Data-Driven Approaches to Global Sustainable Development

(Economic, Social, and Environmental Aspects)

Research Project
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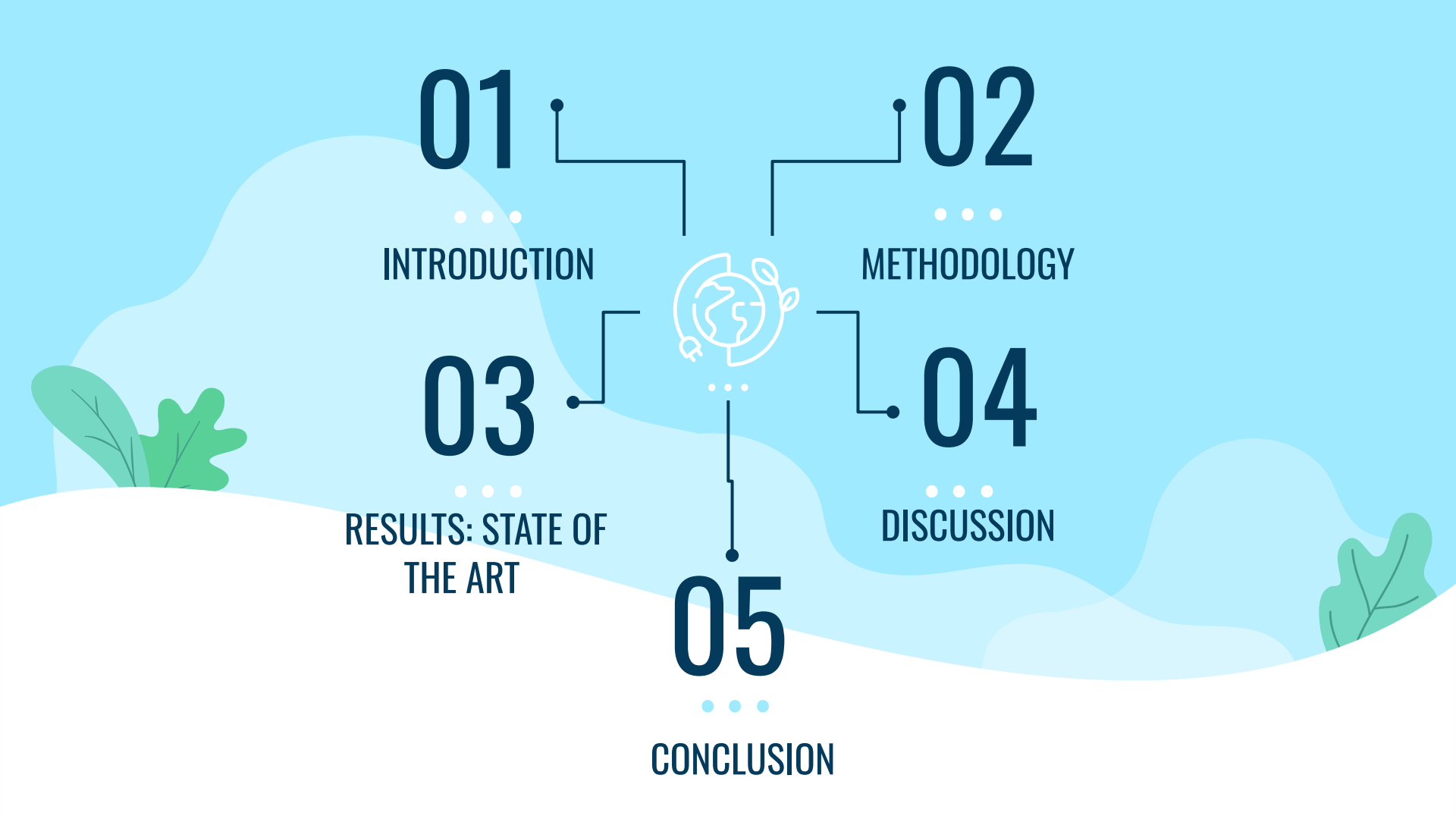
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INTRODUCTION

- The SDGs aim to drive action **on critical global issues**.
- SDG progress is monitored and shared through **annual reporting,** with a focus on goal interactions and SDG 17.
- SDGs are designed to be **integrated and indivisible,** ensuring a balanced approach that considers **economic, social, and environmental dimensions**

The Problem: SDG Interconnectedness

SDGs are **highly interconnected**

Synergy: When progress in one SDG **positively reinforces** another.

Trade-off: When progress in one SDG **negatively affects** another.

METHODOLOGY

ARTICLE COLLECTION

SEARCH STRATEGY

- **Keywords:**

"A systematic study of sustainable development goal (SDG) interactions"
"SDG trade-offs and synergies"
"Data-driven approaches to SDG measurement"

Google Scholar for initial broad coverage
Web of Science for selection and validation

FILTERING AND DATA SOURCE VALIDATION

- **Language Filter:** Only **English-language** publications
- **Time frame: 2016 onwards**
- **Data Source Validation:**Majority of sources are **peer-reviewed journal articles.**Books, policy reports, and conference papers were selectively included
- **Source Priority:Highly cited** studies were prioritized.Authors with **high H-index** were preferred.**Q1 & Q2 journals indexed in Web of Science** were preferred mostly.

