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Comparative Analysis of LEED-ND & DGNB-UD Rating System

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Abstract: LEED Neighborhood Development (ND) is a sustainable certification rating system for a smart green neighborhood development conceived by the USA. Similarly, DGNB Urban Districts (UD) is a smart green certification rating system conceived by Germany. LEED-ND has set a standard for the smart green urban practices particularly in the USA and DGNB-UD has set a standard for the smart green practices particularly in Germany. However both sustainable district certification systems are applied also internationally to a growing extent. The comparative analysis in the LEED-ND and DGNB-UD identifies both common and different elements of the two smart green planning standards. This paper aims to comparatively analyze LEED-ND and DGNB-UD based on the Smart Green Criteria established by this paper. The paper analyzes statistically each Smart Green Criteria of LEED-ND and DGNB-UD. The comparative analysis of Smart Green Criteria of LEED-ND and DGNB-UD will highlight viewpoint and significance of each system. The comparative analysis of LEED-ND and DGNB-UD will highlight strengths, weaknesses, and differences of both smart green urban district certification and rating systems. As a conclusion, the paper addresses the five Smart Green Criteria in order of importance for future sustainable urban assessment measurements: Smart Green Site, Smart Green Economy, Smart Green Transportation, Smart Green Community, and Smart Green Infrastructure.

Keywords: LEED-ND; DGNB-UD; sustainability criteria; smart and green city; green certification rating system; weighting criteria; methodology; design and planning tool

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1. Introduction

Since the first decade of the 21st century the majority of the world's population live in cities and the portion of the world's urban population is increasing every year [1]. The growth percentage is an average of 1.85% (CIA, 2013) [2]. The global urban problems are increasing in proportion to the growing urban population and the increasing building activities in urban areas. The main challenges are for instance growing resource consumption and energy consumption, related greenhouse gas emissions, waste production and environmental pollution, safety issues, and degradation of historical landmarks [3]. The growth of urban areas and related pressure on resources and the environment is raising the necessity of a transition towards sustainable urban developments. Development of strong urban sustainability is based on a balanced approach of social, environmental and economical sustainability aspects [4]. Sustainable urban development has to address multiple aspects such environmental protection, transportation, walkability, employment, social infrastructure, safety, etc. Sustainable building and urban district rating and certification systems, such as LEED (Leadership in Energy & Environmental Design, USA) [5] and DGNB (Deutsche Gesellschaft für nachhaltiges Bauen, "German Association for Sustainable Building", Germany) [6], started on building scale and gradually expanded towards the rating and certification of neighborhoods and urban districts. A neighborhood is an area in a city that are or could be, at least to certain extend, independent regarding multiple aspects such as economy, physical, transport, and cultural systems. The maximum size is a defining feature of a neighborhood unit. The boarders of a neighborhood unit can be defined by the possibility to reach each part of an individual unit within a 5-minute walk (Perry, 1929) [7], which leads to a size of 1/2 mile (804.6 Meters) radius (Farr, 2008) [8]. It is typically based on a comfortable distance for walking from the center of the neighborhood to its edge.

Since the 1990s, commonly named "green" and sustainable building assessment systems have been developed to integrate sustainable agendas into the construction industry. Early on, LEED and DGNB primarily focused on a building-level. However, the focus of assessing and certifying sustainability aspects extended from a building-level to a neighborhood-level by both LEED and DGNB, and other important international Sustainable Building assessment and certification systems as well. The United States Green Building Council (USGBC) launched a Neighborhood Development (ND) assessment and certification system (LEED-ND) in 2009. DGNB launched an Urban District (German: "Quartier") assessment and certification (DGNB Quartier, "DGNB-UD") in 2011. The aim of both systems is the assessment and certification of urban areas according to sustainability criteria. Likewise, Building Research Establishment (BRE) that developed BREEAM [9] launched BREEAM Communities in 2009. The Japan GreenBuild Council (JaGBC) and Japan Sustainable Building Consortium (JSBC) that developed CASBEE (Comprehensive Assessment System for Building Environmental Efficiency) [10], launched CASBEE-UD in 2007.

There is an increasing research on the assessment and certification of sustainable neighborhoods. Recent studies include; comparative analysis of BREEAM Communities, CASBEE-UD, and LEED-ND (Ha, 2008) [11]; comparative analysis of BREEAM Communities, CASBEE-UD, LEED-ND, and DGNB-UD (Reith 2014) [12]; comparative analysis of BREEAM Communities, LEED-ND, and DGNB-UD (Hamedani, 2012) [13]. Studies discussed in these research papers focus mostly on the content structure and components of the assessment systems.

Ha [11] focuses particularly on the general overview of each assessment. Ha's study does comparative analysis on LEED-ND, BREAM Communities, and CASBEE-UD. In comparing three systems from three different countries, Ha's study, averaging three systems, draws out 10 Smart Green Criteria. Smart Green Site (21.79%), Smart Green Transportation (19.57%), Smart Green Building (13.64%), Smart Green Infrastructure (11.85%), Smart Green Community (8.33%), Smart Green Regional Priority (6.2%), Smart Green Water (6.66%), Smart Green Resources (4.93%), Smart Green Construction (4.21%), Smart Green Economy (2.24%) [11]. This paper adopts Smart Green Criteria based on the HA's study. HA's study excludes DGNB-UD, hence, this paper revises the Smart Green Criteria to fit current comparative study of LEED-ND and DGNB-UD. The problem of Ha's study is the lack of information on how the original criteria of each country's system is applied to the Smart Green Criteria.

