Snowball Search and global quantification of the references

Table of contents

1 Setup

```
#|

library(bibtex)
library(openalexR)
```

```
Thank you for using openalexR!
To acknowledge our work, please cite the package by calling
`citation("openalexR")`.
```

```
library(writexl)
# library(dplyr)
# library(ggplot2)
# library(knitr)

kp <- bibtex::read.bib("./key-paper.bib")
dois <- sapply(
    kp,
```

```
    function(x) {
        x$doi
    }
)
```

2 Searches

2.1 OpenAlex

2.1.1 Setup OpelAnex usage and do snowball serarch

```
#|

library(ggraph)
```

```
Loading required package: ggplot2
```

```
library(tidygraph)
```

```

Attaching package: 'tidygraph'

The following object is masked from 'package:stats':

    filter
```

```
key_works <- oa_fetch(
    entity = "works",
    doi = dois,
    verbose = FALSE
)

ids <- openalexR:::shorten_oaid(key_works$id)

citing_kp <- lapply(
    ids,
    function(id) {
```

```
        oa_fetch(
            entity = "works",
            output = "tibble",
            cites = id,
            verbose = FALSE
        )
    }
)
```

```
Warning in oa_fetch(entity = "works", output = "tibble", cites = id, verbose =
FALSE): No collection found!
```

```
names(citing_kp) <- ids

cited_by_kp <- lapply(
    ids,
    function(id) {
        oa_fetch(
            entity = "works",
            output = "tibble",
            cited_by = id,
            verbose = FALSE
        )
    }
)
names(cited_by_kp) <- ids

if (file.exists("snowball.rds")) {
    snowball <- readRDS("snowball.rds")
} else {
    snowball <- oa_snowball(
        identifier = ids,
        verbose = FALSE
    )
    saveRDS(snowball, "snowball.rds")
}

flat_snow <- snowball2df(snowball) |>
    as_tibble()
```

2.1.2 Save snowball as Excel file (`snowball_excel.xlsx`)

```
###
no_edges <- snowball$edges |>
    unlist() |>
    table() |>
    sort() |>
    as.data.frame() |>
    rename(
        no_connections = Freq,
        id = Var1
    )

###
no_referenced_works <- sapply(
    snowball$node["referenced_works"][[1]],
    length
)

no_referenced_works <- data.frame(
    id = snowball$node["id"],
    no_referenced_works = no_referenced_works
)

###
citations_per_year <- flat_snow |>
    select(
        id,
        publication_year,
        cited_by_count
    ) |>
    mutate(
        years_published = 2023 - publication_year
    ) |>
    mutate(
        avg_citations_per_year = cited_by_count / years_published
    ) |>
    arrange(desc(cited_by_count)) |>
    select(
        id,
        avg_citations_per_year
    ) |>
```

```r
    rename(cited_global_per_year = avg_citations_per_year)

###

export <- flat_snow |>
    select(
        id,
        publication_year,
        display_name,
        doi,
        cited_by_count,
        ab
    ) |>
    rename(
        cited_global = cited_by_count,
        title = display_name,
        abstract = ab
    )


export$author <- sapply(
    flat_snow$author,
    function(z) {
        paste(unlist(z["au_display_name"]), collapse = ", ")
    }
)


export$author_institute <- sapply(
    flat_snow$author,
    function(z) {
        paste(unlist(z["institution_display_name"]), collapse = ", ")
    }
)


export$institute_country <- sapply(
    flat_snow$author,
    function(z) {
        paste(unlist(z["institution_country_code"]), collapse = ", ")
    }
)
```

```r
concepts <- lapply(
    flat_snow$concepts,
    function(x){
        x |>
        select(level, display_name, score)
    }
)

export$concepts_l0  <- sapply(
    concepts,
    function(x) {
       x |>
       filter(level == 0) |>
       mutate(name = paste0(display_name, " (", round(score, digits = 3), ")")) |>
       select(name) |>
       unlist() |>
       paste0(collapse = ", ")
    }
)

export$concepts_l1  <- sapply(
    concepts,
    function(x) {
       x |>
       filter(level == 1) |>
       mutate(name = paste0(display_name, " (", round(score, digits = 3), ")")) |>
       select(name) |>
       unlist() |>
       paste0(collapse = ", ")
    }
)

export$concepts_l2  <- sapply(
    concepts,
    function(x) {
       x |>
       filter(level == 2) |>
       mutate(name = paste0(display_name, " (", round(score, digits = 3), ")")) |>
       select(name) |>
       unlist() |>
       paste0(collapse = ", ")
```

```
    }
)

export$concepts_l3  <- sapply(
    concepts,
    function(x) {
       x |>
       filter(level == 3) |>
       mutate(name = paste0(display_name, " (", round(score, digits = 3), ")")) |>
       select(name) |>
       unlist() |>
       paste0(collapse = ", ")
    }
)

export$concepts_l4  <- sapply(
    concepts,
    function(x) {
       x |>
       filter(level == 4) |>
       mutate(name = paste0(display_name, " (", round(score, digits = 3), ")")) |>
       select(name) |>
       unlist() |>
       paste0(collapse = ", ")
    }
)

export$concepts_l5  <- sapply(
    concepts,
    function(x) {
       x |>
       filter(level == 5) |>
       mutate(name = paste0(display_name, " (", round(score, digits = 3), ")")) |>
       select(name) |>
       unlist() |>
       paste0(collapse = ", ")
    }
)


xlsx <- export |>
    full_join(no_edges, by = "id") |>
```

```
    full_join(no_referenced_works, by = "id") |>
    full_join(citations_per_year, by = "id") |>
    dplyr::relocate(author, .after = id) |>
    arrange(desc(cited_global))

la <- xlsx$abstract |>
    nchar() >= 3000

xlsx$abstract[la] <- substr(xlsx$abstract[la], 1, 3000)

xlsx |>
    dplyr::relocate(cited_global_per_year, .after = cited_global) |>
    dplyr::relocate(no_referenced_works, .after = doi) |>
    dplyr::relocate(no_connections, .before = abstract) |>
    dplyr::relocate(concepts_l0, .before = abstract) |>
    dplyr::relocate(concepts_l1, .before = abstract) |>
    dplyr::relocate(concepts_l2, .before = abstract) |>
    dplyr::relocate(concepts_l3, .before = abstract) |>
    dplyr::relocate(concepts_l4, .before = abstract) |>
    dplyr::relocate(concepts_l5, .before = abstract) |>
    dplyr::relocate(author_institute, .before = abstract) |>
    dplyr::relocate(institute_country, .before = abstract) |>
    writexl::write_xlsx(file.path(".", "data", "snowball_excel.xlsx"))
```

2.1.3 Graph of links between references

```
#|

snowball$nodes$cited_by_count_by_year <- snowball$nodes$cited_by_count / (2024 - snowball$noc

### Size cited_by_count_by_year
p_cby <- snowball |>
    as_tbl_graph() |>
    ggraph(graph = , layout = "stress") +
    geom_edge_link(aes(alpha = after_stat(index)), show.legend = FALSE) +
    geom_node_point(aes(fill = oa_input, size = cited_by_count_by_year), shape = 21, color =
    geom_node_label(aes(filter = oa_input, label = id), nudge_y = 0.2, size = 3) +
    scale_edge_width(range = c(0.1, 1.5), guide = "none") +
    scale_size(range = c(3, 10), guide = "none") +
    scale_fill_manual(values = c("#a3ad62", "#d46780"), na.value = "grey", name = "") +
```

```
    theme_graph() +
    theme(
        plot.background = element_rect(fill = "transparent", colour = NA),
        panel.background = element_rect(fill = "transparent", colour = NA),
        legend.position = "bottom"
    ) +
    guides(fill = "none") +
    ggtitle("Cited by average count per year")

ggsave("cited_by_count_by_year.pdf", plot = p_cby, device = cairo_pdf, width = 20, height = 1
```

```
Warning: Using the `size` aesthetic in this geom was deprecated in ggplot2 3.4.0.
i Please use `linewidth` in the `default_aes` field and elsewhere instead.
```

```
ggsave("cited_by_count_by_year.png", plot = p_cby, width = 20, height = 15, bg = "white")

### Size cited_by_count
p_cb <- snowball |>
    as_tbl_graph() |>
    ggraph(graph = , layout = "stress") +
    geom_edge_link(aes(alpha = after_stat(index)), show.legend = FALSE) +
    geom_node_point(aes(fill = oa_input, size = cited_by_count), shape = 21, color = "white"
    geom_node_label(aes(filter = oa_input, label = id), nudge_y = 0.2, size = 3) +
    scale_edge_width(range = c(0.1, 1.5), guide = "none") +
    scale_size(range = c(3, 10), guide = "none") +
    scale_fill_manual(values = c("#a3ad62", "#d46780"), na.value = "grey", name = "") +
    theme_graph() +
    theme(
        plot.background = element_rect(fill = "transparent", colour = NA),
        panel.background = element_rect(fill = "transparent", colour = NA),
        legend.position = "bottom"
    ) +
    guides(fill = "none") +
    ggtitle("Cited by count")

ggsave("cited_by_count.pdf", plot = p_cb, device = cairo_pdf, width = 20, height = 15)
ggsave("cited_by_count.png", plot = p_cb, width = 20, height = 15, bg = "white")
```

