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Architecture of Nature-Based Smart City Introducing BaaS by Utilizing UAF

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Research trend on Smart City

- Smart city can enhance the quality of life of various stakeholders, including residents and local industries, by utilizing various cutting-edge technologies, such as IoT (Mall et al., 2023).
- Systems Engineering Vision 2035 emphasizes the necessity of designing balanced solutions, such as smart cities, to satisfy various stakeholder needs for capability, dependability, sustainability, social acceptability (INCOSE, 2021).
- The resilient smart city architecture perspective includes a focus on addressing risks, such as cascading failures, in terms of evolving needs, external context (INCOSE, 2023a).
- Considering that cities can exacerbate some of the world's most severe environmental and socioeconomic challenges, cities need to make peace with nature (UNEP, 2021)
- The acceleration of nature-based solutions (NbS) adoption can enhance urban resilience, mitigate urban heat island effects, improve air quality (UNEP, 2021)

Research trend can be seen in the previous research is that smart city aims at achieving sustainability by leveraging advanced technologies and the focus for considering nature appeared.

Literature Review of NbS

- The European Commission defines NbS as solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social, and economic benefits and help build resilience (The European Commission, 2022).
- These nature-based actions protect, sustainably manage, and restore ecosystems, effectively addressing societal challenges while benefiting both people and nature (IUCN, 2023).
- Multilevel governance and the removal of barriers to NbS expansion are critical, particularly the involvement of all stakeholder groups (UNEP, 2021).
- Aligning NbS with urban priorities, fostering partnerships among public, private, and nongovernmental organizations (NGOs), and creating intermediaries are key strategies required in smart cities (Xie et al., 2022).

Although NbS implement in smart city offers various benefits, the best way to use these benefits and the specific operations required to achieve them, remain unclear.

Biophilia as a Service (BaaS)

- Biophilia as a Service (BaaS), is defined as an integrated nature conservation service to protect natural environment. (Chen et al., 2024).
 - BaaS promotes nature safeguard action, while collaborating a range of stakeholders, based on the biophilia awareness.

What is biophilia?

- The innate tendency of humanity to focus on and to affiliate with nature, defined in the book *Biophilia*, by Edward O. Wilson, and he emphasizes the significance of biophilia for conservation and protection. (Wilson, 1984)

Research Motivations and Objectives

Motivations



We need to clarify how to realize these benefits based on local natural environment and how to collaborate with each stakeholder.



For sustainable smart city, it is significant to consider the entire picture in an integrated view, including which departments should play what roles, and which stakeholders should be collaborated with.

Objectives



We refer to sustainable and resilient smart city in harmony with nature as a nature-based smart city (NBSC) and define the architecture of NBSC introducing BaaS.



We consider NBSC introducing BaaS as an SoS and describe the architecture of NBSC introducing BaaS by utilizing the Unified Architecture Framework (UAF).

Model-UAF (Unified Architecture Framework)

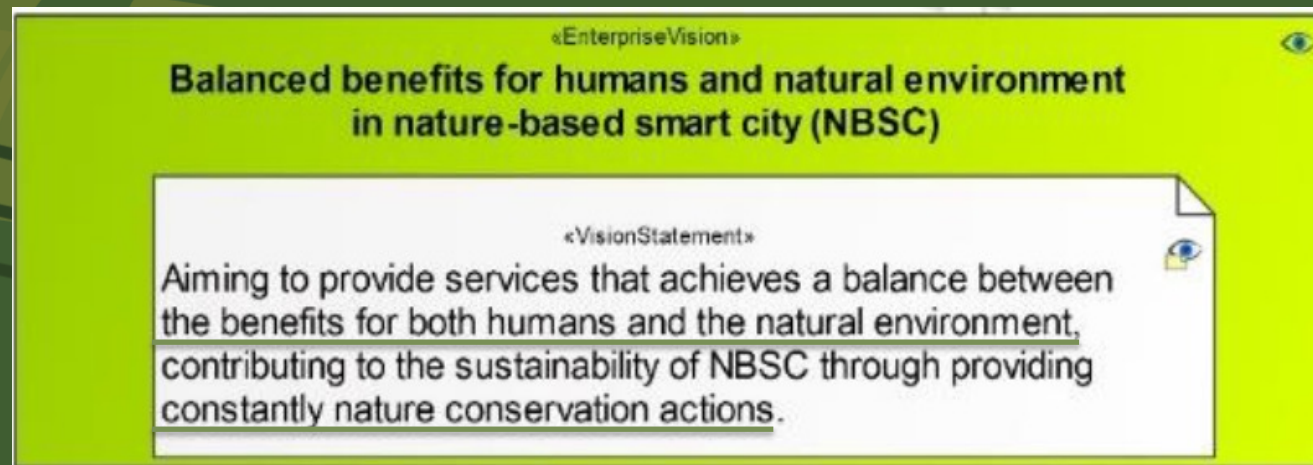
- What is UAF?
 - UAF is a comprehensively integrated framework that is suitable to describe enterprise architecture as a System of Systems (SoS).
- Why choose UAF?
 - It provides a means to analyze architecture from the viewpoints of strategic, operation, services, resources, and others, to meet the needs of stakeholders from an integrated view.