Hamedani's [13] study focuses particularly on the criteria, indicators, and evaluation of LEED-ND, CASBEE-UD, BREAM Communities 09, BREAM Communities 12, and DGNB-UD. Hamedani's study is most comprehensive study on the comparative analysis of four different systems to date. However, being encyclodpedic in nature, the results of indicator comparison was in part too categorical, losing the larger picture of each systems' perspective and focus. However, this paper is indebted to Hamedani's paper on one issue. It adopts similar allocation of criteria of LEED-ND and DGNB-UD to the ten Smart Green Criteria set up by this paper. In contrast to Hamedani's paper, which allocates the criteria of LEED-ND and DGNB-UD to the ten Smart Green Criteria multiple times, making the data less reliable, this paper limits the allocation of original criteria to just a single time.

According to the findings of literature analysis on sustainable urban district and neighborhood systems, executed by the authors of this paper, LEED-ND and DGNB-UD are the most comprehensive sustainable assessment and certification systems for urban districts and neighborhoods. Accordingly, the authors decided to focus on LEED-ND and DGNB-UD, in order to identify the addressed sustainability assessment criteria as well as to compare the specific methods applied in the two assessments and certification systems. The method of the described research is the theoretical analysis and comparison of LEED-ND and DGNB-UD. The results of this research are described in the following section 2 of this paper. In section 2.1 the assessment criteria and certification methods of LEED-ND and DGNB-UD are identified and assigned to 10 Smart Green City Criteria, which have been defined by the authors. In the following sections LEED-ND and DGNB-UD are compared according to the defined smart green criteria: 2.2 Smart Green Site, 2.3 Smart Green Transportation, 2.4 Smart Green Economy, 2.5 Smart Green Building, 2.6 Smart Green Infrastructure, 2.7 Smart Green Community, 2.8 Smart Green Ecology, 2.8 Smart Green Program, 2.9 Smart Green Water, and 2.10 Smart Green Innovation.

2. Discussions and Results

2.1 Analysis of sustainability assessment method and definition of smart green criteria

LEED-ND is a point based assessment and certification system. The maximum number of points that can be achieved is 110. For each sustainable neighborhood project points are achieved by fulfilling criteria, which are assigned to different criteria groups. The rating system is divided into four certification categories. "Platinum" certificate is the highest achievable rating, and applied to projects, which have achieved more than 80 points. "Gold" certificate is the second highest rating applied to

projects which have achieved 60 - 79 points. “Silver” certificate is the third highest rating and applied to projects which have achieved 50 - 59 points, while “Certified” certificate is the most basic rating which is applied to projects that have achieved 40 - 49 points. Weighting is applied in the system by weighting of impact categories.

DGNB-UD is a complex point impact factors and percentage based assessment and certification system. The maximum percentage that can be achieved by a project is 100%. The rating system is divided into three certification categories. “Gold” certificate is the highest rating, which is applied to projects that achieve more than 80%. “Silver” certificate is the second highest rating, which is applied to projects that achieve from 65% - 80%. “Bronze” certificate is the third highest rating, which is applied to projects that achieve from 50% - 65%. Weighting is applied in the system by weighting of single evaluation categories and impact factors for criteria.

Based on the analysis of LEED-ND and DGNB-UD with the information provided in the documents released by USGBC [5] and DGNB [6], five different criteria groups in LEED-ND and DGNB-UD can be identified. The five criteria groups (impact categories) in LEED-ND and their specific weighting are: 1., Smart Location & Linkage (sll, max. 25% of totally achievable 110 points = 27.5 points max.), 2. Neighborhoods Pattern & Design (npd, max. 40% of totally achievable 110 points = 44 points max), 3. ,Green Infrastructure & Buildings (gib, max. 26% totally achievable 110 points = 28.6 point max.), 4. Innovation and Design Process (idp, max. 5% of totally achievable 110 points = 5.5 point max.), 5., Regional Priority Credits (rpc, max. 4% of totally achievable 110 points = 4.4 point max.). The five criteria groups (single evaluation categories) in DGNB-UD are; 1. Environmental Quality (ENV, max. 22.5% of totally achievable 100% = 22.5 points max.), 2. Economical Quality (ECO, 22.5% of totally achievable 100% = 22.6 points max.), 3. Sociocultural & Functional Quality (SOC, 22.5% of totally achievable 100% = 22.5 points max.), 4. Technical Quality (TEC, 22.5% of totally achievable 100% = 22.3 points max.), 5. Process Quality (PRO, 10% of totally achievable 100% = 10 points max.).

Based on the overall points allocated to LEED-ND and DGNB-UD, 10 Smart Green criteria have been defined by the authors for comparative analysis and discussions of the two sustainable urban district and neighborhood assessment systems: 1. Smart Green Site, 2. Smart Green Transportation, 3. Smart Green Economy, 4. Smart Green Building, 5. Smart Green Infrastructure, 6. Smart Green Community, 7. Smart Green Ecology, 8. Smart Green Program, 9. Smart Green Water, and 10. Smart Green Innovation. In the following sections the authors estimate the specific impact of each of the 10 Smart Green criteria in % on the overall achievable impact of 100%, which is the sum of all 10 Smart Criteria impacts in %.

