respond to the climate crisis and changes in the environment and ecology, and suggest ways to participate as a democratic citizen.	20	○
Ecology and environment	[12 EE 01 – 03] They analyze ethical conflict situations related to the environment, recognize various perspectives on the situation, listen to the opinions of others, and present their own opinions with a sense of responsibility for conflict resolution.	-	○

Subject	Achievement standard	CBI indicator relevance	
		Number	Degree
Ecology and environment	[12 EE 02 – 01] We understand that environmental systems are complex systems composed of global ecosystems and social systems, and recognize that systemic thinking is necessary to understand their interactions.	-	○
Ecology and environment	[12 EE 03 – 02] Domestic and international environmental issues and issues related to soil and biology are explored in depth in relation to resilience, irreversibility, and diversity, and the main causes and effects of environmental problems and issues are analyzed to derive implications and solutions.	7,8	●
Ecology and environment	[12 EE 04 – 02] We explore specific examples of impacts and damage caused by climate change, such as a decline in biodiversity and a decline in quality of life, and recognize them in connection with climate change vulnerability and climate justice.	1,2, 7 to 9; 11~28	●
Ecology and environment	[12 EE 05 – 01] We analyze sustainable development goals (SDGs) and explore various ways to create a sustainable society through discussions on standards for a happy life.	entire	◎

Note. *The figures and letters in square bracket indicate classified codes of each achievement standards in each subject.

health and well-being (indicator 13) and urban agriculture (indicator 14) in the ecosystem services sector represent the value of biodiversity to benefit humans, which It is also related to integrated science [10 IS 2-02-01] and ecoloy and environment [12 EE 04 – 02].

3.3. Actual application of CBI for education

3.3.1. Comprehensive results of CBI evaluation for education in Cheongju-si

The results of the evaluation of urban biodiversity in Cheongju by CBI for education are shown in Table 5, with scores ranging from 82 to 85. The scores in Table 5 are assigned 0, 1, 2, 3, and 4 points according to each indicator, and were calculated accordingly.

3.3.2. Comparison with 2017 CBI evaluation results

The CBI scores of Cheongju City evaluated by Chungcheongbuk-do (Lee et al., 2017) and the results evaluated by this study as educational CBI were compared (Table 5). Direct comparison and interpretation are difficult due to differences in the version of the CBI used for evaluation, changes in indicators accordingly, evaluation data, and evaluation purpose. However, we would like to confirm the monitoring function of CBI by examining several indicators.

Regarding the natural area (indicator 1), Chungcheongbuk-do (Lee et al., 2017) assigned 508 ㎢, 54% (4 points) to the natural area ratio of Cheongju in 2017 using the land cover medium classification. Based on the same data, if the natural area ratio of Cheongju in 2021 is calculated, the area of the natural area is 418 ㎢, which corresponds to 44% of the area of Cheongju. It can be seen that the area of the natural area has decreased by about 10% compared to four years ago. In a study by Yun et al.(2016), which classified cities according to population size and land-name ratio, it can be inferred that the urbanization of Cheongju, which had a high proportion of natural areas to be classified as a forest type, is accelerating. In this study using the urban ecology map, the proportion of natural areas was calculated as 57.64%. It is the same in that 4 points are awarded when natural areas account for 20% or more of the total area of a city, but there is a large difference in actual figures.

According to a study by Park et al.(2016), it is necessary to understand and apply the

Table 5. Comparison of 2017 Cheongju CBI evaluation results and educational CBI evaluation results