	Motivation Mv	Taxonomy Tx	Structure Sr	Connectivity Cn	Processes Pr	States St	Sequences Sq	Information If	Parameters Pm	Constraints Ct	Roadmap Rm	Traceability Tr
Architecture Management Am	Architecture Principles Am-Mv	Architecture Extensions Am-Tx	Architecture Views Am-Sr	Architectural References Am-Cn	Architecture Development Method Am-Pr			Dictionary Am-If	Architecture Parameters Am-Pm	Architecture Constraints Am-Ct	Architecture Roadmap Am-Rm	Architecture Traceability Am-Tr
Summary & Overview												
Strategic St	Strategic Motivation St-Mv	Strategic Taxonomy St-Tx	Strategic Structure St-Sr	Strategic Connectivity St-Cn	Strategic Processes St-Pr	Strategic States St-St	Strategic Sequences St-Sq	Strategic Information St-If	Strategic Parameters St-Pm	Strategic Constraints St-Ct	Strategic Roadmaps St-Rm	Strategic Traceability St-Tr
Operational Op		Operational Taxonomy Op-Tx	Operational Structure Op-Sr	Operational Connectivity Op-Cn	Operational Processes Op-Pr	Operational States Op-St	Operational Sequences Op-Sq	Operational Information Op-If	Operational Parameters Op-Pm	Operational Constraints Op-Ct	Operational Roadmaps Op-Rm	Operational Traceability Op-Tr
Services Sv		Services Taxonomy Sv-Tx	Services Structure Sv-Sr	Services Connectivity Sv-Cn	Services Processes Sv-Pr	Services States Sv-St	Services Sequences Sv-Sq	Services Information Sv-If	Services Parameters Sv-Pm	Services Constraints Sv-Ct	Services Roadmaps Sv-Rm	Services Traceability Sv-Tr
Personnel Ps		Personnel Taxonomy Ps-Tx	Personnel Structure Ps-Sr	Personnel Connectivity Ps-Cn	Personnel Processes Ps-Pr	Personnel States Ps-St	Personnel Sequences Ps-Sq	Personnel Information Ps-If	Personnel Parameters Ps-Pm	Personnel Constraints Ps-Ct	Personnel Roadmaps Ps-Rm	Personnel Traceability Ps-Tr
Resources Rs		Resources Taxonomy Rs-Tx	Resources Structure Rs-Sr	Resources Connectivity Rs-Cn	Resources Processes Rs-Pr	Resources States Rs-St	Resources Sequences Rs-Sq	Resources Information Rs-If	Resources Parameters Rs-Pm	Resources Constraints Rs-Ct	Resources Roadmaps Rs-Rm	Resources Traceability Rs-Tr
Security Sc		Security Taxonomy Sc-Tx	Security Structure Sc-Sr	Security Connectivity Sc-Cn	Security Processes Sc-Pr					Security Constraints Sc-Ct		Security Traceability Sc-Tr
Projects Pj					Projects Processes Pj-Pr						Projects Roadmaps Pj-Rm	Projects Traceability Pj-Tr
Standards Sd											Standards Roadmaps Sd-Rm	Standards Traceability Sd-Tr
Actual Resources Ar			Actual Resources Structure Ar-Sr	Actual Resources Connectivity Ar-Cn		Simulation				Evaluation		

Architecture of Nature-Based Smart City (NBSC) Introducing BaaS by Utilizing UAF

Strategic Structure for NBSC introducing BaaS

- Vision
 - The future state of NBSC Introducing BaaS is “Balanced benefits for humans and natural environment in NBSC”, by providing constantly nature conservation action.