2.2 Smart Green Site

Both LEED-ND and DGNB-UD emphasize the importance of site-specific assessment criteria. However there is one main difference between the two systems. LEED-ND provides its own impact category for this criterion, while DGNB-UD does not. In LEED-ND, only by positive assessment of the specific site of an urban development 25% of total points can be achieved, reaching already for approximately 50% of the basic certification. In contrast, DGNB-UD does not provide its own single evaluation category for the site but includes specific urban district site properties to specific single evaluation categories and assigns properties to single evaluation criteria. Connection to the existing

urban environment is a key aspect of smart green site selection. Figure 1 is the comparison table on Smart Green Site. Based on this table, LEED-ND gives more credits for site selection criteria than DGNB-UD. Of the points allocated, LEED-ND emphasizes on "Preferred Locations (sll1)" and "Locations with Reduced Automobile Dependence (sll3)", whereas DGNB-UD emphasizes on "Efficient Land Use (ECO2.2)" and "Urban Integration (SOC4.1)". According to LEED-ND, a high number of credit points can be achieved by location of an urban development site in a dense urban area and good connection to a public transportation system. According to DGNB-UD, selection of a specific site with a certain quality alone does not contribute to the achievement of a considerable amount of assessment credits. Site-specific criteria are related to single evaluation categories such as Environmental Quality and Sociocultural & Functional Quality. Smart and efficient land use system and proper urban integration addresses. The USA based LEED-ND system, has been developed in a country of vast land, is rooted in urban and suburban dichotomy. LEED-ND rewards urban developments that depart from automobile-dependent culture of suburban towns, by emphasizing urban areas as potential candidates for new urban development sites, and accordingly deemphasizing natural wetlands and agricultural lands. The Germany based DGNB-UD system, being developed in a moderate-size land, is confronted with a limitation of vacant land. DGNB-UD recognizes for instance efficient land use, the integration of new urban development in existing urban developments and mixed uses, and water and soil protection. LEED-ND has allocated approximately 25% and DGNB-UD has allocated approximately 19.4% of the overall achievable points to criterion 1. Smart Green Site. An overview of the specific LEED-ND and DGNB-UD criteria that can be assigned to Smart Green Site are listed in Figure 1.

Figure 1. Comparison Table on Smart Green Site of LEED-ND and DGNB-UD.

Smart Green Site					
	LEED-ND			**DGNB**	
sllpr1	Smart Location		ECO2.2	Efficient Land Use	6.8
sllpr3	Wetland and Water body Conservation		ENV1.2	Water and Soil Protection	1.8
sllpr4	Agricultural Land Conservation		ENV2.1	Land Use	2.7
sllpr5	Floodplain Avoidance		ENV2.3	Energy-Efficient Development Layout	1.8
sll1	Preferred Locations	10	ENV2.4	Resource-Efficient Infrastructure, Earthworks	1.8
sll2	Brownfield Redevelopment	2		Management	
sll3	Locations w/ reduced Automobile Dependence	7	SOC4.1	Urban Integration	2.7
sll4	Bicycle Network and Storage	1	SOC4.2	Urban Design	1.8
sll5	Housing and Jobs proximity	3			
sll6	Steep Slope Protection	1			
sll7	Site Design for Habitat or Wetland & Water	1			
	Body Conservation				
gib7	Minimized Site Disturbance in Design &	1			
	Construction				
rpc1	Regional Priority	4			
	Sum	**30**		**Sum**	**19.4**

2.3 Smart Green Economy

Smart Green Economy is represented in DGNB-UD with a single evaluation categories accounting for 22.5% of overall achievable score. In contrast, LEED-ND has no specific impact category assigned to economical aspects. Assessment criteria that can be assigned to economical aspects are integrated in LEED-ND in other impact categories. Accordingly the most salient aspect of DGNB-UD compared with LEED-ND is Smart Green Economy. In Figure 2, LEED-ND and DGNB-UD are compared with each

other regarding the specific evaluation and impact categories and criteria which can be assigned to economical aspects and accordingly to the criterion 2. Smart Green Economy. Based on the research findings, DGNB-UD pays almost 4 times more attention to the Smart Green Economy than LEED-ND. Of the points allocated, LEED-ND emphasizes on "Mixed-income Diverse Communities (npd4)", whereas DGNB-UD emphasizes on "Life Cycle Cost (ECO1.1)" and "Fiscal Effects on the Municipality (ECO1.2)". LEED-ND's point of view on Smart Green Economy focuses on the issues of vitalization of local economy whereas DGNB-UD's point of view focuses on the long-term energy use economy and public authority's management economy. LEED-ND has allocated 8% and DGNB-UD has allocated 23.8% of the overall achievable score to Smart Green Economy.

Figure 2. Comparison Table on Smart Green Economy of LEED-ND and DGNB-UD.