2.1.4 Identification of references with more than one edge

This is the number of connections (`connection_count`)of the paper (`id`)

```
#|

mult_edge <- flat_snow |>
    select(id, connection_count) |>
    filter(connection_count > 1) |>
    arrange(desc(connection_count))

links <- flat_snow |>
    filter(id %in% mult_edge$id)

links |>
    select(id, display_name, publication_year, doi, connection_count) |>
    arrange(desc(connection_count)) |>
    knitr::kable()
```

id	display_name	publication_year	doi	connection_count
W2204133637	Sustainability Transitions Research: Transforming Science and Practice for Societal Change	2017	https://doi.org/10.1146/annurev-environ-102014-021340	736
W2520870351	Exploring the governance and politics of transformations towards sustainability	2017	https://doi.org/10.1016/j.eist.2016.09.001	526
W2028219093	Societal transformation in response to global environmental change: A review of emerging concepts	2014	https://doi.org/10.1007/s13280-014-0582-z	407
W3001406994	Transformations to sustainability: combining structural, systemic and enabling approaches	2020	https://doi.org/10.1016/j.cosust.2019.12.006	296
W4220786370	Critical social science perspectives on transformations to sustainability	2022	https://doi.org/10.1016/j.cosust.2022.101060	169
W4379647013	Untangling theories of transformation: Reflections for ocean governance	2023	https://doi.org/10.1016/j.marpol.2023.105615	56
W2127769725	Resilience Thinking: Integrating Resilience, Adaptability and Transformability	2010	https://doi.org/10.5751/es-03610-150420	51
W2127643778	Global environmental change II	2011	https://doi.org/10.1177/030913251142570	37
W2883507726	The Dark Side of Transformation: Latent Risks in Contemporary Sustainability Discourse	2018	https://doi.org/10.1111/anti.12405	35
W4362677325	Transforming technology: The evolution from biogas to biomethane in Austria	2023	https://doi.org/10.1016/j.eist.2023.100724	27
W2078778096	Transformational adaptation when incremental adaptations to climate change are insufficient	2012	https://doi.org/10.1073/pnas.1115521109	24
W2156304718	Typology of sociotechnical transition pathways	2007	https://doi.org/10.1016/j.respol.2007.01.003	24
W2274815048	Resilience, Adaptability and Transformability in Social-ecological Systems	2004	https://doi.org/10.5751/es-00650-090205	24

id	display_name	publication_year	doi	connection_count
W2315807902	Sustainability transformations: a resilience perspective	2014	https://doi.org/10.5751/es-06799-190401	1
W2790286726	A perspective on radical transformations to sustainability: resistances, movements and alternatives	2018	https://doi.org/10.1007/s11625-018-0543-8	1
W2804856255	Adaptation versus transformation: What's the difference?	2018	https://doi.org/10.1016/j.eist.2017.10.007	1
W2960049214	Urban Transformations to Sustainability	2019	https://doi.org/10.3390/su11143881	1
W2966776423	Socio-technical transitions to sustainability: a review of criticisms and elaborations of the Multi-Level Perspective	2019	https://doi.org/10.1016/j.cosust.2019.06.0	1
W3038661345	Scaling the impact of sustainability initiatives: a typology of amplification processes	2020	https://doi.org/10.1186/s42854-020-00007-9	1
W3136925835	Developing bottom-up actor coalitions for transforming complex rural territorial pathways	2021	https://doi.org/10.1016/j.cosust.2021.02.0	1
W3154787182	Transformation beyond conservation: how critical social science can contribute to a radical new agenda in biodiversity conservation	2021	https://doi.org/10.1016/j.cosust.2021.03.0	1
W3163883782	Assessing nature-based solutions for transformative change	2021	https://doi.org/10.1016/j.oneear.2021.04.	1
W3185847870	The role of data in transformations to sustainability: a critical research agenda	2021	https://doi.org/10.1016/j.cosust.2021.06.0	1
W4200343243	Assessing the transformative potential of urban food	2021	https://doi.org/10.1038/s42949-021-00041-x	1
W4281563038	The Urgency of Transforming Biodiversity Governance	2022	https://doi.org/10.1017/9781108856348.0	1
W4379231521	Tracking and accelerating transformations to the SDGs: a review of existing knowledge	2023	https://doi.org/10.1007/s11625-023-01342-z	1
W4386384026	Pathways of small-scale gold miners: Addressing sustainability transformations	2023	https://doi.org/10.1016/j.gloenvcha.2023.	1
W1976759885	ADAPTIVE GOVERNANCE OF SOCIAL-ECOLOGICAL SYSTEMS	2005	https://doi.org/10.1146/annurev.energy.3	2
W2009175240	Navigating Transitions Ahead: Politics, Practice, and Sustainable Transition Management	2007	https://doi.org/10.1068/a39310	2
W2011383307	Resilience and Stability of Ecological Systems	1973	https://doi.org/10.1146/annurev.es.04.11	2
W2048226523	Co-research and participation: roles of researchers in sustainability transitions	2014	https://doi.org/10.1007/s11625-014-0258-4	2
W2067440677	Engaging with the politics of sustainability transitions	2011	https://doi.org/10.1016/j.eist.2011.02.003	2
W2096885696	A safe operating space for humanity	2009	https://doi.org/10.1038/461472a	2

id	display_name	publication_year	doi	connection_count
W2099330507	Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study	2002	https://doi.org/10.1016/s0048-7333(02)00062-8	6
W2130677668	Tipping Toward Sustainability: Emerging Pathways of Transformation	2011	https://doi.org/10.1007/s13280-011-0186-9	7
W2772946006	Innovation Systems for Transformations towards Sustainability? Taking the Normative Dimension Seriously	2017	https://doi.org/10.3390/su9122253	6
W2800906031	Is the 1.5°C target possible? Exploring the three spheres of transformation	2018	https://doi.org/10.1016/j.cosust.2018.04.0	6
W2904191354	Unpacking social-ecological transformations: Conceptual, ethical and methodological insights	2018	https://doi.org/10.1177/2053019618817922	7
W2918193921	Capitalism in sustainability transitions research: Time for a critical turn?	2020	https://doi.org/10.1016/j.eist.2019.02.005	6
W3036820224	Sustainability transformations: socio-political shocks as opportunities for governance transitions	2020	https://doi.org/10.1016/j.gloenvcha.2020	6
W3044590679	Sustainability-oriented labs in real-world contexts: An exploratory review	2020	https://doi.org/10.1016/j.jclepro.2020.123	6
W3081355632	A Transformative Perspective on Climate Change and Climate Governance	2020	https://doi.org/10.1007/978-3-030-49040-9_1	7
W3082596907	Scales of approaches to anticipatory climate governance: Different conceptions of the future and implications for the present	2020	https://doi.org/10.1002/wcc.673	3
W3089192400	Retaining droughts or social shifts? Exploring drivers of large-scale transformations in a transformed country	2020	https://doi.org/10.1016/j.gloenvcha.2020	6
W3090562667	Sustainable agriculture: Recognizing the potential of conflict as a positive driver for transformative change	2020	https://doi.org/10.1016/bs.aecr.2020.08.0	6
W3108934821	Leverage points perspective on social networks to understand sustainability transformations: evidence from Southern Transylvania	2020	https://doi.org/10.1007/s11625-020-00881-z	7
W3138695760	Transformational adaptation in drylands	2021	https://doi.org/10.1016/j.cosust.2021.03.0	6
W3157154384	The migration-sustainability paradox: transformations in mobile worlds	2021	https://doi.org/10.1016/j.cosust.2021.03.0	6
W3183047539	Reflexivity in Political Ecology Research: How can the Covid-19 Pandemic Transform us Into Better Researchers?	2021	https://doi.org/10.3389/fhumd.2021.6529	9
W3204115470	Transformation, and agency: Why are people going back-to-the-land in Greece?	2021	https://doi.org/10.1007/s11625-021-01043-5	7

id	display_name	publication_year	doi	connection_count
W3206417499	Enhancing theories of change for food systems transformation under climate change	2021	https://doi.org/10.1016/j.gfs.2021.100583	6
W4205298166	Operationalising sustainability transformations: Assessing the transformative potential of democratic practices in environmental governance	2022	https://doi.org/10.1016/j.esg.2021.100131	6
W4210526201	Sustainable market transformation: A refined framework for analyzing causal loops in transitions to sustainability	2022	https://doi.org/10.1016/j.eist.2022.01.010	6
W4212926313	Systemic Transition	2020	https://doi.org/10.1007/978-3-030-02006-4_433-1	7
W4214711221	Transforming environmental governance: critical action intellectuals and their praxis in the field	2022	https://doi.org/10.1007/s11625-022-01108-z	7
W4224269837	Exploring the Love Triangle of Authoritarianism, Populism, and COVID-19 Through Political Ecology: Time for a Break-Up?	2022	https://doi.org/10.3389/fhumd.2022.6539	9
W4234459924	Transitions to Sustainable Development	2019	https://doi.org/10.1007/978-3-319-71058-7_52-1	7
W4236504206	Transitions to Sustainable Development	2020	https://doi.org/10.1007/978-3-319-95867-5_52	7
W4281571651	Prospects of Low Trophic Marine Aquaculture Contributing to Food Security in a Net Zero-Carbon World	2022	https://doi.org/10.3389/fsufs.2022.875509	9
W4285628495	Systems thinking as a paradigm shift for sustainability transformation	2022	https://doi.org/10.1016/j.gloenvcha.2022	6
W4285197485	Disrupting the governance of social-ecological rigidity traps: Can pluralism foster change towards sustainability?	2022	https://doi.org/10.1016/bs.aecr.2022.04.0	6
W4292486321	Editorial: Discussing structural, systemic and enabling approaches to socio-environmental transformations: Stimulating an interdisciplinary and plural debate within the social sciences	2022	https://doi.org/10.3389/fsoc.2022.968018	9
W4293173604	Understanding the social enablers and disablers of pesticide reduction and agricultural transformation	2022	https://doi.org/10.1016/j.jrurstud.2022.0	6
W4308158201	Mapping sustainable transformed agricultural landscapes: An analysis based on local food actors' ideal visions of agriculture	2023	https://doi.org/10.1016/j.agee.2022.10823	6
W4367316381	Towards a systemic approach to energy transformation in Algeria	2023	https://doi.org/10.1007/s41207-023-00367-1	7