Strategic Structure for NBSC introducing BaaS

There are four goals which are defined based on the vision for NBSC, considering drivers, challenges and opportunities.

- Convenience and Efficiency in harmony with nature(Id="1")

- Keep peace with nature

- Enhance biophilia awareness (Id="2")

- Develop an understanding of nature

- Contribute to sustainable natural resources (Id="3")

- The contribution of sustainable management

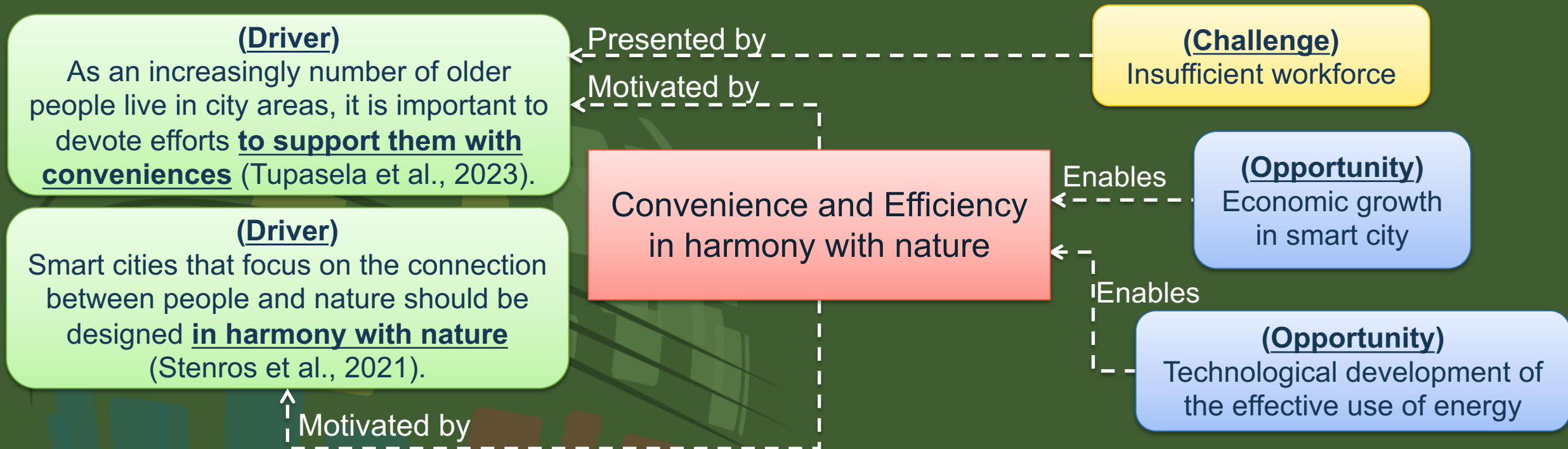
- Nature safeguard action development (Id="4")

- Respect the value of residents in NBSC

<div>«EnterpriseGoal»</div> <div>Convenience and Efficiency in harmony with nature</div> <div>Id = "1"</div> <div>Text = "Support for a convenient and effective infrastructure plan in harmony with nature"</div>	<div>«EnterpriseGoal»</div> <div>Enhance biophilia awareness</div> <div>Id = "2"</div> <div>Text = "Provide opportunities to contribute to develop an understanding of nature "</div>
<div>«EnterpriseGoal»</div> <div>Contribute to sustainable natural resources</div> <div>Id = "3"</div> <div>Text = "Contribute to the sustainable management of the natural resources"</div>	<div>«EnterpriseGoal»</div> <div>Nature safeguard action development</div> <div>Id = "4"</div> <div>Text = "Plan and execute nature safeguard actions while respecting the value of residents"</div>