Smart Green Economy					
	LEED-ND			**DGNB**	
npd4	Mixed-Income Diverse Communities	7	ECO1.1	Life Cycle Cost	6.8
npd13	Local Food Production	1	ECO1.2	Fiscal Effects on the Municipality	4.5
			ECO2.1	Value Stability	4.5
			ENV1.1	Life Cycle Assessment	2.7
			ENV2.5	Local Food Production	0.9
			PRO3.1	Management	1.1
			PRO3.2	Construction Site and Construction Progress	1.1
			PRO3.3	Marketing	1.1
			PRO3.4	Quality Assurance and Monitoring	1.1
	Sum	**8**		**Sum**	**23.8**

2.4 Smart Green Transportation

The impact of assessment criteria related to Smart Green Transportation on the overall rating is much higher in LEED-ND than in DGNB-UD. LEED-ND, being primarily developed by the leaders of New Urbanism movement [5] in the USA, pays particular attention to the walkability of a urban areas. The concept of walkability is a derivative of reduction of carbon footprint and promotion of human health. In Figure 3, LEED-ND and DGNB-UD are compared with each other regarding the specific evaluation and impact categories and criteria which can be assigned to transportation aspects and accordingly to the criterion Smart Green Transportation. Based on research findings, LEED-ND pays almost 3 times more attention to the Smart Green Transportation than DGNB-UD. Of the points allocated, LEED-ND emphasizes on "Walkable Streets (npd1)" and "Compact Development (npd2)", whereas DGNB-UD emphasizes on "Quality of Transport System (TEC3.1)". LEED-ND's point of view on smart green transportation system is that it prefers walkable streets and public transportation system focusing on the reduction of automobile usage. DGNB-UD's point of view on transportation shares the idea of fossil fuel use dependency reduction of the LEED-ND, it is stressing less on the walkability than LEED-ND. LEED-ND has allocated 26% of the overall points to Smart Green Transportation and DGNB-UD has allocated 9.2%. Adding percentages of Smart Green Site and Smart Green Transportation, LEED-ND has allocated 56% and DGNB-UD has allocated 28.6% of the overall available score to these two criteria. In LEED-ND, site selection and transportation counts for more than half of overall impact. In DGNB-UD, the two criteria count for only approximately one quarter of the overall impact.

Figure 3. Comparison Table on Smart Green Transportation of LEED-ND and DGNB-UD.

Smart Green Transportation					
LEED-ND			DGNB		
npdpr1	Walkable Streets		TEC3.1	Quality of Transport Systems	4
npdpr2	Compact Development		TEC3.2	Quality of Motor Transport Infrastructure	1.3
npdpr3	Connected and Open Community		TEC3.3	Quality of Public Transport Infrastructure	1.3
npd1	Walkable Streets	12	TEC3.4	Quality of Bicycle Infrastructure	1.3
npd2	Compact Development	6	TEC3.5	Quality of Pedestrian Infrastructure	1.3
npd5	Reduced Parking Footprint	1			
npd6	Street Network	2			
npd7	Transit Facilities	1			
npd8	Transportation Demand Management	2			
npd14	Tree-Lined and Shaded Streets	2			
	Sum	**26**		**Sum**	**9.2**

2.5 Smart Green Community

In Figure 4, LEED-ND and DGNB-UD are compared with each other regarding the specific evaluation and impact categories and criteria which can be assigned to community aspects and accordingly to the criterion Smart Green Community. Based on the findings of this research, LEED-ND emphasizes on "Community Outreach and Involvement (npd12)", whereas DGNB-UD emphasizes on "Open Space Offer (SOC3.1)". LEED-ND's point of view emphasizes participatory role of community whereas DGNB-UD's point of view emphasizes physical public space of community. LEED-ND has allocated 7% and DGNB-UD has allocated 12.5% of the overall impact to Smart Green Community. Smart Green Community is the fourth most salient aspect of DGNB-UD. In DGNB-UD, Smart Green Economy (26%), Smart Green Site (19.4%), Smart Green Community (12.4%), and Smart Green Economy (12.2%) are the four most important smart green criteria with higher impacts than the remaining six smart design criteria.

Figure 4. Comparison Table on Smart Green Community of LEED-ND and DGNB-UD.

Smart Green Community					
LEED-ND			DGNB		
npd9	Access to Civic and public Spaces	1	PRO1.1	Participation	1.7
npd10	Access to Recreation Facilities	1	SOC1.1	Social and Functional Mix	1.8
npd11	Visitability and Universal Design	1	SOC2.1	Objective / Subjective Safety	1.8
npd12	Community outreach and involvement	2	SOC2.2	Public Space Amenity Value	1.8
npd15	Neighborhood Schools	1	SOC3.1	Open Space Offer	2.7
idp2	LEED ® Accredited professional	1	SOC3.2	Inclusive Access	1.8
			SOC4.4	Art in Public Space	0.9
	Sum	**7**		**Sum**	**12.5**