id	display_name	publication_year	doi	connection_count
W4377699785	Rural politics in undemocratic times: Exploring the emancipatory potential of small rural initiatives in authoritarian Hungary	2023	https://doi.org/10.1016/j.geoforum.2023.	0
W4383518737	Spatial dimensions of social-ecological transformations: polity, politics, policy	2023	https://doi.org/10.1080/15487733.2023.2	0
W1964410407	Adaptation and transformation	2014	https://doi.org/10.1007/s10584-014-1303-0	7
W1968852400	Diagnosing transformative change in urban water systems: Theories and frameworks	2013	https://doi.org/10.1016/j.gloenvcha.2012	0
W1979877171	Toward a spatial perspective on sustainability transitions	2012	https://doi.org/10.1016/j.respol.2012.02.0	0
W1982748232	Transdisciplinary research in sustainability science: practice, principles, and challenges	2012	https://doi.org/10.1007/s11625-011-0149-x	7
W1990722542	Barriers in transitions: Understanding complex chains of change	2011	https://doi.org/10.1016/j.techfore.2010.1	0
W1998481836	Mainstreaming adaptation responses to climate change through theories of transformation	2012	https://doi.org/10.1016/j.gloenvcha.2011	0
W1999167944	Planetary boundaries: Guiding human development on a changing planet	2015	https://doi.org/10.1126/science.1259855	0
W2008485484	Simple models, powerful ideas: Towards effective integrative practice	2012	https://doi.org/10.1016/j.gloenvcha.2012	0
W2007762019	Contextualizing Reflexive Governance: the Politics of Dutch Transitions to Sustainability	2007	https://doi.org/10.1080/15239080701622	0
W2011880877	The practice of transition management: Examples and lessons from four distinct cases	2010	https://doi.org/10.1016/j.futures.2009.11	0
W2030655414	The economics of degrowth	2012	https://doi.org/10.1016/j.ecolecon.2012.0	0
W2037833995	Governance, complexity, and resilience	2010	https://doi.org/10.1016/j.gloenvcha.2010	0
W2052509976	Studying the complexity of change: toward an analytical framework for understanding deliberate social-ecological transformations	2014	https://doi.org/10.5751/es-06966-190454	2
W2094701299	A socio-metabolic transition towards sustainability? Challenges for another Great Transformation	2011	https://doi.org/10.1002/sd.410	2
W2097137616	Tracking progress: From integrative transitions to transformative diversity	2011	https://doi.org/10.1016/j.eist.2011.03.005	0
W2099776967	Navigating transformations in governance of Chilean marine coastal resources	2010	https://doi.org/10.1073/pnas.1012021107	3
W2116805608	Conceptualizing, Observing, and Influencing Social–Ecological Transitions	2009	https://doi.org/10.5751/es-02857-140203	2
W2117275491	Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy	2008	https://doi.org/10.1080/09537320802292	0

id	display_name	publication_year	doi	connection_count
W2122963205	Environmental innovation and societal transitions: Introduction and overview	2011	https://doi.org/10.1016/j.eist.2011.04.010	3
W2138268098	Social Theory and Climate Change	2010	https://doi.org/10.1177/026327641036149	2
W2142130708	Designing long-term policy: rethinking transition management	2009	https://doi.org/10.1007/s11077-009-9103-5	2
W2144768886	The governance of sustainable socio-technical transitions	2005	https://doi.org/10.1016/j.respol.2005.07.0	3
W2149155747	Transforming governance and institutions for global sustainability: key insights from the Earth System Governance Project	2012	https://doi.org/10.1016/j.cosust.2012.01.0	3
W2154302927	More evolution than revolution: transition management in public policy	2001	https://doi.org/10.1108/14636680110803	3
W2160174160	Theorizing power in transition studies: the role of creativity and novel practices in structural change	2013	https://doi.org/10.1007/s11077-013-9173-2	2
W2231169545	Transformational responses to climate change: beyond a systems perspective of social change in mitigation and adaptation	2016	https://doi.org/10.1002/wcc.384	2
W2334451172	A Theory of Transformative Agency in Linked Social-Ecological Systems	2013	https://doi.org/10.5751/es-05072-180327	2
W2516150870	The politics of sustainability transitions	2016	https://doi.org/10.1080/1523908x.2016.1	2
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id	display_name	publication_year	doi	connection_count
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id	display_name	publication_year	doi	connection_count
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id	display_name	publication_year	doi	connection_count
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id	display_name	publication_year	doi	connection_count
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W4221068961	Engaging with the future: framings of adaptation to climate change in conservation	2022	https://doi.org/10.1080/26395916.2022.20	
W4221096131	How managing transitions towards building movements of affect: Advancing agroecological practices and transformation in Brazil	2022	https://doi.org/10.1016/j.geoforum.2022.	
W4226169891	Governing for Transformative Change across the Biodiversity–Climate–Society Nexus	2022	https://doi.org/10.1093/biosci/biac031	
W4229374930	Patterns of research into urban experimentation in the fields of sustainability transitions and environmental governance	2022	https://doi.org/10.1080/09654313.2022.20	

id	display_name	publication_year	doi	connection_count
W4229441600	Downscaling doughnut economics for sustainability governance	2022	https://doi.org/10.1016/j.cosust.2022.101	0
W4231224974	Index	2020	https://doi.org/10.1017/9781108688277.0	7
W4239977309	Seeds of the Future in the Present	2018	https://doi.org/10.1017/9781316647554.0	7
W4240193250	Preface	2018	https://doi.org/10.1017/9781316647554.0	7
W4245228308	Index	2019	https://doi.org/10.1017/9781108766975.0	7
W4281568170	Enabling Transformative Biodiversity Governance in the Post-2020 Era	2022	https://doi.org/10.1017/9781108856348.0	7
W4282828301	Will climate disasters spark transformative policy change and why?	2022	https://doi.org/10.1332/030557321x16508	2
W4283163279	Managing vulnerability in the Green Climate Fund	2022	https://doi.org/10.1080/17565529.2022.20	0
W4283774529	The human–technical–environmental systems framework for sustainability analysis	2022	https://doi.org/10.1007/s11625-022-01177-0	7
W4285081322	Archetypes of system transition and transformation: Six lessons for stewarding change	2022	https://doi.org/10.1016/j.erss.2022.10264	0
W4288489135	Transformational adaptation and country ownership: competing priorities in international adaptation finance	2022	https://doi.org/10.1080/14693062.2022.21	0
W4291237335	Cultures as leverage points for sustainability transformation: two pathways for transformation research	2022	https://doi.org/10.1016/j.cosust.2022.101	0
W4294132990	Assessing biodiversity policy designs in Australia, France and Sweden. Comparative lessons for transformative governance of biodiversity?	2022	https://doi.org/10.1080/1523908x.2022.21	0
W4294365732	Transformative adaptation and implications for transdisciplinary climate change research	2022	https://doi.org/10.1088/2752-5295/ac8b9d	8
W4295895107	Leader-transformative approaches in international development: A brief history and five uniting principles	2022	https://doi.org/10.1016/j.wsif.2022.10263	0
W4297225818	Are Citizens Ready for Active Climate Engagement or Stuck in a Game of Blame? Local Perceptions of Climate Action and Citizen Participation in Chilean Patagonia	2022	https://doi.org/10.3390/su141912034	0
W4300194998	Transitions to Sustainable Development	2010	https://doi.org/10.4324/9780203856598	4
W4303474787	Territorial transformation through the prism of the concept of territoire: A French contribution	2022	https://doi.org/10.1016/j.eist.2022.10.001	0
W4304822863	Food systems transformations in South America: Insights from a transdisciplinary process rooted in Uruguay	2022	https://doi.org/10.3389/fsufs.2022.887034	2
W4307224017	Methodology Underpinning the State of Climate Action Series	2022	https://doi.org/10.46830/writn.22.00064	0