PRISMA Flow Diagram

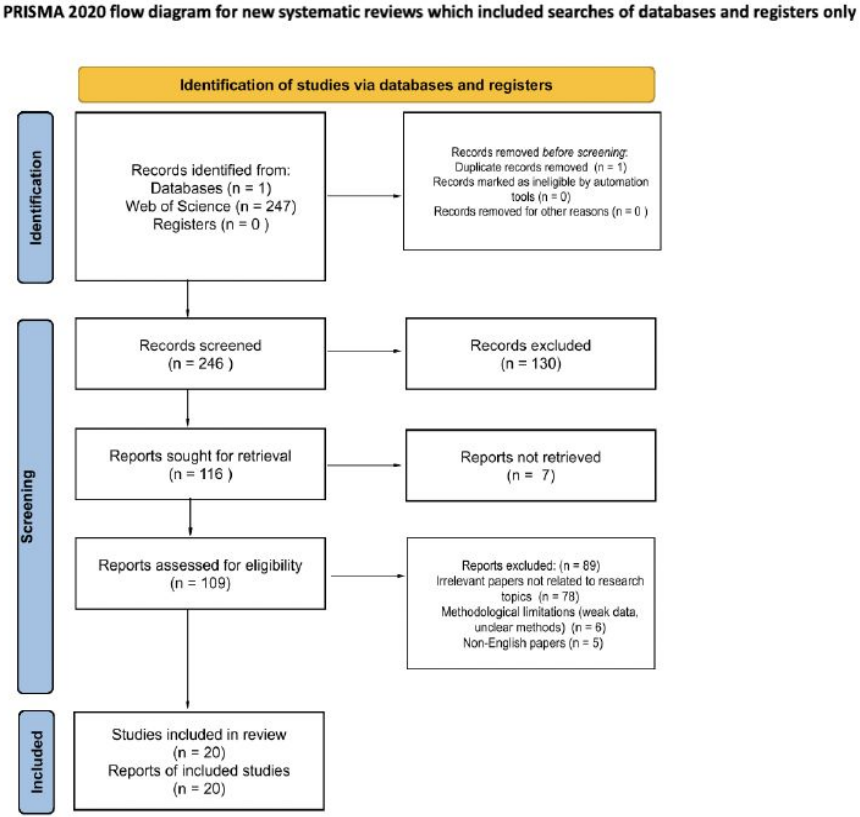

Figure 2.1: Systematic literature review and reporting - PRISMA Flow Diagram

METHODOLOGY

Systematic Review & PRISMA Approach

Text Preparation

- **Identification** – **247 records**, after applying keywords.
- **Screening** – After removing **1 duplicate**, **246 studies** were screened by title and abstract.Exclusion of **130 studies** unrelated to SDG interactions.
- **Eligibility** – From the remaining **116 studies**, **7 were inaccessible** due to institutional restrictions. From **109 full-text** studies, **89 studies** were excluded (**78 unrelated, 6 methodologically weak, and 5 non-English**).
- **Inclusion** – **20 high-quality studies** met all inclusion criteria.

STATE-OF-THE-ART

Synergies Across SDGs

Social & Economic Synergies: SDG 1 (No Poverty) & SDG 2 (Zero Hunger) → SDG 3 (Good Health) through improved nutrition & living conditions .

Clean Water & Renewable Energy: SDG 6 (Water) & SDG 7 (Energy) drive economic growth, public health, & sustainable development.

Urbanization & Innovation: SDG 11 (Sustainable Cities) & SDG 9 (Industry & Innovation) boost infrastructure, economic resilience, & green technology.

Trade-Offs

Economic Growth vs. Environmental Protection
Industrialization & economic growth (SDG 8 & 9) **increase emissions & resource consumption** (SDG 12 & 13).

Food Security vs. Ecosystem Sustainability
Expanding agriculture (SDG 2) **leads to water scarcity & deforestation** (SDG 6 & 15).

The role of integrated policy making

Align economic, social, and environmental goals to maximize synergies.

Mitigate trade-offs through sustainable resource management & circular economy.

Global partnerships (SDG 17) enable knowledge-sharing & policy alignment.