2.6 Smart Green Infrastructure

In Figure 5, LEED-ND and DGNB-UD are compared with each other regarding the specific evaluation and impact categories and criteria which can be assigned to infrastructure aspects and accordingly to the criterion Smart Green Infrastructure. Based on the findings of this research, DGNB-UD has put more emphasis on this criterion than LEED-ND. LEED-ND emphasizes on "District Heating and Cooling (gib12)" and "Wastewater Management (gib14)", whereas DGNB-UD emphasizes on "Rain Water Management (TEC1.3)" and "Energy Technology (TEC1.1)". LEED-ND's point of view displays particular condition of USA suburban area where the building stock consist generally of wood

houses equipped with individual heating and cooling systems. LEED-ND emphasizes on centralized mechanical, electrical and plumbing (MEP) systems by providing more points to gib12 and gib14. DGNB-UD emphasizes on decentralized rainwater management systems and primary energy efficient and energy productive technological systems. LEED-ND has allocated 8% and DGNB-UD has allocated 12.3% of the overall impact to Smart Green Infrastructure. In DGNB-UD, the impact difference of the two criteria Smart Green Community (12.5%) and Smart Green Infrastructure (12.3%) is very small.

Figure 5. Comparison Table on Smart Green Infrastructure of LEED-ND and DGNB-UD.

Smart Green Infrastructure					
	LEED-ND			**DGNB**	
npd10	Access to Recreation Facilities	1	SOC1.2	Social and Commercial Infrastructure	1.8
gib12	District Heating and Cooling	2	TEC1.1	Energy Technology	2.6
gib13	Infrastructure Energy Efficiency	1	TEC1.2	Efficient Waste Management	2.6
gib14	Wastewater Management	2	TEC1.3	Rain Water Mangement	4
gib15	Recycled Content in Infrastructure	1	TEC1.4	Information and Telecommunication Management	1.3
gib16	Solid Waste management Infrastructure	1			
	Sum	**8**		**Sum**	**12.3**

2.7 Smart Green Building

In Figure 6, LEED-ND and DGNB-UD are compared with each other regarding the specific evaluation and impact categories and criteria which can be assigned to sustainable building aspects and accordingly to the criterion Smart Green Building. Based on the findings of this research, LEED-ND emphasizes on “Certified Green Building (gib5)” and “Building Energy Efficiency (gib2)”, whereas DGNB-UD emphasizes on “Total Primary Energy Demand and Renewable (ENV2.2)”, “Energy Technology (TEC1.1)”, and “Efficient Waste Management (TEC1.2).” LEED-ND focuses on LEED certification level of the individual buildings. DGNB-UD emphasizes more on DGNB certification of buildings as well as on publicly accessible areas and settings. LEED-ND has allocated 11% and DGNB-UD has allocated 8.9% of the overall achievable impact to Smart Green Building.

Figure 6. Comparison Table on Smart Green Building of LEED-ND and DGNB-UD.

Smart Green Building					
	LEED-ND			**DGNB**	
gibpr1	Certified Green Building		ENV2.2	Total Primary Energy Demand and Renewable	2.7
gibpr2	Minimum Building Energy Efficiency			Primary Energy Share	
gibpr3	Minimum Building Water Efficiency		SOC2.3	Noise Protection and Sound Insulation	1.8
gibpr4	Construction Activity Pollution Prevention		SOC4.3	Use of Existing Structures	1.8
gib1	Certified Green Buildings	5	TEC2.1	Maintainance, Upkeep and Cleaning	2.6
gib2	Building Energy Efficiency	2			
gib3	Building Water Efficiency	1			
gib5	Existing Building Reuse	1			
gib6	Historic Resource Preservation and Adaptive Use	1			
gib10	Solar Orientation	1			
	Sum	**11**		**Sum**	**8.9**

2.8 Smart Green Ecology

In Figure 7, LEED-ND and DGNB-UD are compared with each other regarding the specific evaluation and impact categories and criteria which can be assigned to ecological aspects and

accordingly to the criterion Smart Green Ecology. LEED-ND emphasizes on "On-Site Renewable Energy Sources (gib11)" and "Brownfield Redevelopment (sll2)", DGNB-UD emphasizes on "Changing Urban Microclimate (ENV1.3)" and "Considering Urban Microclimate (ENV1.5)". LEED-ND's point of view on Smart Green Ecology focuses on the renewability of energy and natural resources. In addition, it focuses on the adaptive reuse of building and environment. DGNB-UD's point of view on Smart Green Ecology focuses on the urban microclimate performance. LEED-ND considers natural environment preservation issues in the Smart Green Ecology, whereas, DGNB-UD considers site-specific conditions that might affect local Smart Green Ecology performance. LEED-ND has allocated 9% and DGNB-UD has allocated 7.2% of the overall achievable impact to Smart Green Ecology. As a consequence, the impact of Smart Green Ecology on the overall rating is higher in LEED-ND than in DGNB-UD.

Figure 7. Comparison Table on Smart Green Ecology of LEED-ND and DGNB-UD.