id	display_name	publication_year	doi	connection_count
W4308741572	Towards a deeper understanding of up-scaling in socio-technical transitions: The case of energy communities	2022	https://doi.org/10.1016/j.erss.2022.10286	0
W4309037377	TRANSITIONS OF THE GREEN TRANSFORMATION. THE CASE OF THE EUROPEAN UNION	2022	https://doi.org/10.3846/tede.2022.17993	0
W4310004272	Adaptive seeds: a scenario approach to explore power shifts in sustainability transformations	2022	https://doi.org/10.1007/s11625-022-01251-7	7
W4311654461	Transdisciplinary transformative change: An analysis of some best practices and barriers and the role of critical social science in getting us there	2022	https://doi.org/10.21203/rs.3.rs-2330434/v1	2
W4312190462	Explaining societal change through bricolage: Transformations in regimes of water governance	2022	https://doi.org/10.1177/25148486221143	6
W4312201874	A Novel Framework for Inner-Outer Sustainability Assessment	2022	https://doi.org/10.3390/challe13020064	0
W4313241558	Gender in sustainability transition studies: Concepts, blind spots and future orientations	2023	https://doi.org/10.1016/j.eist.2022.10068	0
W4313300531	Food system transformation: Urban perspectives	2023	https://doi.org/10.1016/j.cities.2022.1041	0
W4313461244	The role of institutions in food system transformations: lessons learned from transdisciplinary engagements in Ethiopia, the Philippines, and Indonesia	2022	https://doi.org/10.1080/26395916.2022.2	0
W4315788807	Degrowth and agri-food systems: a research agenda for the critical social sciences	2023	https://doi.org/10.1007/s11625-022-01276-y	7
W4317814938	From hegemony-reinforcing to hegemony-transcending transformations: horizons of possibility and strategies of escape	2023	https://doi.org/10.1007/s11625-022-01257-1	7
W4319013622	Measuring Transformational Impact of Cooperatives	2023	https://doi.org/10.1007/978-3-031-17403-2_14	2
W4319787226	Greening recovery – Overcoming policy incoherence for sustainability transformations	2023	https://doi.org/10.1002/eet.2049	2
W4320155464	Transitions through the dynamics of adaptive cycles: Evolution of the Finnish agrifood system	2023	https://doi.org/10.1016/j.agsy.2023.10360	0
W4321787171	Visualizing Equitable Housing: A Prototype for a Framework	2023	https://doi.org/10.3390/su15054110	0
W4322581595	Navigating Local Pathways to Sustainability Through Environmental Stewardship: A Case Study in East Gippsland, Australia	2023	https://doi.org/10.1007/978-3-031-18268-6_9	2

id	display_name	publication_year	doi	connection_count
W4323300951	Scaling-up place-based and transdisciplinary research to foster agrifood system transformation: Insights from the Aliment'Actions project in western France	2023	https://doi.org/10.3389/fsufs.2023.88635	2
W4328110970	Unit of common metrics? Our Common Agenda report and the epistemic infrastructure of the Sustainable Development Goals	2023	https://doi.org/10.1111/1758-5899.13176	2
W4328120242	Transdisciplinary transformative change: an analysis of some best practices and barriers, and the potential of critical social science in getting us there	2023	https://doi.org/10.1007/s10531-023-02576-0	2
W4360851671	Collaborative water management through revitalizing social power relationships: a social network analysis of Qanat stakeholders in Iran	2023	https://doi.org/10.1007/s00271-023-00856-9	2
W4362660655	Exploring visions and vision clusters of sustainable food packaging - The case of Finland	2023	https://doi.org/10.1016/j.futures.2023.10	0
W4367307370	Generating transformative capacity: ICLEI Africa's urban natural assets for Africa programme	2023	https://doi.org/10.1080/13549839.2023.2	0
W4367599260	Ontology of sustainable agriculture narratives: implications for the transformative potential of regenerative agriculture	2023	https://doi.org/10.1007/s10460-023-10444-4	2
W4376115239	Reforming Lethal Dingo Management in Australia	2023	https://doi.org/10.3390/d15050642	0
W4376566904	Modelling pathways between transdisciplinarity and transformation: Lessons from practice	2023	https://doi.org/10.14512/gaia.32.1.10	2
W4381432119	Place-based solutions for global social-ecological dilemmas: An analysis of locally grounded, diversified, and cross-scalar initiatives in the Amazon	2023	https://doi.org/10.1016/j.gloenvcha.2023	0
W4381936659	Socio-technical transitions and sustainable agriculture in Latin America and the Caribbean: a systematic review of the literature 2010–2021	2023	https://doi.org/10.3389/fsufs.2023.114526	2
W4382133137	How to achieve the net-zero target? Lessons learned from past transformations	2023	https://doi.org/10.1371/journal.pstr.0000	2
W4382623225	Pathways beyond agency? Pluralizing structure(s) in sustainability transitions	2023	https://doi.org/10.1016/j.erss.2023.10312	0
W4384130040	The role of disasters in shaping narratives of resilience and transformation in Puerto Rico	2023	https://doi.org/10.1016/j.crsust.2023.100	0
W4384658028	Why Unsustainable Practices Remain Dominant? A Practice Theory Reinterpretation of Gramsci	2023	https://doi.org/10.1177/00380385231178	0
W4384810933	The liberal limits to transformation in the Green Climate Fund	2023	https://doi.org/10.1080/17565529.2023.2	0

2.1.5 Identification of Concepts

OpenAlex assigns all works concepts. The concepts are in hirarchical order, ranging from 0 to 3. The higher the number, the more specific the concept. The concepts are assigned to the paper (`id`)

2.1.5.1 Level 0

```
x <- lapply(
    flat_snow[["concepts"]],
    FUN = function(x) {
        x[["display_name"]][x[["level"]] == 0]
    }
) |>
    unlist() |>
    table() |>
    as.data.frame() |>
    rename(
        l1_concept = Var1,
        count = Freq
    ) |>
    arrange(desc(count))

writexl::write_xlsx(x, file.path(".", "data", "concepts_l0.xlsx"))

knitr::kable(x)
```

l1_concept	count
Political science	1136
Biology	1110
Sociology	917
Economics	914
Business	822
Computer science	787
Geography	601

l1_concept	count
Philosophy	523
Engineering	444
Physics	340
Psychology	279
Environmental science	217
Chemistry	202
Mathematics	175
Medicine	117
Art	39
Geology	39
History	30
Materials science	9

2.1.5.2 Level 1

```
x <- lapply(
    flat_snow[["concepts"]],
    function(x) {
        x[["display_name"]][x[["level"]] == 1]
    }
) |>
    unlist() |>
    table() |>
    as.data.frame() |>
    rename(
        l1_concept = Var1,
        count = Freq
    ) |>
    arrange(desc(count))

writexl::write_xlsx(x, file.path(".", "data", "concepts_l1.xlsx"))

knitr::kable(x)
```

l1_concept	count
Ecology	1048
Law	832
Environmental resource management	480
Finance	375

l1_concept	count
Social science	360
Pedagogy	346
Archaeology	332
Environmental planning	325
Public relations	295
Environmental ethics	241
Economic system	234
Epistemology	227
Artificial intelligence	220
Biochemistry	219
Quantum mechanics	212
Management	199
Knowledge management	195
Management science	160
Linguistics	147
Operating system	146
Process management	145
Economic growth	136
Engineering ethics	134
Environmental economics	130
Neuroscience	109
Social psychology	108
Programming language	103
Political economy	102
Marketing	98
Natural resource economics	97
Public administration	91
Pathology	90
Anthropology	89
Economic geography	84
Thermodynamics	81
Machine learning	77
Computer security	75
Mathematical analysis	75
Industrial organization	72
Paleontology	70
Risk analysis (engineering)	69
Electrical engineering	61
Mechanical engineering	60
Civil engineering	56
Regional science	56

l1_concept	count
World Wide Web	56
Psychotherapist	52
Cartography	51
Microeconomics	44
Psychiatry	43
Macroeconomics	42
Market economy	41
Pure mathematics	39
Computer network	38
Statistics	38
Algorithm	33
Demography	33
Economy	33
Public economics	33
Optics	32
Oceanography	30
Embedded system	27
Positive economics	26
Structural engineering	25
Waste management	25
Development economics	22
Law and economics	22
Evolutionary biology	21
Financial economics	20
Data science	19
Geometry	19
Aesthetics	17
Geodesy	17
Neoclassical economics	17
Botany	16
Database	16
Visual arts	16
Agroforestry	15
Literature	15
Meteorology	15
Software engineering	15
Advertising	14
Humanities	13
Environmental engineering	12
International trade	12
Nursing	12

l1_concept	count
Communication	11
Physical geography	11
Telecommunications	11
Theology	11
Gender studies	10
Library science	10
Data mining	9
Fishery	9
Forestry	9
Genetics	9
Internet privacy	9
Organic chemistry	9
Systems engineering	9
Water resource management	9
Acoustics	8
Architectural engineering	8
Agricultural economics	7
Astronomy	7
Climatology	7
Developmental psychology	7
Operations management	7
Socioeconomics	7
Accounting	6
Astrobiology	6
Cognitive science	6
Combinatorics	6
Internal medicine	6
Media studies	6
Aerospace engineering	5
Chromatography	5
Composite material	5
Econometrics	5
Environmental protection	5
Mathematical economics	5
Petroleum engineering	5
Transport engineering	5
Agricultural science	4
Art history	4
Clinical psychology	4
Earth science	4
Engineering management	4

l1_concept	count
Mathematical physics	4
Reliability engineering	4
Agronomy	3
Applied psychology	3
Astrophysics	3
Cognitive psychology	3
Food science	3
Information retrieval	3
Operations research	3
Ophthalmology	3
Physical chemistry	3
Soil science	3
Virology	3
Biotechnology	2
Classical mechanics	2
Commerce	2
Computer vision	2
Demographic economics	2
Economic policy	2
Engineering physics	2
Environmental health	2
Financial system	2
Geomorphology	2
Geotechnical engineering	2
Gynecology	2
Immunology	2
Medical education	2
Microbiology	2
Multimedia	2
Polymer chemistry	2
Atmospheric sciences	1
Biochemical engineering	1
Cell biology	1
Chemical engineering	1
Condensed matter physics	1
Economic history	1
Endocrinology	1
Ethnology	1
Forensic engineering	1
Human–computer interaction	1
International economics	1

l1_concept	count
Keynesian economics	1
Labour economics	1
Mathematics education	1
Molecular biology	1
Nanotechnology	1
Natural language processing	1
Nuclear engineering	1
Nuclear physics	1
Parallel computing	1
Psychoanalysis	1
Radiology	1
Remote sensing	1
Theoretical computer science	1
Welfare economics	1