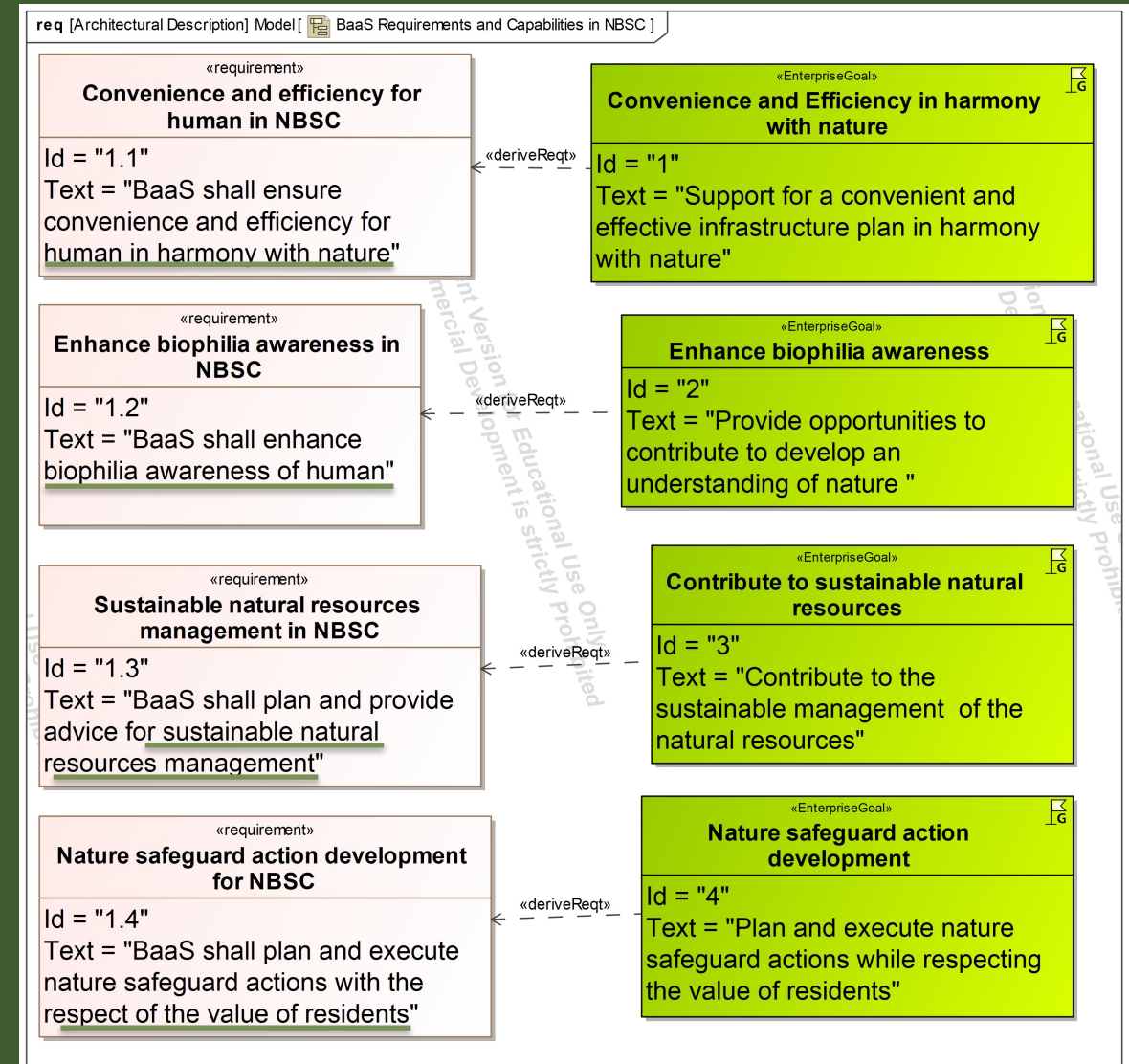
Strategic Motivation: Convenience and efficiency in harmony with nature

- Goal (Id="1") : Convenience and Efficiency in harmony with nature
 - It is crucial to ensure that NBSC residents are conveniently and effectively served to contribute to their well-being in harmony with nature.