Smart Green Ecology					
	LEED-ND			**DGNB**	
sllpr2	Imperiled Species and Ecological Communities		ENV1.3	Changing Urban Microclimate	2.7
sll2	Brownfield Redevelopment	2	ENV1.4	Biodiversity and Interlinking Habitats	1.8
sll8	Restoration of Habitat or Wetlands and Water Bodies	1	ENV1.5	Considering Possible Impacts on the Envirionment	2.7
sll9	Long-term Conservation Management of Habitat or Wetlands & Water bodies	1			
gib9	Heat Island Reduction	1			
gib11	On-Site Renewable Energy Sources	3			
gib17	Light Pollution Reduction	1			
	Sum	**9**		**Sum**	**7.2**

2.9 Smart Green Program

In Figure 8, LEED-ND and DGNB-UD are compared with each other on Smart Green Program. LEED-ND evaluates "Mixed-Use Neighborhood Centers (npd3)", DGNB-UD emphasizes on "Development Layout and Flexible Use (SOC3.3)" and "Integrated Planning (PRO2.2)". LEED-ND emphasizes "Mixed-Use" and DGNB-UD emphasizes flexibility and integration in Smart Green Program. Smart Green Program of LEED-ND is closely connected to Smart Green Community. Criteria of program and community in LEED-ND focuses on mixed-use of urban programs, mix of different social classes, and diversity of job opportunities. The purpose of LEED-ND in both criteria is promotion of social dynamism using an inclusive strategy. The concept of DGNB-UD's Smart Green Program is somewhat different from LEED-ND's Smart Green Program. It's a viewpoint from the governing body. It weighs on planning strategy and municipal operation. LEED-ND has allocated 4% and DGNB-UD has allocated 5.7%.of the overall achievable impact to Smart Green Program

2.10 Smart Green Water

In Smart Green Water, two systems measuring criteria vary depending on the urgent needs of natural disasters. In Figure 9 LEED-ND and DGNB-UD are compared with each other regarding the specific evaluation and impact categories and criteria which can be assigned to urban water management related aspects and accordingly to the criterion Smart Green Water. LEED-ND emphasizes on "Stormwater

(gib3)" and "Water-Efficient Landscaping (gib4)", DGNB-UD has "Water Circulation Systems (ENV2.6)". LEED-ND particularly emphasizes on stormwater management systems and reduced water consumption for irrigation of gardening and landscaping. DGNB-UD considers the urban water cycle, including stormwater management as well as the reuse and recycling of secondary water resources. LEED-ND has allocated 5% and DGNB-UD has allocated 1.8%. of the overall achievable impact to Smart Green Water It is expected that in future Smart Green Water will have a higher impact on the overall rating due to both increasing freshwater shortages and urban flood problems.

Figure 8. Comparison Table on Smart Green Program of LEED-ND and DGNB-UD.

Smart Green Program (Mixed-Use)					
	LEED-ND			**DGNB**	
npd3	Mixed-Use Neighborhood Centers	4	PRO2.1	Concept Development Process	1.1
			PRO2.2	Integrated Planning	1.7
			PRO2.3	Municipal Involvement	1.1
			SOC3.3	Development Layout and Flexible Use	1.8
	Sum	**4**		**Sum**	**5.7**

Figure 9. Comparison Table on Smart Green Water of LEED-ND and DGNB-UD.

Smart Green Water					
	LEED-ND			**DGNB**	
gib4	Water-Efficient Landscaping	1	ENV2.6	Water Circulation Systems	1.8
gib8	Stormwater Management	4			
	Sum	**5**		**Sum**	**1.8**

2.11 Smart Green Innovation

In Smart Green Innovation, LEED-ND recognizes the innovative approach. Figure 9 is the comparison table on Smart Green Innovation. LEED-ND emphasizes on "Innovation and Exemplary Performance (idp1)", DGNB-UD does not have a separate criteria for Smart Green Innovation. LEED-ND has allocated 5% and DGNB-UD has allocated 0% of the overall achievable impact to Smart Green Innovation. This does not mean DGNB-UD does not recognize innovative aspect. In DGNB-UD, it is not separate criteria as is the case in LEED-ND. In DGNB-UD, innovative aspects could be found, for instance, in Energy Technology (Smart Green Infrastructure) and in Integrated Planning (Smart Green Program).

Figure 10. Comparison Table on Smart Green Safety of LEED-ND and DGNB-UD.

Smart Green Innovation					
	LEED-ND			**DGNB**	
idp1	Innovation and Exemplary performance	5			
	Sum	**5**		**Sum**	**0**