2.1.5.3 Level 2

```
x <- lapply(
    flat_snow[["concepts"]],
    function(x) {
        x[["display_name"]][x[["level"]] == 2]
    }
) |>
    unlist() |>
    table() |>
    as.data.frame() |>
    rename(
        l2_concept = Var1,
        count = Freq
    ) |>
    arrange(desc(count))

writexl::write_xlsx(x, file.path(".", "data", "concepts_l2.xlsx"))

knitr::kable(x)
```

l2_concept	count
Sustainability	690
Corporate governance	391

l2_concept	count
Politics	375
Transformative learning	321
Climate change	247
Sustainable development	227
Context (archaeology)	214
Gene	209
Agriculture	157
Action (physics)	128
Adaptation (eye)	116
Process (computing)	112
Agency (philosophy)	110
Perspective (graphical)	90
Resilience (materials science)	81
Transformational leadership	81
Government (linguistics)	77
Psychological resilience	76
Alternative medicine	66
Futures contract	64
Scale (ratio)	59
Stakeholder	59
Framing (construction)	54
Scholarship	54
Normative	51
Content (measure theory)	50
Citizen journalism	49
Order (exchange)	49
Reflexivity	46
Power (physics)	45
Vulnerability (computing)	45
Anthropocene	42
Renewable energy	42
Ecosystem	41
Urban planning	41
Work (physics)	41
Vision	38
Conceptual framework	37
Earth system science	37
Leverage (statistics)	37
Sociotechnical system	37
Circular economy	36
Value (mathematics)	34

l2_concept	count
Mainstream	33
Population	33
Energy (signal processing)	32
Biodiversity	31
Production (economics)	31
Scope (computer science)	31
Variety (cybernetics)	31
Psychological intervention	30
Set (abstract data type)	30
Diversity (politics)	28
Economic Justice	28
Field (mathematics)	28
Narrative	28
State (computer science)	28
Transformation processes	26
China	25
Empirical research	25
Incentive	25
Negotiation	25
Resource (disambiguation)	25
Niche	23
Social change	23
Qualitative research	22
Typology	22
Accountability	21
Ecological systems theory	21
Indigenous	21
Operationalization	21
Business model	20
Disease	20
Empowerment	20
Equity (law)	20
Greenhouse gas	20
Interdependence	20
Status quo	20
Transdisciplinarity	20
Urbanization	20
Discipline	19
Key (lock)	19
Intermediary	18
Natural resource	18

l2_concept	count
Nexus (standard)	18
Quality (philosophy)	18
Function (biology)	17
Relevance (law)	17
Conceptualization	16
Dynamics (music)	16
Habitat	16
Tourism	16
Consumption (sociology)	15
Meaning (existential)	15
Pace	15
Technological change	15
Cognitive reframing	14
Electricity	14
Land use	14
Space (punctuation)	14
Stakeholder engagement	14
Dimension (graph theory)	13
Face (sociological concept)	13
Futures studies	13
Identity (music)	13
Paradigm shift	13
Adaptive management	12
Metropolitan area	12
Restructuring	12
Social learning	12
Bridging (networking)	11
German	11
Perception	11
Relation (database)	11
Scarcity	11
Situated	11
Systems thinking	11
Transparency (behavior)	11
Argument (complex analysis)	10
Embeddedness	10
General partnership	10
Livestock	10
Resistance (ecology)	10
Social capital	10
Software deployment	10

l2_concept	count
Term (time)	10
Architecture	9
CLARITY	9
Commons	9
Complex adaptive system	9
Entrepreneurship	9
Focus group	9
Identification (biology)	9
Index (typography)	9
Innovation system	9
Living lab	9
MEDLINE	9
Natural (archaeology)	9
Risk management	9
Supply chain	9
System dynamics	9
Tipping point (physics)	9
Unintended consequences	9
Viewpoints	9
Anticipation (artificial intelligence)	8
Citizen science	8
Control reconfiguration	8
European union	8
Flexibility (engineering)	8
Fossil fuel	8
Multidisciplinary approach	8
Private sector	8
Unpacking	8
Adaptability	7
Ambiguity	7
Credibility	7
Developing country	7
Disaster risk reduction	7
Environmental justice	7
Flood myth	7
Globe	7
Health care	7
Humanity	7
Institutional change	7
Legislature	7
Local government	7

l2_concept	count
Plural	7
Position (finance)	7
Poverty	7
Special education	7
Structure and agency	7
Underpinning	7
Action research	6
Autonomy	6
Bibliometrics	6
Competition (biology)	6
Construct (python library)	6
Development (topology)	6
Diversification (marketing strategy)	6
Experiential learning	6
Green infrastructure	6
Higher education	6
Human settlement	6
Intermediation	6
Intervention (counseling)	6
Lagging	6
Latin Americans	6
Legislation	6
Lens (geology)	6
Modernization theory	6
Novelty	6
Participatory action research	6
Premise	6
Prosperity	6
Public health	6
Service (business)	6
Social media	6
Sociocultural evolution	6
Spatial planning	6
Structuring	6
Water resources	6
Amazon rainforest	5
Anthropocentrism	5
Biosphere	5
Capacity building	5
Clothing	5
Competitive advantage	5

l2_concept	count
Coproduction	5
Corporate social responsibility	5
Deforestation (computer science)	5
Destabilisation	5
Distribution (mathematics)	5
Efficient energy use	5
Element (criminal law)	5
Emerging technologies	5
Empirical evidence	5
Environmental policy	5
Exploratory research	5
Financial crisis	5
Fishing	5
Focus (optics)	5
Formative assessment	5
Heuristic	5
Institutionalisation	5
Interpretation (philosophy)	5
Knowledge production	5
Maladaptation	5
Openness to experience	5
Payment	5
Pluralism (philosophy)	5
Policy analysis	5
Popularity	5
Public policy	5
Resource efficiency	5
Sample (material)	5
Sanitation	5
Scenario planning	5
Scrutiny	5
Social system	5
Sociology of scientific knowledge	5
Stock (firearms)	5
Strengths and weaknesses	5
Summit	5
The arts	5
Theory of change	5
Water supply	5
Action plan	4
Biofuel	4

l2_concept	count
Blueprint	4
Boundary (topology)	4
Capital (architecture)	4
Centrality	4
Citation	4
Composite number	4
Conflict transformation	4
CONTEST	4
Conversation	4
Coping (psychology)	4
Creativity	4
Dependability	4
Desk	4
Earth (classical element)	4
Energy consumption	4
Environmental impact assessment	4
Environmental law	4
Extant taxon	4
Food waste	4
Globalization	4
Greening	4
Hazard	4
Human systems engineering	4
Injustice	4
Institutional theory	4
Intersectionality	4
Leadership style	4
Materialism	4
Mindset	4
Modernity	4
Natural hazard	4
Nature versus nurture	4
Neutrality	4
Parallels	4
Path dependence	4
Performative utterance	4
Phenomenon	4
Praxis	4
Product (mathematics)	4
Realm	4
Reputation	4

l2_concept	count
Social dynamics	4
Strategic planning	4
Treaty	4
Wicked problem	4
Acknowledgement	3
Agile software development	3
Appeal	3
Appropriation	3
Best practice	3
Big data	3
Business ethics	3
Certification	3
Character (mathematics)	3
Co-creation	3
Coherence (philosophical gambling strategy)	3
Competence (human resources)	3
Conceptual model	3
Control (management)	3
Damages	3
Dependency (UML)	3
Dialectic	3
Disadvantaged	3
Dual (grammatical number)	3
Embodied cognition	3
Emerging markets	3
Environmental stewardship	3
Evolutionary economics	3
Exploit	3
Financial intermediary	3
Flourishing	3
Food packaging	3
Food processing	3
Foregrounding	3
Fragmentation (computing)	3
Frame (networking)	3
GRASP	3
Grazing	3
Heuristics	3
Inclusion (mineral)	3
Indonesian	3
Industrial Revolution	3

l2_concept	count
Industrialisation	3
Interdisciplinarity	3
Interim	3
Internet of Things	3
Interpersonal communication	3
Interpersonal ties	3
Knowledge base	3
Lean manufacturing	3
Literacy	3
Logit	3
Macro	3
Mediation	3
Outbreak	3
Path (computing)	3
Phase (matter)	3
Plan (archaeology)	3
Planet	3
Portfolio	3
Portuguese	3
Pragmatism	3
Procurement	3
Productivity	3
Profit (economics)	3
Public engagement	3
Public transport	3
Qualitative property	3
Ranking (information retrieval)	3
Rationality	3
Reading (process)	3
Reciprocity (cultural anthropology)	3
Recreation	3
Reductionism	3
Redundancy (engineering)	3
Safeguarding	3
Salience (neuroscience)	3
Salient	3
Scaling	3
Selection (genetic algorithm)	3
Social responsibility	3
Software	3
Stressor	3