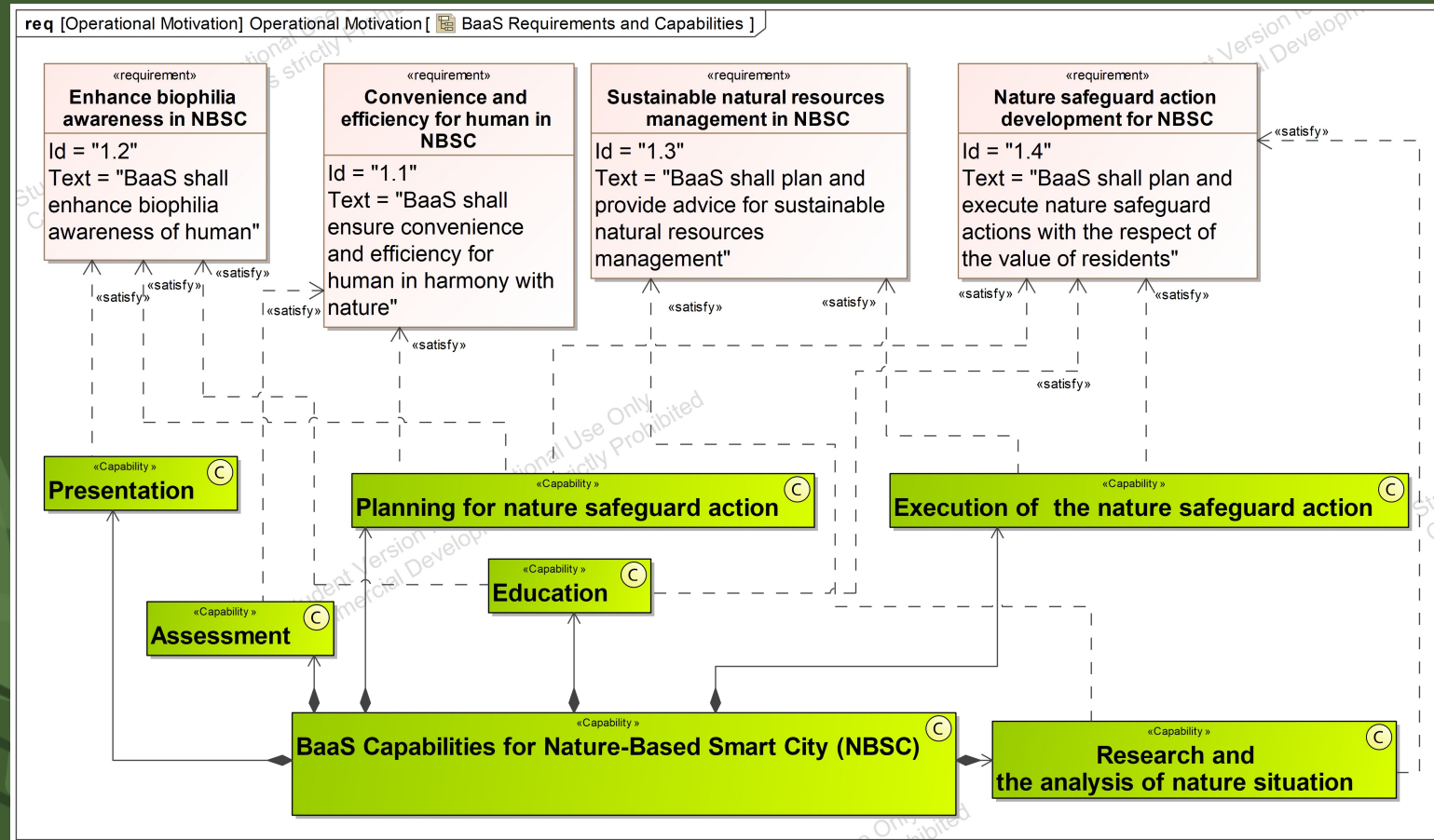
BaaS Requirements: Nature-centric convenience and efficiency for human

- Convenience and efficiency for human in NBSC (Id="1.1")
- Enhance biophilia awareness in NBSC (Id="1.2")
- Sustainable natural resources management in NBSC (Id="1.3")
- Nature safeguard action development for NBSC (Id="1.4")



