Forests and forestry in support of Sustainable Development Goals (SDGs): A bibliometric analysis

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Supplementary Table S1. Sustainable development goals (SDGs) and the targets that are relevant to forestry.

Goal	Targets relevant to forestry	Explanations	References
SDG 1 **No poverty** - End poverty in all its forms everywhere	1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day	Forests can increase the income of surrounding residents through eco-tourism, forest products, etc., and forest provides the necessities of life for the surrounding residents, so there is no need to buy these items (wood only energy, medicine, etc.), thereby supporting target 1.1.	Gavin M C et al., 2009 Yemiru T et al., 2010 Wang R J et al., 2022
	1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters	Forest ecosystems are more diverse and more stable than single agricultural systems. Forest products are less affected by natural disasters than crops, thereby increasing the resilience of the poor to disasters, supporting target 1.5.	Duffy et al., 2021 Wunder S et al., 2014 Fisher, M et al., 2010
SDG 2 **Zero hunger**	2.1 By 2030, end hunger and ensure access by all people, in particular the	1. Direct effects： Forest can provide food including woody food, meat, fruit, etc.	Khatri D et al., 2017 Asprilla P J et al., 2019

- End hunger, achieve food security and improved nutrition and promote sustainable agriculture.	poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round	2. Indirect effects：Forests enhance the productive potential of agriculture and fisheries through soil and water conservation, nutrient cycling, soil formation, biodiversity conservation, etc. Forestry contributes to food security by providing income for the people. Therefore, forestry can support target 2.1.	
	2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment	The forestry sector provides people with non-farm employment and increases their income which supports target 2.3.	Lippe R S et al., 2021 Li Y S et al., 2019
SDG 3 Good health & Well-being - Ensure healthy lives and promote well-being for all at all ages.	3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	Forest plants remove air pollution by intercepting particulate matter on the surface of the plant and absorbing gaseous pollutants through the leaves of the leaves. Forest soil reduces water and soil pollution by adsorption and retention functions. Forest purification water, air, soil support target 3.9.	Nowak D J et al., 2014; Brown K R et al., 2013
SDG 5 Gender equality - Achieve gender equality and	5.5 Ensure women's full and effective participation and equal opportunities for leadership at all levels of decisionmaking in	Forestry employs women, adding opportunities for women to participate in management and decision -making which supports target 5.5.	Atmiş E et al., 2007 Das N et al., 2011 Coleman E A., 2013

empower all women and girls	political, economic and public life		
SDG 6 Clean Water and Sanitation - Ensure availability and sustainable management of water and sanitation for all	6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	Forests and trees have functions such as regulating runoffs and supporting groundwater supply. It is an important source of water source which support target 6.6.	Zhang B et al., 2010 Gonzales P et al., 2017
SDG 7 Affordable and clean energy - Ensure access to affordable, reliable, sustainable and modern energy for all.	7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	Forests can provide biofuels and can be used as the energy of the public to warm, cook, and industrial manufacture, thereby supporting target 7.1.	Jacobson M et al.,2020
	7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	Forest-based biofuels have the characteristics of renewable and sustainable and are an important renewable energy source that supports target 7.2.	Jåstad E O et al., 2019 Deng Y Y et al., 2015
SDG 8 Decent work & Economic growth - Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.	8.9 By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products	The forest ecosystem can provide recreational venues and cultural services. It is an important sustainable tourist place and can support target 8.9.	Tampakis S et al，2019
SDG 11 Sustainable cities and communities - Make cities and	11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage	Forests are included in some areas as part of the World Heritage Site or adjacent areas. Forests can enhance a sense of community belonging, enhance the beauty of the surrounding environment,	Piras F et al，2021 Parrotta, J A et al，2007

human settlements inclusive, safe, resilient and sustainable.		stimulate artistic expression and promote local tourism, etc. Sustainable forest management can contribute to the protection of local cultural and natural heritage, thereby contributing to target 11.4.	
	11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities	Forests as green and public spaces for recreation can contribute to the achievement of target 11.7.	Konijnendijk C C et al., 2006 Nitoslawski SA et al., 2019
SDG 12 **Responsible consumption and production** - Ensure sustainable consumption and production patterns.	12.2 By 2030, achieve the sustainable management and efficient use of natural resources	Sustainable forest management and responsible consumption of forest products can support target 12.2.	Panico et al., 2022
SDG 13 **Climate action** - Take urgent action to combat climate change and its impacts.	13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries	Forest plants perform photosynthesis, absorb carbon dioxide from the atmosphere, reduce the concentration of greenhouse gases in the atmosphere, and mitigate climate change, thereby supporting target 13.1.	Favero A et al., 2018 Kindermann G et al., 2008
SDG 15 **Life on land** - Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and	15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements	This target clarifies the protection and restoration of forests, which is also the purpose of forestry.	
	15.2 By 2020, promote the implementation of sustainable management of	This target clarifies sustainable forest management, stopping deforestation, restoring degraded	