Item	Indicators and content	2017 Score	2021 Score
Native biodiversity	Percentage of Natural Areas	4	4
	Ecological network	4	4
	Native biodiversity in urban areas (algae)	4	4
	Changes in the number of native vascular plant species	0	0
	Changes in the number of native birds	0	0
	Changes in the number of native arthropod species	0	0
	Selected: Amphibians	0	delete*
	Choose: Fish	0	delete
	Habitat restoration	newly open*	1
	Percentage of Protected Areas	0	2
	Alien species rate	4	4
Ecosystem service	Control the amount of water	4	4
	Climate control	3	4
	Natural areas and park areas (recreation services)	2	4
	Health and Wellness – Proximity to Parks	newly open	3
	Food Security - Urban Agriculture	newly open	4
	Educational service	2	delete
Governance and Management	Number of functions related to biodiversity (institutional capacity)	4	4
	Budget Allocated to Biodiversity	3	4
	Policies, Rules and Regulations – Biodiversity Strategies and Action Plans	0	4
	Natural Capital Valuation Status	newly open	0
	Current status of green space and river management plan	newly open	4
	Biodiversity-related response to climate change	newly open	4
	Policies, regulations and incentives for green infrastructure	newly open	2
	Number of institutions carrying out work related to biodiversity (inter-governmental cooperation)	4	4
	Participation and partnership (consultation process)	3	3
	Engagement and partnership (non-governmental)	4	4
	Number of biodiversity-related projects implemented by the city each year	0	2
	Education	4	4
	Recognize	1	1 to 4
	Citizen science	newly open	4
sum/perfect score		50/92[a]	82~85 /112[b]

Note. *New ones have been created or removed due to changes in CBI evaluation indicators.
[a,b]The scores between 2017 and 2021Cheongju CBI were not significantly different as a statistical result of wilcox test using RStudio 2024.04.2.+764.

characteristics of each environmental information map when calculating the CBI index. In the case of land cover map, detailed type information is insufficient, such as errors in classification due to scale limitations, the inclusion of green areas such as urban parks as natural elements, and errors in classifying forest edge development areas into forest types. The urban ecological status map has

characteristics such as the fact that military bases are classified as special areas and that urban park types can be excluded from natural elements. In order to increase the accuracy, it is judged that it is better to use the site-based urban ecological status map.

4. Discussion

4.1. Educational CBI as a tool for biodiversity education

Menzel and Bögeholz(2009) summarized the difficulties of biodiversity from an educational point of view. They argue that the nature of the term biodiversity leaves room for it to be equated with and conceptually reduced to species diversity, that the cause of biodiversity loss is complex, but it is likely to focus on an ecological perspective, and that biodiversity is a problem in a specific region. Points that were highly likely to be accepted were pointed out.

Educational CBI can be a supplement to the above difficulties. First, a number of indicators for biodiversity other than species diversity, especially ecosystem diversity, can be included to avoid narrowing the concept. Indicators 3 to 6 are related to species diversity, and indicators 1, 2, 3, 7, 8, 10, 12, and 19 are related to ecosystem diversity. Although the range of natural areas is slightly different for each indicator, based on the urban ecological status map, various biotopes are included in the city, and the need to protect them and maintain connectivity can be known. In the cases of indicators 2 and 8, it is possible to learn about genetic diversity through maintenance and connectivity of microhabitats by ecological networks against habitat fragmentation, and forest genetic resource protection areas, respectively.

Second, it is easy to introduce social, economic and political approaches to biodiversity issues. The CBI, the parent of the CBI for Education, was created to assess and monitor the progress of cities' biodiversity conservation efforts. Unlike the Shannon-Wiener index (H´) and the Simpson index, which are representative diversity indices used in the scientific field, CBI measures environmental, economic, and social variables necessary for urban societies to manage biodiversity. Representative economic indicator 16 evaluates financial efforts to maintain and enhance biodiversity through city budgets, and indicators 10 to 14, which are ecosystem service indicators, and indicator 18, which is related to the assessment of natural capital, evaluate the economic value of various services provided by nature. By valuing, it is possible to recognize and evaluate the value. Indicators of governance and management items are all related to social, political and legal approaches. This is also shown in the results of a study examining the relevance of the biodiversity curriculum framework and CBI for education. The scientific, social, economic, and political characteristics of each indicator were partially revealed in Research Result 2. Analysis of Curriculum for Utilization of CBI for Education. In addition to science subjects, relevance to educational CBI indicators was found in general social studies, geography, environment, and technology and home economics subjects. In addition, CBI for education can methodologically support science teachers. Science teachers, who are the main subjects of biodiversity education in general, have difficulty dealing with methodologies such as discussion, critical reading, role play, and writing activities that are not commonly used in science education (Gayford, 2000). CBI for education helps science teachers introduce various perspectives by the characteristics of the indicators themselves, without using unfamiliar methods. As such, linking each area through educational CBI will provide learners with complex perspectives such as science, society, politics, economy, and environment to enhance understanding of

biodiversity issues and expand the scope of biodiversity education.