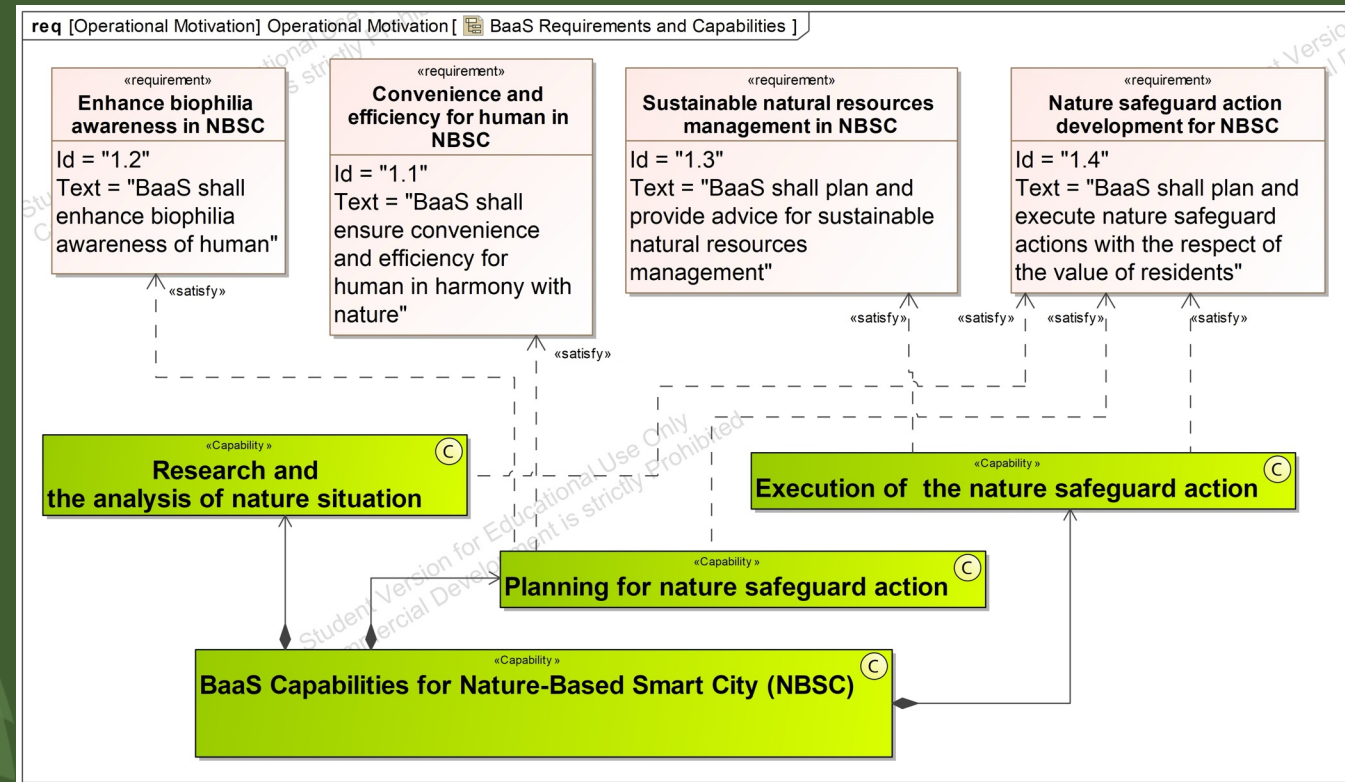
BaaS Capabilities: satisfy <nature-centric convenience and efficiency for human> ^(1/3)

- Six Capabilities are defined that contribute to the achievement of the goals.
- BaaS capabilities for NBSC satisfy and support the nature-centric convenience and efficiency for human.