l2_concept	count
Structural equation modeling	3
Subsidy	3
Surface runoff	3
Temporality	3
Test (biology)	3
Theme (computing)	3
Thriving	3
Timeline	3
Tragedy (event)	3
Virtue	3
Watershed	3
Wetland	3
Wildlife	3
Workforce	3
Affect (linguistics)	2
Air quality index	2
Alliance	2
Aotearoa	2
Archetype	2
Baltic sea	2
Branching (polymer chemistry)	2
Bricolage	2
Business ecosystem	2
Capability approach	2
Catalysis	2
Clean energy	2
Cloud computing	2
Coal	2
Coevolution	2
Cognition	2
Cohesion (chemistry)	2
Commodification	2
Common ground	2
Community engagement	2
Comparative advantage	2
Comparative case	2
Compass	2
Component (thermodynamics)	2
Consciousness	2
Conservation biology	2
Consistency (knowledge bases)	2

l2_concept	count
Consolidation (business)	2
Consumerism	2
Content analysis	2
Convention	2
Coral	2
Coral reef	2
Craft	2
Critical theory	2
Curriculum	2
Cybernetics	2
Dance	2
Decentralization	2
Declaration	2
Delphi method	2
Demand side	2
Demographics	2
Dichotomy	2
Dignity	2
Dilemma	2
Directive	2
Disconnection	2
Divergence (linguistics)	2
Documentation	2
Dystopia	2
Ecological psychology	2
Enabling	2
Enforcement	2
Engineering design process	2
Environmental crisis	2
Environmental education	2
Environmental quality	2
Everyday life	2
Excellence	2
Explanatory power	2
Externality	2
Facilitation	2
Financialization	2
Fish	2
Flemish	2
Frontier	2
Gold mining	2

l2_concept	count
Green innovation	2
Grid	2
Hierarchy	2
Honor	2
Human capital	2
Human evolution	2
Human geography	2
Hydropower	2
Ideal (ethics)	2
Idealism	2
Ignorance	2
Image (mathematics)	2
Impact assessment	2
Industrial policy	2
Industrial society	2
Inequality	2
Information and Communications Technology	2
Ingenuity	2
Institutional economics	2
Intellectual property	2
Irrigation	2
Knowledge engineering	2
Language change	2
Leapfrogging	2
Liberalization	2
Local community	2
Malaria	2
Management system	2
Marketing management	2
Materiality (auditing)	2
Measure (data warehouse)	2
Metaphor	2
Modal	2
Modalities	2
Multitude	2
Musical	2
Neglect	2
Neighbourhood (mathematics)	2
Neoliberalism (international relations)	2
Newspaper	2
Niche construction	2

l2_concept	count
Norm (philosophy)	2
Norwegian	2
Objectivity (philosophy)	2
Ocean observations	2
Outcome (game theory)	2
Outreach	2
Participatory planning	2
Peasant	2
Peninsula	2
Performance art	2
Plea	2
Policy Sciences	2
Pollution	2
Port (circuit theory)	2
Practice theory	2
Preparedness	2
Prioritization	2
Privilege (computing)	2
Profitability index	2
Project management	2
Provisioning	2
Psychometrics	2
Psychosocial	2
Public good	2
Public interest	2
Public participation	2
Rangeland	2
Reef	2
Refugee	2
Reinterpretation	2
Reproduction	2
Restoration ecology	2
Revenue	2
Rhetoric	2
Rhetorical question	2
Rigour	2
Science education	2
Science policy	2
Section (typography)	2
Servant	2
Shock (circulatory)	2

l2_concept	count
Sky	2
Social group	2
Social innovation	2
Social justice	2
Social theory	2
Socioeconomic development	2
Soil water	2
Spatial heterogeneity	2
Strategic management	2
Subject (documents)	2
Subjectivity	2
Surprise	2
Systems theory	2
Tanzania	2
Task (project management)	2
Technology policy	2
Temporalities	2
Terminology	2
The Imaginary	2
The Renaissance	2
Trap (plumbing)	2
TRIPS architecture	2
Utopia	2
Water quality	2
Welfare	2
Wind power	2
Wine	2
Witness	2
Work in process	2
Absorptive capacity	1
Abstraction	1
Acceleration	1
Access to finance	1
Agent-based model	1
Ambivalence	1
Analogy	1
Analytic hierarchy process	1
Anger	1
Antibiotics	1
Applied ethics	1
Archipelago	1

l2_concept	count
Arctic	1
Argumentation theory	1
Artificial neural network	1
Asia pacific	1
Assemblage (archaeology)	1
Asset (computer security)	1
Attractor	1
Audit	1
Autoethnography	1
Automotive industry	1
Aviation	1
Balanced scorecard	1
Baseline (sea)	1
Basic income	1
Bathing	1
Behavior change	1
Bespoke	1
Biobank	1
Biodegradable plastic	1
Biogas	1
Biologist	1
Biomass (ecology)	1
Bivariate analysis	1
Blame	1
Blank	1
Block (permutation group theory)	1
Blockchain	1
Boundary-work	1
Bounded function	1
Bounded rationality	1
Branching process	1
Bridge (graph theory)	1
Buddhism	1
Business case	1
Business risks	1
Business system planning	1
Butterfly	1
Cape	1
Car sharing	1
Carbon dioxide	1
Cardinal point	1

l2_concept	count
Causal model	1
Causality (physics)	1
Ceiling (cloud)	1
Champion	1
Chaotic	1
Chart	1
Chemical industry	1
Christian ministry	1
Civilization	1
Classifier (UML)	1
Clean technology	1
Closing (real estate)	1
Coastal management	1
Coastal zone	1
Coding (social sciences)	1
Collaborative learning	1
Collective efficacy	1
Colonialism	1
Commercialism	1
Commodity	1
Community organization	1
Community participation	1
Comparability	1
Complex system	1
Complexity management	1
Compliance (psychology)	1
Compromise	1
Computable general equilibrium	1
Conflation	1
Conflict resolution	1
Consciousness raising	1
Consequentialism	1
Constellation	1
Constitution	1
Construal level theory	1
Consumer behaviour	1
Contradiction	1
Conurbation	1
Copernicus	1
Core (optical fiber)	1
Cosmetics	1

l2_concept	count
Creative destruction	1
Crisis management	1
Crisis response	1
Critical infrastructure	1
Critical reflection	1
Criticism	1
Crop protection	1
Cross disciplinary	1
Cultural psychology	1
Cultural values	1
Curiosity	1
Current (fluid)	1
Data collection	1
Data envelopment analysis	1
Data-driven	1
Debt	1
Decision tree	1
Deconstruction (building)	1
Deep learning	1
Deep time	1
Deliverable	1
Demand management	1
Denial	1
Deontological ethics	1
Descriptive statistics	1
Desegregation	1
Design thinking	1
Dialog box	1
Dialogical self	1
Diffusion	1
Digital content	1
Digital transformation	1
Disaster research	1
Discrete choice	1
Disruptive innovation	1
Distance decay	1
Divestment	1
Division of labour	1
Domain (mathematical analysis)	1
Domestic market	1
Domestication	1

l2_concept	count
Download	1
Downstream (manufacturing)	1
DPSIR	1
Drone	1
Dual purpose	1
Duration (music)	1
Dynamic capabilities	1
Dynamism	1
E-commerce	1
Ecological crisis	1
Ecological efficiency	1
Ecological engineering	1
Economic recovery	1
Economic rent	1
Educational technology	1
Electronic waste	1
Emergency management	1
Emic and etic	1
Energy conservation	1
Energy demand	1
Energy sector	1
Environmental degradation	1
Environmental pollution	1
Environmental restoration	1
Environmental security	1
Environmental sociology	1
Environmentally friendly	1
Enzyme	1
Episteme	1
Estonian	1
Ethics of care	1
Ethnic group	1
Ethos	1
European region	1
Event (particle physics)	1
Evolutionary psychology	1
Evolutionary theory	1
Experiential knowledge	1
Explanatory model	1
Explication	1
Exposition (narrative)	1

l2_concept	count
Expression (computer science)	1
Expropriation	1
Extended producer responsibility	1
Extension (predicate logic)	1
Extinction (optical mineralogy)	1
Facilitator	1
Factor market	1
Factory (object-oriented programming)	1
Fantasy	1
Feeling	1
Fidelity	1
Financial market	1
Floodplain	1
Flowchart	1
Food chain	1
Food safety	1
Foreign direct investment	1
Forest management	1
Foundation (evidence)	1
Fragility	1
Frugality	1
Fuel cells	1
Fuzzy logic	1
Game design	1
Game mechanics	1
General assembly	1
Generative grammar	1
Genetic testing	1
Geospatial analysis	1
Germination	1
Glacier	1
Glass ceiling	1
Global network	1
Glyphosate	1
Goods and services	1
Graph	1
Grassland	1
Great Rift	1
Green marketing	1
Gross domestic product	1
Groundwater	1

l2_concept	count
Harm	1
Harmony (color)	1
Heading (navigation)	1
Heat stress	1
Hermeneutics	1
Holistic management	1
Homo sapiens	1
Homophily	1
Horizontal and vertical	1
Horse	1
Human development (humanity)	1
Human resources	1
Human rights	1
Human security	1
Human sexuality	1
Human values	1
Hygiene	1
Hyperparameter	1
Ideal type	1
Immediacy	1
Impact factor	1
Implementation	1
Impossibility	1
Impulse (physics)	1
Indigenization	1
Individual mobility	1
Individualism	1
Industrial and production engineering	1
Inertia	1
Inference	1
Inflection point	1
Informal sector	1
Informal settlements	1
Information ethics	1
Information exchange	1
Information flow	1
Information technology	1
Innovation diffusion	1
Innovation management	1
Institution	1
Institutional logic	1