Third, it helps to recognize biodiversity issues at the local level. If instructors look at the places that are mainly exemplified in biodiversity education, they are often biodiversity hotspots such as Africa and tropical rain forests. Although this is a place where action is relatively urgent, if this is repeated, there is a risk that learners will perceive biodiversity issues as a local problem (Menzel and Bögeholz, 2009). In order to prevent this, opportunities should be provided to recognize that biodiversity loss is a global problem, and that it is happening not only in distant countries, but also in this land. A similar point is that the problem of biodiversity loss focuses on exotic species and environments, especially on species, especially large animals, rather than on habitats. Compared to the interest in specific exotic animals, such as elephants and polar bears, interest in plants and endemic or endemic species whose biodiversity loss is serious is lacking both educationally and socially (Gayford, 2000).

In general, urban biodiversity is judged to be poor (Secretariat of the CBD, 2010). As a result of industrialization or urbanization, it is thought that there is little space for organisms to live (Menzel and Bögeholz, 2009). However, on average, 70% of plant species and 94% of bird species found in cities were found to grow naturally in surrounding areas (Secretariat of the CBD, 2010). In this way, learners realize that biodiversity issues are realized at the local level through educational CBI, and that various organisms and their habitats exist around them and can be managed by humans. In addition, CBI indicators for education target living organisms and arthropods such as plants, birds, and butterflies native to cities, enabling recognition of various taxa living in the region. This approach based on the place where one lives is in line with the principle of everyday life in environmental education (Nam, 1995).

The use of CBI for education in biodiversity education is meaningful as a tool to supplement difficulties in existing biodiversity education and to realize biodiversity issues in the lives of urban learners.

4.2. Educational CBI from the perspective of urban environment education

Urban biodiversity assessment by urban learners through educational CBI can also find its meaning in the context of urban environmental education. By assessing urban biodiversity, learners can use the urban environment as a classroom to increase their understanding of the region (Russ and Kransy, 2015). It is possible to grasp the ecological characteristics of the region as well as the budget, administrative system, various institutions, and governance situation. In particular, in order to evaluate governance and management items, it is necessary to look at the homepage and public documents of local governments and search for local governments in the portal. In the process, not only biodiversity, but also the background of the projects and achievements, organizations, and events operated by the local government are learned. It is to understand the urban system in context.

Also, the city can be viewed from the perspective of biodiversity. In addition to sparrows and pigeons, a variety of birds live in the city, trees along roads provide not only beautiful scenery but also shade in summer, and flower beds with bees flying contribute to the ecological network. On the other hand, roads that represent the speed and convenience of urban life act as ecologically artificial barriers and disconnection elements, and are made of asphalt to increase the imperviousness of the city. This perspective helps to recognize the city as a part of the biosphere, including nature, and as a socio-ecological system that evolves while interacting with people

(Russ and Kransy, 2015). Furthermore, we can understand that man-made socio-economic systems are fundamentally connected to natural ecosystems. Local interests extend globally.

By assessing the biodiversity of the city in which they live, learners learn skills as citizens along with an understanding of the region. According to Russ and Kransy(2015), through urban environment education, youth can learn life and civic skills and improve their self-esteem, and the community can improve their empowerment. This is because the development of the individual and society are interrelated. People with critical thinking, active citizenship, etc. participate in urban planning and work to solve community problems. The overarching objective of the biodiversity curriculum framework is to help students become environmentally savvy, skilled and committed citizens committed to individually and collectively working to maintain and enhance biodiversity at the local or global level, it can be expected that biodiversity education through educational CBI will serve as a stepping stone to help grow from youth to citizens and expand the field of view from the region to the earth.