reverse land degradation and halt biodiversity loss.	all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally	forests, and afforestation which is the purpose of forestry.	
	15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation neutral world	Deforestation is one of the causes of land degradation. Protecting and restoring forest ecosystems is an effective way to prevent soil degradation which supports target 15.3.	Kouassi J L et al., 2021 Grinand C et al., 2020 Chazdon R L et al., 2008
	15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development	Forests in mountain ecosystems provide diverse services and goods to mountain landscapes, and the protection and restoration of mountain forests which supports target 15.2.	Sears R R et al., 2018
	15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species	Forests are vital habitats for terrestrial biota and support more than half of the terrestrial animal and plant species. Protecting and restoring forests can support target 15.5.	Millenium Ecosystem Assessment 2005 Klenner W et al., 2009 Brockerhoff E G et al., 2008

Table S2. Keywords of Sustainable development goals (SDGs) and targets (Wang et al., 2022). The keywords of the targets are indicated in bold.

Goals and targets	Keywords
1.1	By 2030, **eradicate extreme poverty** for all people everywhere, currently measured as people living on less than $1.25 a day
1.5	By 2030, **build** the **resilience** of the poor and those **in vulnerable situations** and **reduce** their **exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters**
2.1	By 2030, **end hunger** and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to **safe, nutritious and sufficient food** all year round

2.3	By 2030, **double the agricultural productivity and incomes of small-scale food producers**, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment
3.5	**Strengthen the prevention and treatment of substance abuse**, including narcotic drug abuse and harmful use of alcohol
5.5	**Ensure women's full and effective participation and equal opportunities for leadership** at all levels of decisionmaking in political, economic and public life
6.6	By 2020, **protect and restore water-related ecosystems**, including mountains, forests, wetlands, rivers, aquifers and lakes
7.1	By 2030, **ensure** universal **access** to affordable, reliable and modern **energy services**
7.2	By 2030, **increase** substantially the **share of renewable energy** in the global energy mix
8.9	By 2030, devise and **implement policies to promote sustainable tourism** that creates jobs and promotes local culture and products
11.4	Strengthen efforts to **protect and safeguard the world's cultural and natural heritage**
11.7	By 2030, **provide** universal **access to safe, inclusive and accessible, green and public spaces**, in particular for women and children, older persons and persons with disabilities
12.2	By 2030, **achieve the sustainable management and efficient use of natural resources**
13.1	**Strengthen resilience and adaptive capacity** to **climate-related hazards** and **natural disasters** in all countries
15.1	By 2020, **ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services**, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements
15.2	By 2020, **promote** the implementation of **sustainable management of** all types of **forests**, **halt deforestation, restore degraded forests** and substantially **increase afforestation and reforestation** globally
15.3	By 2030, **combat desertification**, **restore degraded land and soi**l, including land affected by desertification, drought and floods, and strive to achieve a land degradation neutral world
15.4	By 2030, **ensure the conservation of mountain ecosystems**, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development
15.5	Take urgent and significant action to **reduce the degradation of natural habitats, halt the loss of biodiversity** and, by 2020, protect and **prevent the extinction of threatened species**

Table S3. The seven-point-scale framework of Griggs et al (Griggs; 2015 et al) to analyze the relationship between SDGs. The 'Seven-Point Scale' framework from Griggs et al. (2017) who classified the interactions at 7 levels:, (+3) indivisible, (+2) reinforcing, (+1) enabling, (0) consistent, (-1) constraining, (-2) counteracting, (-3) canceling. Definitions of the seven levels are from Griggs et al.

Interactions	Synergies			Neutral	Trade-offs		
Scoring	+3	+2	+1	0	-1	-2	-3
Definition*	The strongest form of positive interaction in which one objective is inextricably linked to the achievement of another."	"One objective directly creates conditions that lead to the achievement of another objective."	"The pursuit of one objective enables the achievement of another objective."	"A neutral relationship where one objective does not significantly interact with another or where interactions are deemed to be neither positive nor negative."	"A mild form of negative interaction when the pursuit of one objective sets a condition or a constraint on the achievement of another."	"The pursuit of one objective counteracts another objective."	"The most negative interaction is where progress in one goal makes it impossible to reach another goal and possibly leads to a deteriorating state of the second. A choice has to be made between the two."

Table S4 Interactions between SDG15 and other SDGs at target level. The interactions were assessed based on the 'Seven-Point Scale' framework from Griggs et al. (2017) who classified the interactions at 7 levels: (+3) indivisible, (+2) reinforcing, (+1) enabling, (0) consistent, (-1) constraining, (-2) counteracting, (-3) canceling. The definitions of the 7 levels of interactions are given in Supplementary Table 2 .