BaaS Capabilities: satisfy <nature-centric convenience and efficiency for human> (2/3)

- **Research and analysis of nature situation**
 - The ability of conducting research and analyzing situation of nature while collaborating with other stakeholders
- **Planning for nature safeguard action**
 - The ability of planning for nature safeguard action
- **Execution of the nature safeguard action**
 - The ability of performing the action for safeguarding nature collaborating with other stakeholders



BaaS Capabilities: satisfy <nature-centric convenience and efficiency for human> (3/3)

- **Education**

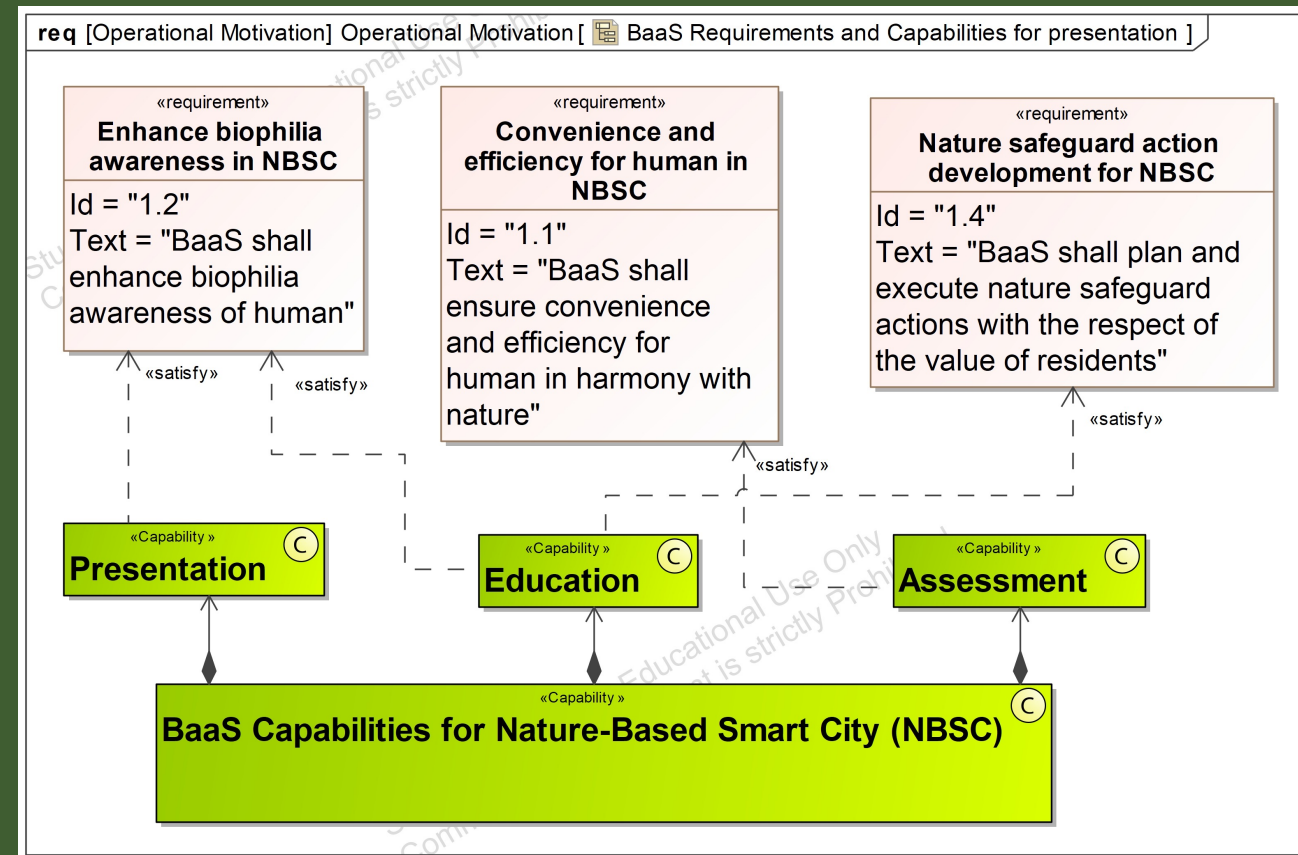
- The ability to help understand nature situation through educating residents or visitors

- **Presentation**

- The ability of presenting the beauty of nature or challenges and safeguard action