l2_concept	count
Integrated pest management	1
Interconnectivity	1
Intercropping	1
International Action	1
International development	1
Intersection (aeronautics)	1
Isolation (microbiology)	1
Jargon	1
Journalism	1
Judgement	1
Kingdom	1
Knowledge transfer	1
Knowledge-based systems	1
Kuznets curve	1
Lead (geology)	1
Leadership development	1
Legal research	1
Life course approach	1
Life satisfaction	1
Lift (data mining)	1
Limit (mathematics)	1
Linear discriminant analysis	1
Linearity	1
Link (geometry)	1
Listing (finance)	1
Lithium (medication)	1
Living systems	1
Local Development	1
Lock (firearm)	1
Looming	1
Loss and damage	1
Mandate	1
Mangrove	1
Marine conservation	1
Marine spatial planning	1
Matching (statistics)	1
Material flow	1
Material flow analysis	1
Maturity (psychological)	1
Maya	1
Medical equipment	1

l2_concept	count
Mega-	1
Megacity	1
Membrane	1
Mental health	1
Mental model	1
Merge (version control)	1
Mesoamerica	1
Mesopotamia	1
Methodological individualism	1
Metric (unit)	1
Miami	1
Microfoundations	1
Miller	1
Mindfulness	1
Mode (computer interface)	1
Modular design	1
Monitoring and evaluation	1
Moral responsibility	1
Movement (music)	1
Multinomial logistic regression	1
National innovation system	1
Natural disaster	1
Natural gas	1
Net (polyhedron)	1
Network effect	1
Niche market	1
Normal science	1
Normalization (sociology)	1
Normative ethics	1
North west	1
Nothing	1
Nuclear power	1
Nuclear power plant	1
Nursing research	1
Object (grammar)	1
Occupancy	1
Officer	1
Open innovation	1
Opportunism	1
Optimism	1
Organisational change	1

l2_concept	count
Orthodoxy	1
Oxymoron	1
Path analysis (statistics)	1
Path dependency	1
Performativity	1
Period (music)	1
Persistence (discontinuity)	1
Personal mobility	1
Personality	1
Photovoltaic system	1
Planned economy	1
Plastic bag	1
Pluvial	1
Point (geometry)	1
Policy development	1
Polluter pays principle	1
Pooling	1
Positivism	1
Posthumanism	1
Postmodernism	1
Precipitation	1
Predation	1
Predictability	1
Predictive maintenance	1
Preference	1
Presentation (obstetrics)	1
Presumption	1
Principal (computer security)	1
Prism	1
Professionalization	1
Project finance	1
Pronoun	1
Property (philosophy)	1
Property rights	1
Proxy (statistics)	1
Prudence	1
Public service	1
Publishing	1
Punctuated equilibrium	1
Questionnaire	1
Rainwater harvesting	1

l2_concept	count
Rapeseed	1
Raw material	1
Realism	1
Redevelopment	1
Redress	1
Reference model	1
Reforestation	1
Regional development	1
Regional innovation system	1
Relocation	1
Resource allocation	1
Resource depletion	1
Resource management (computing)	1
Responsible Research and Innovation	1
Reuse	1
Rhythm	1
Risk assessment	1
Root cause	1
Rope	1
Rural area	1
Sanctions	1
Scalability	1
Scheme (mathematics)	1
Scientific evidence	1
Seawater	1
Secondary sector of the economy	1
Sect	1
Security studies	1
Sense of agency	1
Sense of place	1
Sequence (biology)	1
Setback	1
Sharing economy	1
Simple (philosophy)	1
Sketch	1
Skills management	1
Smart grid	1
Social business	1
Social connectedness	1
Social equality	1
Social impact assessment	1

l2_concept	count
Social institution	1
Social marketing	1
Social mobility	1
Social policy	1
Social relation	1
Social security	1
Social solidarity	1
Social work	1
Sociality	1
Solar energy	1
sort	1
Spacecraft	1
SPARK (programming language)	1
Spatial ecology	1
Spatial organization	1
Spatial variability	1
Special section	1
SPHERES	1
Stability (learning theory)	1
Stars	1
Statistical analysis	1
Structuration theory	1
Subjectification	1
Submarine pipeline	1
Substitution (logic)	1
Sump (aquarium)	1
Superordinate goals	1
Support vector machine	1
Survey data collection	1
Sustenance	1
Swarm behaviour	1
Table (database)	1
Tariff	1
Teaching method	1
Technological evolution	1
Technology transfer	1
Textile	1
Textile industry	1
The arctic	1
The Internet	1
Thematic map	1

l2_concept	count
Theory of the firm	1
Thermal	1
Toolbox	1
Top-down and bottom-up design	1
TOPSIS	1
Traceability	1
Tracing	1
Track (disk drive)	1
Tracking (education)	1
Trajectory	1
Transaction cost	1
Transactional leadership	1
Transitive relation	1
Transport system	1
Travel behavior	1
Trilogy	1
Trojan horse	1
Truck	1
Turbine	1
Turnover	1
Umwelt	1
Uncanny	1
Uncertainty	1
Unit (ring theory)	1
Unitary state	1
Upgrade	1
Urban agglomeration	1
Urban forestry	1
Usability	1
Utilitarianism	1
Valuation (finance)	1
Value creation	1
Value proposition	1
Variable (mathematics)	1
Variables	1
Variation (astronomy)	1
Vegetation (pathology)	1
Video game	1
Visualization	1
Voltage	1
Warning system	1

l2_concept	count
Warrant	1
Wastewater	1
Water diversion	1
Water energy	1
Water use	1
Watson	1
West germany	1
West virginia	1
Wilderness	1
Wildness	1
Window (computing)	1
Wonder	1
Zero (linguistics)	1
Zoning	1

2.1.5.4 Level 3

```
x <- lapply(
    flat_snow[["concepts"]],
    function(x) {
        x[["display_name"]][x[["level"]] == 3]
    }
) |>
    unlist() |>
    table() |>
    as.data.frame() |>
    rename(
        l3_concept = Var1,
        count = Freq
    ) |>
    arrange(desc(count))

writexl::write_xlsx(x, file.path(".", "data", "concepts_l3.xlsx"))

knitr::kable(x)
```

l3_concept	count
Transition (genetics)	127
Food security	82

l3_concept	count
Transformation (genetics)	74
Social sustainability	69
Panacea (medicine)	65
Transition management (governance)	61
Sustainability organizations	60
Environmental governance	34
Adaptive capacity	30
Legitimacy	27
Livelihood	27
Democracy	26
Grassroots	26
Sustainable agriculture	26
Civil society	25
Collective action	25
Ecosystem services	25
Climate change adaptation	24
Climate governance	23
Infectious disease (medical specialty)	20
Urban sustainability	17
Environmental change	16
Urban resilience	16
Agroecology	14
Energy policy	12
Multi-level governance	12
Social transformation	12
Stewardship (theology)	12
Deliberation	11
Promotion (chess)	11
Technocracy	11
Thematic analysis	11
Climate change mitigation	10
Political ecology	10
Solidarity	10
Collaborative governance	9
Energy system	9
Global governance	9
Planetary boundaries	9
Capitalism	8
Climate justice	8
Global warming	8
Investment (military)	8

l3_concept	count
Originality	8
Sustainable consumption	8
Climate Finance	7
Climate resilience	7
Geopolitics	7
Hegemony	7
Mainstreaming	7
Sustainable business	7
Agrarian society	6
Backcasting	6
Constructive	6
Degrowth	6
Dominance (genetics)	6
Extreme weather	6
Ideology	6
Natural resource management	6
Political economy of climate change	6
Scopus	6
Through-the-lens metering	6
Traditional knowledge	6
Agricultural productivity	5
Corporate sustainability	5
Ecological niche	5
Green growth	5
Landscape ecology	5
Social movement	5
Socioeconomic status	5
Urban density	5
Boundary object	4
Carbon fibers	4
Ecological resilience	4
Electronic business	4
Elite	4
Emancipation	4
Energy security	4
Global change	4
Health policy	4
Incrementalism	4
Legitimation	4
Opposition (politics)	4
Pastoralism	4

l3_concept	count
Product-service system	4
Project governance	4
Risk governance	4
Servant leadership	4
Social network analysis	4
Socio-ecological system	4
Sustainable transport	4
Value chain	4
Vulnerability assessment	4
2019-20 coronavirus outbreak	3
Agricultural diversification	3
Articulation (sociology)	3
Biodiversity conservation	3
Bureaucracy	3
Causal loop diagram	3
Change management (ITSM)	3
Citation analysis	3
Climate policy	3
Collective identity	3
Collective leadership	3
Community resilience	3
Convention on Biological Diversity	3
Diplomacy	3
Downscaling	3
Ecological footprint	3
Ecosystem management	3
Ecosystem-based management	3
Education for sustainable development	3
Electricity generation	3
Environmental politics	3
Integrated water resources management	3
Kyoto Protocol	3
Land use, land-use change and forestry	3
Learning sciences	3
Network governance	3
Regime shift	3
Settlement (finance)	3
Smart city	3
Social network (sociolinguistics)	3
Sovereignty	3
Stormwater	3