4.3. Usage direction of CBI for education

the biodiversity curriculum framework (Peyton et al., 1995), the current educational situation can be identified and future development directions can be suggested (Lee et al., 2020). As the curriculum was revised, the cognitive domain of understanding the concept of biodiversity (levels Ⅰ and Ⅱ) expanded to include the defining and social domain of values such as preservation and conservation (levels Ⅲ and Ⅳ) (Lee, 2019). CBI for education is Ⅱ. Social politics at the level of conceptual awareness of biodiversity issues and values (G), Ⅲ. It was closely related to monitoring at the level of investigation and evaluation (A) and knowledge and skills (B) [Table Ⅳ -7]. Based on this, I would like to suggest the direction of using CBI for education in biodiversity education.

The balance between knowing, feeling, and acting about the environment is very important, but since proper awareness of the environment is based on the knowledge and skills acquired through environmental education, it is essential to acquire and develop basic knowledge about the environment. (Choi et al., 2007). Likewise, good knowledge of biodiversity concepts is fundamental to effective biodiversity learning. Although the meaning and importance of biodiversity from a global ecological perspective and the causes of its decline are fully covered in science classes, it is difficult to cover the cognitive and social realms beyond the cognitive realm pursued by the achievement standards.

At this point, the use of CBI for education is possible. Building on the concepts learned in science class, CBI for education can be used to capture the practice of biodiversity and ecosystem services, governance and management on a regional scale. In particular, governance and management items are important. When talking about biodiversity conservation efforts with students after science class, they talk about vague environmental protection practices at a personal level, such as reducing disposables and not throwing away garbage. Looking at the policies and systems of local governments through the governance and management items of the CBI for education, and examining in what respects the policies and systems can preserve the city's biodiversity, it will serve as an opportunity to broaden the scope of thinking. In addition, CBI for education can train the knowledge and skills to collect and synthesize information in the process of evaluating each indicator. This knowledge and skills can be applied not only to the field of biodiversity but also to other fields, and belongs to

knowledge information processing capability, which is one of the core competencies to be cultivated in the 2022 revised curriculum.

5. Conclusions

This study explored the utilization of the city biodiversity index (CBI) as a tool for biodiversity education. As most students live in cities, this research was conducted to improve biodiversity education through urban biodiversity.

First, in order to utilize it for biodiversity education, a CBI for Education was devised by revising and supplementing the existing CBI developed to evaluate urban biodiversity. Based on the current educational situation, the relationship between each indicator and biodiversity was clarified through literature research, and the basis data for the evaluation were selected. Most of them followed the 2021 CBI manual, but the data that were difficult to aggregate at the data condition and student level were modified. As a result of analyzing CBI for Education using the biodiversity curriculum framework, the relevance of the indicators was highest at education target level III, Investigation and Evaluation.

Second, an analysis was conducted to confirm that biodiversity education can be conducted using the CBI for Education in connection with various subjects. Among the general high school subjects (groups) of the 2022 revised curriculum, two subjects' achievement standards, Integrated Society and Global Citizenship and Geography, were particularly highly related to the CBI for Education indicators. The relationship between the achievement standards of the subjects Modern Society and Ethics, Life Science, and Integrated Science and the Educational CBI was analyzed at each level. Ecology and Environment, Integrated Science II, and Life Science showed the highest relevance in terms of the meaning, value, and conservation planning of biodiversity. In ethics-related subjects, the CBI indicators were less closely related but could be incorporated to deal with important ethical issues in biodiversity education.

Third, using the CBI for Education, the CBI of Cheongju City was evaluated based on its situation in 2021, and the evaluation results were compared to those of a 2017 CBI-based evaluation of Cheongju City conducted by Chungcheongbuk-do in 2017. Although it was difficult to make a direct comparison due to differences in the version of the CBI used for the evaluations, including changes in indicators, evaluation data, and evaluation purposes, it was confirmed that Cheongju City is undergoing urbanization.

Looking at the significance of the CBI for Education as a tool for biodiversity education, it is meaningful as a tool to supplement existing biodiversity education and overcome difficulties in teaching the concept of biodiversity and integrating it into non-science subjects, fostering a greater understanding of biodiversity issues in the lives of urban learners. From the perspective of urban environmental education, the CBI for Education helps to cultivate a better understanding of many aspects of the student's local region and facilitates the teaching of citizenship skills. In addition, it encourages the recognition of the city as a part of the biosphere where biodiversity can be implemented and managed and as a socio-ecological system that evolves while interacting with humans.

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