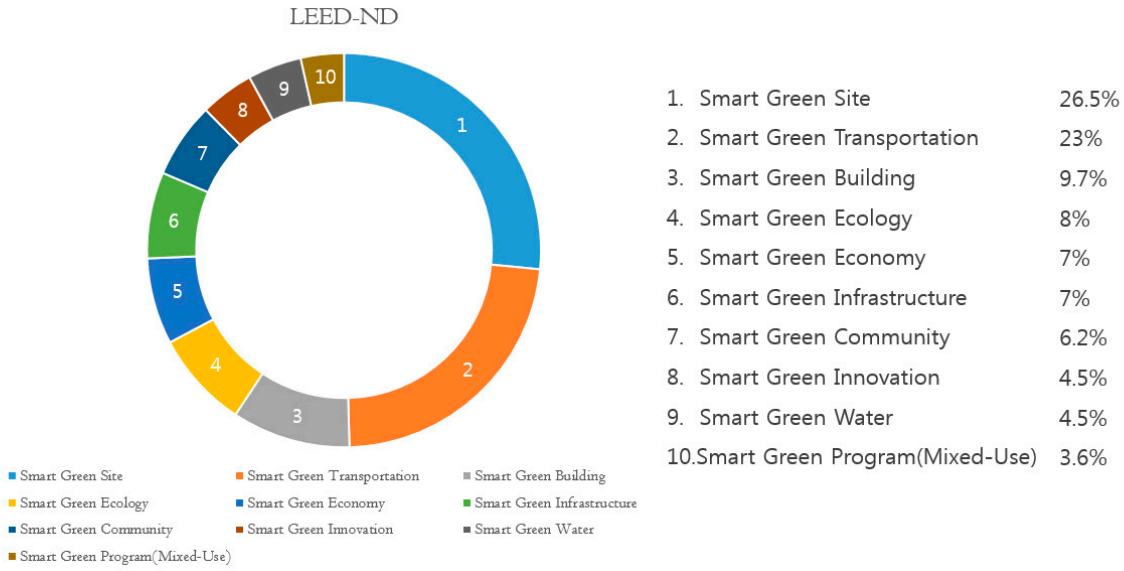
3. Conclusions

In the framework of this paper the two sustainable urban neighborhood and district assessment and certification systems LEED-ND and DGNB-UD have been analyzed in order to compare the presence and impact of the sustainability assessment criteria that are addressed in the two systems. The assessment criteria and certification methods of LEED-ND and DGNB-UD have been identified and assigned to 10

Smart Green City Criteria: 1. Smart Green Site, 2. Smart Green Transportation, 3. Smart Green Economy, 4. Smart Green Building, 5. Smart Green Infrastructure, 6. Smart Green Community, 7. Smart Green Ecology, 8. Smart Green Program, 9. Smart Green Water, and 10. Smart Green Innovation.

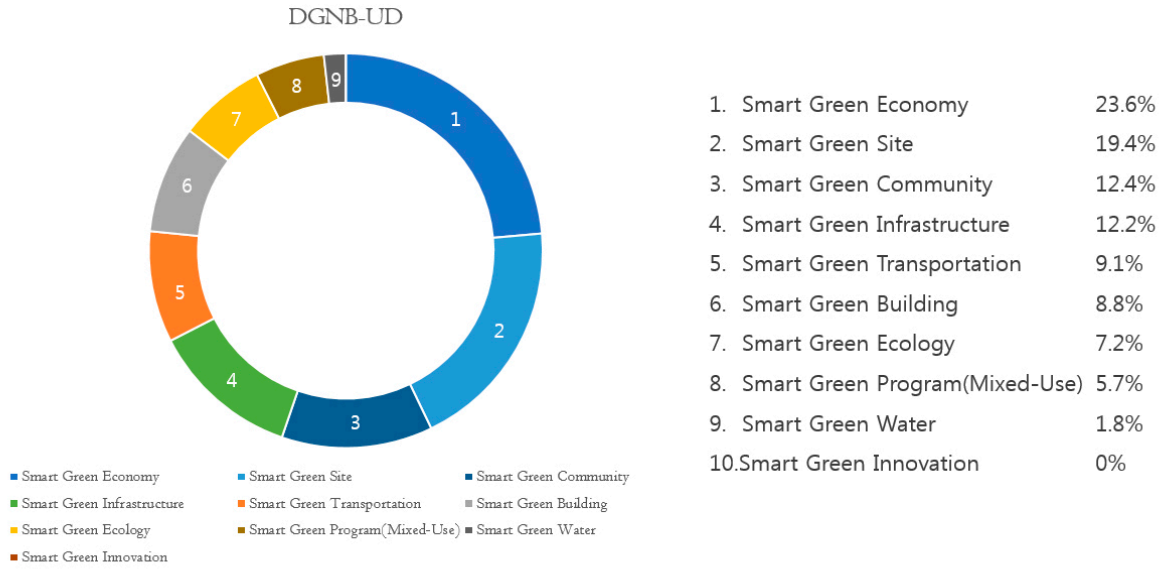
The specific impact of the each of the 10 Smart Green assessment criteria in percentage related to total (100%) for LEED-ND is illustrated in Figure 11., Based on the research results the emphasis of LEED-ND is on the following Smart Green criteria, from higher to lower impact: Smart Green Site (26.5% of total achievable impact), Smart Green Transportation (23% of total achievable impact), Smart Green Building (9.7% of total achievable impact), Smart Green Ecology (8% of total achievable impact), and Smart Green Economy (7% of total achievable impact). It is estimated these five Smart Green criteria take up close to three quarters (74.2%) of overall achievable impact. In LEED-ND, close to half of overall achievable impact (48.7%) is allocated to the criteria Smart Green Site and Smart Green Transportation. In the USA, Natural Resources & Defense Council(NRDC)'s Smart Growth Plan and Congress of New Urbanism(CNU)'s Sustainable Urban vision have significantly shaped the importance of choosing the urban development site according to sustainability criteria and reducing carbon footprint in transportation by reduction of individual motorized transport by the design of walkable neighborhoods.

Figure 11. Statistical Table of LEED-ND's Overall Points Allocation to Smart Green Criteria.