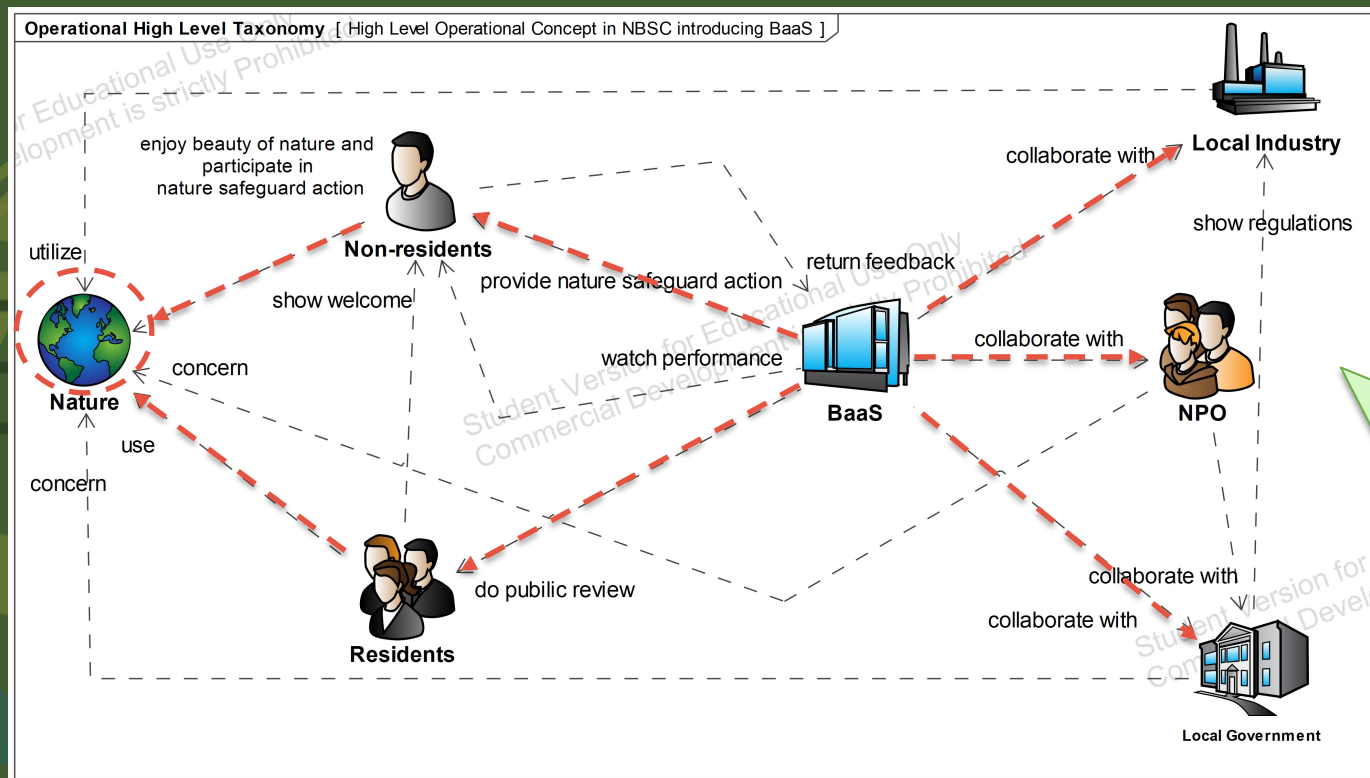
- **Assessment**

- The ability to assess performance of participants in nature safeguard action and improvements of nature



BaaS Operational Activity in NBSC introducing BaaS

- Based on the vision, goals, requirements, and capabilities that we defined, high-level operational activity is described to show a variety of stakeholders related to the NBSC introducing BaaS.



BaaS collaborating with related stakeholders and services as an integrated service, contributes to the balanced benefits of humans and nature in NBSC.

Conclusion

We defined the architecture of NBSC introducing BaaS as a SoS by utilizing UAF, from strategic structure and operational activity view.



For future work, how BaaS collaborates with other services, such as forestry, effectively contributing to safeguarding natural environment as an integrated service, will be focused.



- ✓ By introducing BaaS to NBSC, we described an integrated service for nature conservation to promote safeguarding nature in NBSC.
- ✓ Operational process of BaaS in the context of NBSC were described, and we obtained the iterative operational process, contributing to spread and establish biophilia awareness in local area which benefits to humans and nature.



Thank you!

Q&A