l3_concept	count
Strategic environmental assessment	3
Sustainable energy	3
Systematic review	3
Technological innovation system	3
Transferability	3
Urban climate	3
Urban ecosystem	3
Urbanism	3
Water scarcity	3
Web of science	3
Agricultural biodiversity	2
Beijing	2
Biorefinery	2
Business process	2
Carbon footprint	2
Citizenship	2
Climate risk	2
Climate science	2
Conservation psychology	2
Conservation science	2
Contextualization	2
CRISPR	2
Destinations	2
Devolution (biology)	2
Ecological economics	2
Ecological health	2
Ecological modernization	2
Energy law	2
Environmentalism	2
Fisheries management	2
Global value chain	2
Governmentality	2
Green economy	2
Health promotion	2
Knowledge integration	2
Las vegas	2
Leadership	2
Leadership studies	2
Low-carbon economy	2
Marine ecosystem	2
Marine protected area	2

l3_concept	count
Orchestration	2
Phenotype	2
Phoenix	2
Polity	2
Population growth	2
Qualitative analysis	2
Rebound effect (conservation)	2
Regulatory state	2
Representation (politics)	2
Service provider	2
Shared leadership	2
Social identity theory	2
Social vulnerability	2
Software development	2
Stakeholder analysis	2
Stakeholder theory	2
Sustainability reporting	2
Sustainable Agriculture Innovation Network	2
Sustainable management	2
Sustainable tourism	2
Sustainable Value	2
Systemic risk	2
Threatened species	2
Transnational governance	2
Urban design	2
Urban ecology	2
Value network	2
Virtue ethics	2
Welfare state	2
Wildlife conservation	2
Agonism	1
Agribusiness	1
Agricultural policy	1
Agroecosystem	1
Air travel	1
Antibiotic resistance	1
Aquaculture	1
Aquifer	1
Artisanal fishing	1
Austerity	1
Behaviour change	1

l3_concept	count
Betweenness centrality	1
Bibliographic coupling	1
Big Five personality traits	1
Biodiesel	1
Bioenergy	1
Biological integrity	1
Biome	1
Bioproducts	1
Business analysis	1
Business value	1
Carbon dioxide in Earth's atmosphere	1
Carbon neutrality	1
Carbon sequestration	1
Carnivore	1
Chimera (genetics)	1
Choreography	1
Climate model	1
Cloud computing security	1
Co-citation	1
Code (set theory)	1
Community forestry	1
Compartmentalization (fire protection)	1
Conditionality	1
Confirmatory factor analysis	1
Conservatism	1
Construals	1
Cooperative learning	1
Coral bleaching	1
Coral reef protection	1
Critical realism (philosophy of perception)	1
Cultural geography	1
Data quality	1
Decolonization	1
Desalination	1
Dingo	1
Distributive justice	1
Dormancy	1
Duopoly	1
Earth Summit	1
Eco-innovation	1
Economic collapse	1

l3_concept	count
Economic governance	1
Economic interventionism	1
Economic reform	1
Economic shortage	1
Ecosystem approach	1
Egalitarianism	1
Electrification	1
Energy engineering	1
Energy intensity	1
Energy management	1
Energy market	1
Energy planning	1
Energy storage	1
Energy supply	1
Environmental consciousness	1
Environmental issues with coral reefs	1
Environmental management system	1
Environmental Sustainability Index	1
Epistemic virtue	1
Epoch (astronomy)	1
Erasmus+	1
Exploitation of natural resources	1
Exploratory factor analysis	1
Extreme heat	1
Fashion industry	1
Fast fashion	1
Fisheries Research	1
Fishing industry	1
Flood mitigation	1
Flood risk management	1
Focal point	1
Food sector	1
Fukushima Nuclear Accident	1
Game Developer	1
Global health	1
Health administration	1
Health equity	1
Health informatics	1
Health security	1
Healthcare system	1
Historical geography	1

l3_concept	count
Hospitality	1
Human genetics	1
Human–wildlife conflict	1
Hydrogen fuel	1
Impact investing	1
Industrial ecology	1
Institutional investor	1
Integrated coastal zone management	1
Intergenerational equity	1
Internal consistency	1
International investment	1
Intrapersonal communication	1
Ionic liquid	1
Knowledge creation	1
Land cover	1
Land grabbing	1
Land management	1
Land-use planning	1
Legal realism	1
Life-cycle assessment	1
Linkage (software)	1
Mains electricity	1
Marketization	1
Medical genetics	1
Meta-ethics	1
Militarization	1
Millennium Development Goals	1
Modal shift	1
Negative feedback	1
New england	1
New horizons	1
Nomological network	1
Non-renewable resource	1
Normative social influence	1
Nuclear disaster	1
Ocean chemistry	1
Offshore wind power	1
Oppression	1
Organic farming	1
Overfishing	1
Overgrazing	1

l3_concept	count
Pacific islanders	1
Parliament	1
Participatory design	1
Per capita	1
Photovoltaics	1
Plasmodium falciparum	1
Poaching	1
Populism	1
Project commissioning	1
Project management triangle	1
Project portfolio management	1
Prosumer	1
Quality assurance	1
Random graph	1
Rangeland management	1
Redistribution (election)	1
Relationship marketing	1
Renewable fuels	1
Requirements engineering	1
Resilience of coral reefs	1
Resource curse	1
Resource recovery	1
Return on marketing investment	1
Ribosomal RNA	1
Right to the city	1
Riparian zone	1
Risk perception	1
RNA	1
Robustness (evolution)	1
Ruderal species	1
Rule of law	1
Rurality	1
Sampling frame	1
Science Citation Index	1
Seagrass	1
Social activism	1
Social conflict	1
Social determinants of health	1
Social injustice	1
Social practice	1
Social reproduction	1

l3_concept	count
Soil carbon	1
Stock assessment	1
Stock market	1
Storytelling	1
Strategic financial management	1
Subsistence agriculture	1
Supply chain management	1
Sustainable design	1
Sustainable production	1
Sustainable society	1
Technical Journalism	1
The Conceptual Framework	1
Total factor productivity	1
Tragedy of the commons	1
Transcription factor	1
Urban agriculture	1
Urban greening	1
Urban politics	1
Vagueness	1
Video game design	1
Vitalism	1
Vulnerability index	1
Wage labour	1
Water infrastructure	1
Water sector	1
Water security	1
Welfare reform	1
Zero-energy building	1

2.1.5.5 Level 4

```
x <- lapply(
    flat_snow[["concepts"]],
    function(x) {
        x[["display_name"]][x[["level"]] == 4]
    }
) |>
    unlist() |>
    table() |>
    as.data.frame() |>
```

```
    rename(
        l4_concept = Var1,
        count = Freq
    ) |>
    arrange(desc(count))

writexl::write_xlsx(x, file.path(".", "data", "concepts_l4.xlsx"))

knitr::kable(x)
```

l4_concept	count
Sustainability science	75
Energy transition	64
Food systems	64
Coronavirus disease 2019 (COVID-19)	20
Democratization	8
Food policy	6
Authoritarianism	5
Business relationship management	4
Ecosystem health	3
United Nations Framework Convention on Climate Change	3
Urban metabolism	3
Complementation	2
Electricity system	2
Fisheries law	2
Neuroleadership	2
Scrum	2
Stormwater management	2
Action learning	1
Artemisinin	1
Aviation biofuel	1
Biorefining	1
Blue carbon	1
Business process modeling	1
Business-to-government	1
Cas9	1
Competence-based management	1
Coral reef organizations	1
Critical geography	1
Data governance	1
Deliberative democracy	1

l4_concept	count
Development geography	1
Ecological forecasting	1
Environmental design and planning	1
Exponential random graph models	1
Fisheries science	1
Food insecurity	1
Genome editing	1
Green chemistry	1
Groundwater recharge	1
Hydrogen vehicle	1
Influencer marketing	1
Jatropha	1
Legal pluralism	1
Malmquist index	1
Market capitalization	1
Measurement of biodiversity	1
Millennium Ecosystem Assessment	1
Natural capital	1
Network security policy	1
Non-coding RNA	1
Nucleic acid structure	1
Placemaking	1
Project charter	1
Psychometric testing	1
Regime change	1
Representative Concentration Pathways	1
Repressor	1
Requirement	1
Ribonucleoprotein	1
Ribosome	1
Scientific consensus	1
Seed dormancy	1
Separate spheres	1
Social movement theory	1
Solidarity economy	1
Sustainable land management	1
Transfer RNA	1

2.1.5.6 Level 5

```r
x <- lapply(
    flat_snow[["concepts"]],
    function(x) {
        x[["display_name"]][x[["level"]] == 5]
    }
) |>
    unlist() |>
    table() |>
    as.data.frame() |>
    rename(
        l5_concept = Var1,
        count = Freq
    ) |>
    arrange(desc(count))

writexl::write_xlsx(x, file.path(".", "data", "concepts_l5.xlsx"))

knitr::kable(x)
```

l5_concept	count
Pandemic	14
Business transformation	4
Complement (music)	2
Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)	2
Artifact-centric business process model	1
Critical security studies	1
Guide RNA	1
Operator (biology)	1
Project stakeholder	1
Pseudouridine	1
Public Sector Marketing	1
Requirements traceability	1
Ribosome biogenesis	1
Small nucleolar RNA	1
Stratification (seeds)	1
Time geography	1
Total human ecosystem	1