The specific impact of the each of the 10 Smart Green assessment criteria in percentage related to total (100%) for DGNB-UD is illustrated in Figure 12. Based on the research results the emphasis of DGNB-UD is on the following Smart Green Criteria, from higher to lower impact: Smart Green Economy (23.6% of total achievable impact), Smart Green Site (19.4% of total achievable impact), Smart Green Community (12.4% of total achievable impact), Smart Green Infrastructure (12.2% of total achievable impact), and Smart Green Transportation (9.1% of total achievable impact). It is estimated these five Smart Green criteria take up slightly more than three quarters (76.7%) of overall achievable impact. In DGNB-UD, 43% of overall achievable impact is allocated to the criteria Smart Green Economy and Smart Green Site.

Figure 12. Statistical Table of DGNB-UD's Overall Points Allocation to Smart Green Criteria.

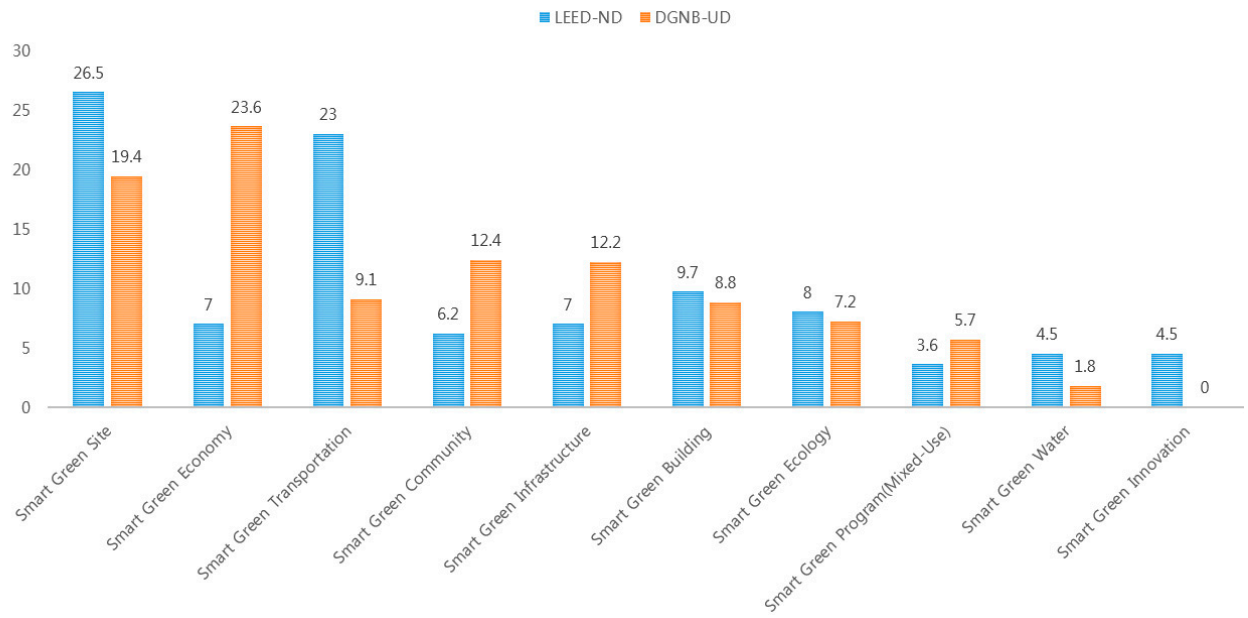


According to the research findings the order and related impact oft Smart Green criteria differs significantly in LEED-ND and in DGNB. DGNB-UD has allocated the highest impact to Smart Green Economy while LEED-ND has allocated only 7% of the overall achievable impact to Smart Green Economy. The difference of Smart Green Economy impact in relation to total achievable between LEED-ND and DGNB-UD is 16.6%, and indicates the highest impact difference amongst the 10 Green Smart criteria (Figure 13). The impact priority of categories and criteria in DGNB-UD indicates that economical aspects are crucial for a long-term sustainable living in and management of an urban district. Furthermore the overall cost of managing smart and green from inception to operation determine the degree of sustainability of urban areas.

LEED-ND has allocated 23% and DGNB-UD has allocated 8.5% of the overall achievable impact to Smart Green Transportation. The difference of Smart Green Transportation impact in relation to total achievable between LEED-ND and DGNB-UD is 14.5%, and indicates the second highest impact difference amongst the 10 Green Smart criteria (Figure 13).

Figure 13 illustrates the specific impact in percentages related to total achievable for each of the 10 Smart Green Criteria, for both assessment and certification systems LEED-ND and DGNB-UD. Based on the illustrated research findings the impact priorities of specific Smart Green criteria in LEED-ND and DGNB-UD are visualized. One could clearly see weighing difference of specific criteria in LEED-ND and DGNB-UD. Clear differences are in Smart Green Economy, Smart Green Transportation, Smart Green Community, and Smart Green Infrastructure. As the figure indicates five Smart Green Criteria in order of importance for future sustainable urban assessment measurements are Smart Green Site, Smart Green Economy, Smart Green Transportation, Smart Green Community, and Smart Green Infrastructure. The impact difference of specific Smart Green criteria is more significant in LEED-ND than in DGNB-UD.

Figure 13. Comparison Table of LEED-ND and DGNB-UD Smart Green Criteria.



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Conflict of Interest

The authors declare no conflict of interest.

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