		SDG 15 Life on Land				
Goals	Targets	15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests,	15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially	15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and	15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable	15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species

		wetlands, mountains and drylands, in line with obligations under international agreements	increase afforestation and reforestation globally	strive to achieve a land degradation neutral world	development	
SDG 1 No Poverty	1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day	15.1 to 1.1: -2；Forest ecosystem conservation could hinder target 2.1, by reducing the income of the surrounding resident. 1.1 to 15.1: +1；Eradicate extreme poverty could reduce environment stress of forest ecosystem.			15.4 to 1.1：-2 Mountain ecosystem conservation could hinder target 2.1, by reducing the income of the surrounding resident. 1.1 to 15.4：+1 Forest ecosystem Eradicate extreme poverty could reduce environment stress of mountain ecosystem.	15.3 to 1.1：-2 Natural habitats could hinder target 2.1, by reducing the income of the surrounding resident. 1.1 to 15.5：+1 Forest ecosystem Eradicate extreme poverty could reduce environment stress of natural habitats.
	1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters					
SDG 2 Zero Hunger	2.1 By 2030, end hunger and ensure access	15.1 to 2.1: -2 Forest ecosystem conservation could			15.3 to 2.1: -2 Mountain ecosystem conservation	15.4to 2.1: -2 Natural habitats could hinder target

	by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round	hinder target 2.1, by reducing the income of the surrounding resident. 2.1 to 15.1: +1 End hunger reduce environmental stress of forest ecosystem			could hinder target 2.1, by reducing the income of the surrounding resident. 2.1 to 15.4:+1 End hunger reduce environmental stress of mountain ecosystem.	2.1, by reducing the income of the surrounding resident. 2.1 to 15.5 :+1 End hunger reduce environmental stress of natural habitats.
	2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment		15.2 to 2.3 :+2 Afforestation provides employment opportunity			
SDG 3	3.9 By 2030, substantially	15.1 to 3.9: +1 Forest ecosystem	15.2 to 3.9 : +1 Afforestation and	15.2 to 3.9 : +1 Combating	15.2 to 3.9 : +1 Mountain ecosystem	

	reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	conservation could improve environmental quality to contribute to target 3.9.	reforestation could improve environmental quality to contribute to target 3.9.	desertification, and restoring degraded land and soil could improve environmental quality to contribute to target 3.9.	conservation could improve environmental quality to contribute to target 3.9.	
SDG 5 Gender Equality	5.5 Ensure women's full and effective participation and equal opportunities for leadership at all levels of decisionmaking in political, economic and public life					
SDG 6	6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	15.1 to 6.6: +2 Forest ecosystem conservation could promotion target 6.6. 6.6 to 15.1: +2 Vice versa			15.4 to 6.6:+2 Mountain ecosystem conservation could promotion target 6.6. 6.6 to 15.1: +2 Vice versa	15.5 to 6.6:+2 Natural habitats protection could promotion target 6.6. 6.6 to 15.1: +2 Vice versa
SDG 7 Affordable and Clean Energy	7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	15.1 to 7.1 :-3 Forest ecosystem conservation could offset ensuring universal access to affordable, reliable, and modern energy services. 7.1 to 15.1:+2			15.4 to 7.4: -3 Mountain ecosystem conservation could offset ensuring universal access to affordable, reliable, and modern energy services. 7.1 to 15.4: +2 Ensuring universal	15.5to 7.4: -3 Natural habitats protection could offset ensuring universal access to affordable, reliable, and modern energy services. 7.1 to 15.5: +2

		Ensuring universal access to affordable, reliable, and modern energy services could contribute to forest ecosystem conservation by reducing logging.			access to affordable, reliable, and modern energy services could contribute to mountain ecosystem conservation by reducing logging.	Ensuring universal access to affordable, reliable, and modern energy services could contribute to natural habitats conservation by reducing logging.
	7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2 to 5.1 : -1 Increasing substantially the share of renewable energy in the global energy mix could lead to environmental stress on forest ecosystems by increasing access to natural resources.			7.2 to 5.4: : -1 Increasing substantially the share of renewable energy in the global energy mix could lead to environmental stress on mountain ecosystems by increasing access to natural resources.	7.2 to 5.5: -1 Increasing substantially the share of renewable energy in the global energy mix could lead to environmental stress on natural habitats by increasing access to natural resources.
SDG 8 Decent Work and Economic Growth	8.9 By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products					
SDG 11 Sustainable Cities and Communities	11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage	15.1 to 11.4: +2 Protecting and safeguarding the world's cultural and natural heritage conducive to forest ecosystem protection. 11.4 to 15.1: +2			15.4 to 11.4:+2 Protecting and safeguarding the world's cultural and natural heritage conducive to mountain ecosystems protection. 11.4 to 15.4: +2	15.5 to 11.4: +2 Protecting and safeguarding the world's cultural and natural heritage conducive to natural habitats protection.

		Vice versa			Vice versa	11.4 to 15.5: +2 Vice versa
	11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities	15.1 to 11.7: +2 Protecting the forest ecosystem around the residential area can promote universal access to safe, inclusive, and accessible, green and public spaces.	15.2 to 11.7: +2 Afforestation around the residential area can promote universal access to safe, inclusive, and accessible, green and public spaces.			
SDG 12 Responsible Consumption and Production	12.2 By 2030, achieve the sustainable management and efficient use of natural resources	12.2 to 15.1:+2 Sustainable management and efficient use of natural resources could promote the protection of forest ecosystems.			12.2 to 15.1:+2 Sustainable management and efficient use of natural resources could promote the protection of mountain ecosystems.	12.2 to 15.1:+2 Sustainable management and efficient use of natural resources could promote the protection of habitats protection.
SDG 13 Climate Action	13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries	15.1 to 13.1: +2 Forest ecosystem protection can be strengthened resilience and adaptive capacity to climate-related hazards and natural disasters.	15.2 to 13.1: +2 Sustainable forest management can be strengthened resilience and adaptive capacity to climate-related hazards and natural disasters.		15.4 to 13.1:+2 Mountain ecosystems.protection can be strengthened resilience and adaptive capacity to climate-related hazards and natural disasters.	15.5 to 13.1:+2 Habitats protection protection can be strengthened resilience and adaptive capacity to climate-related hazards and natural disasters.

Table S5 Top 10 corresponding authors' nationalities on SDGs studies related to forests and forestry

Country	Articles	SCP	MCP	MCP Ratio
USA	49	22	27	0.551
China	44	20	24	0.545
UK	38	14	24	0.632

Australia	22	5	17	0.773
Germany	22	8	14	0.636
Austria	13	3	10	0.769
Italy	13	7	6	0.462
Netherlands	13	6	7	0.538
Switzerland	12	3	9	0.750
Sweden	9	5	4	0.444

Note: Single-country publication (SCP); multiple-country publication (MCP).

Table S6 Top 10 Frequency of national cooperation

From	***To***	***Frequency***
USA	UK	28
USA	Australia	22
USA	Canada	17
UK	Netherlands	16
USA	China	16
USA	Netherlands	16
USA	Germany	15
Germany	Australia	14
UK	France	14
UK	Germany	14

Table S7 High-frequency keywords （Top 30）

Keywords	Frequencies	Keywords	Frequenc
sustainable development goals	93	protected areas	9
ecosystem services	40	land use	9
sustainability	29	conservation	9
climate change	29	un sustainable development goals	8
sdgs	24	governance	8
sustainable development	23	soil organic carbon	7
biodiversity	19	paris agreement	7
remote sensing	16	food security	7
deforestation	14	bioeconomy	7
sustainable development goals (sdgs)	13	sustainable land management	6
land degradation	13	resilience	6
redd+	10	policy	6
indicators	10	monitoring	6
agenda 2030	10	social-ecological	5

		systems	
sustainable forest management	9	sdg	5

Note: sustainable development goals, sdgs, sustainable development, sustainable development goals (sdgs), sdg are the subject words.

Table S8 Reference clustering

Cluster ID	Size	Silhouette	Cluster label (LLR)
0	46	0.831	human well-being
1	42	0.842	food security
2	42	0.922	land use
3	31	0.858	land productivity
4	25	0.860	land tenure
5	24	0.895	tree loss
6	18	0.986	simulation models
7	15	0.945	criteria
8	14	0.993	resilience

Table S9 The top 10 highly-cited references.

Freq	Reference	Title	Journal	Cluster ID
35	UN (2015)	Transf our world		
25	Steffen W et al, (2015)	Planetary boundaries: Guiding human development on a changing planet	Science	0
22	Nilsson M et al, (2016)	Map the interactions between Sustainable Development Goals	Nature	0
19	Keesstra SD et al, (2016)	The significance of soils and soil science towards realization of the United	Soil	6

		Nations Sustainable Development Goals		
14	Wood SLR et al, (2018)	Distilling the role of ecosystem services in the Sustainable Development Goals	Ecosystem Services	2
13	Cowie AL et al, (2018)	Land in balance: The scientific conceptual framework for Land Degradation Neutrality	Environmental Science And Policy	3
11	Le Blanc D et al, (2015)	Towards Integration at Last? The Sustainable Development Goals as a Network of Targets	Sustainable Development	0
11	Diaz S et al, (2015)	The IPBES Conceptual Framework — connecting nature and people	Current Opinion In Environmental Sustainability	2
11	Costanza R et al, (2015)	Changes in the global value of ecosystem services	Global Environmental Change	8

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