The diagram above illustrates the ***complex interdependencies between social, economic, and environmental SDGs*** *Luchian et al. (2025). It highlights the* ***reinforcing effects*** *among key goals such as poverty reduction (SDG 1), economic growth (SDG 8), and industrial innovation (SDG 9) while also visualizing the* ***potential conflicts,*** *such as those between climate action (SDG 13) and industrial expansion (SDG 9). Understanding these linkages is essential for designing integrated policies that balance sustainability priorities.*

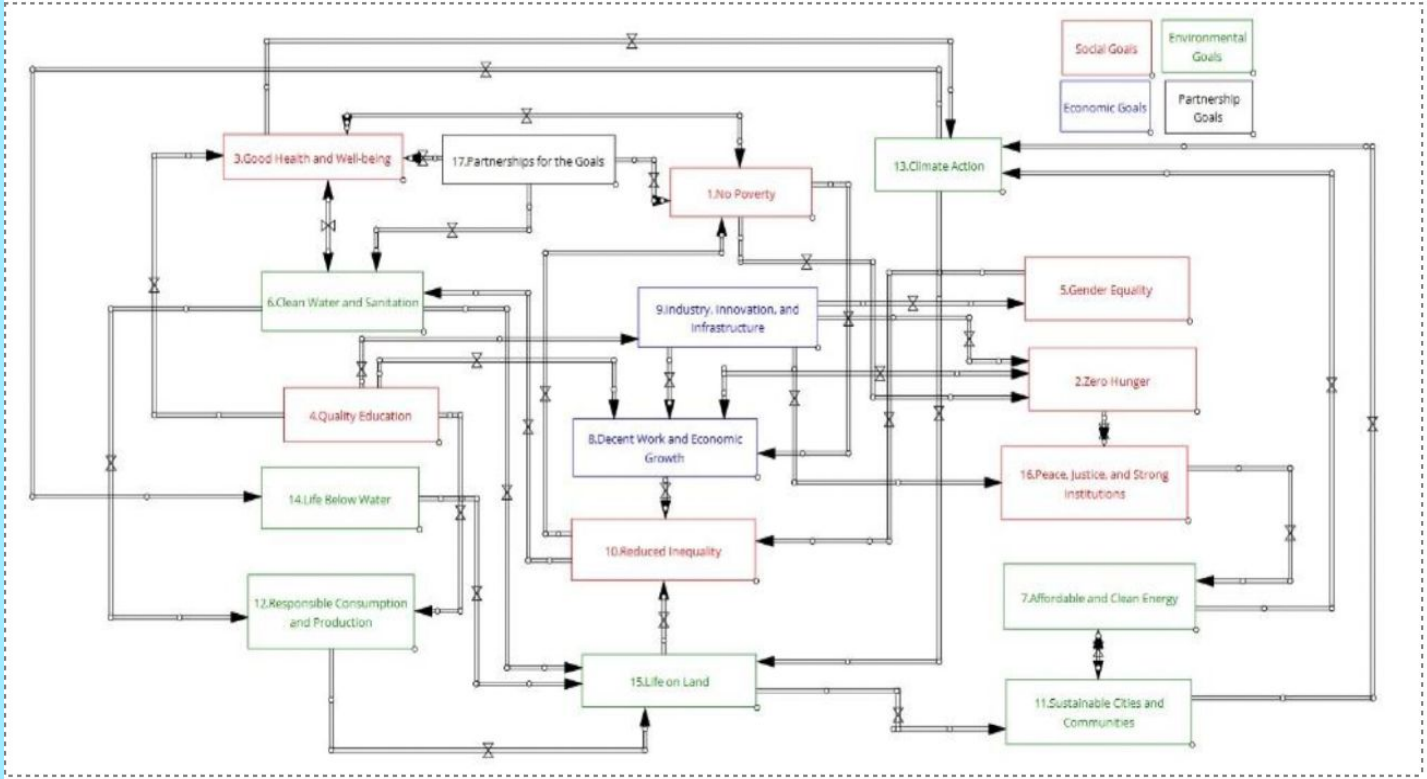

Figure 3.1: Stock-Flow Diagram Illustrating Interdependencies Among SDGs. Source: Luchian et al. (2025)

DISCUSSION

The Role of Data in SDG Implementation & Monitoring

- **High-quality & accessible data** is essential for informed decision-making.
- **Data gaps & outdated information** hinder accurate SDG tracking.
- **Integrating data analytics** improves sustainability assessment & policy decisions.

Challenges in SDG Data Collection & Availability

- **Only 19% of required data is available**, especially in low-income countries.
- **Data gaps & lack of standardization** make global SDG tracking difficult.

Methods Used in SDG Interconnection Analysis

As seen in the Figure 4.1, ***a comprehensive review of methods*** *used to analyze SDG interdependencies is provided with categorizing them into* ***argumentative, literature-based, linguistic, simulation, statistical, and other quantitative approaches*** *Horvath et al. (2022). The findings highlight that different methods serve distinct purposes—****argumentative models*** *like* ***causal loop diagrams*** *conceptualize systemic connections, while* ***simulation techniques*** *such as* ***agent-based modeling*** *enable dynamic scenario testing.* ***Statistical methods,*** *including* ***correlation analysis*** *and* ***regression models,*** *offer empirical insights but often struggle with causality Horvath et al. (2022).*

Categories and assigned methods to analyse SDG entity interactions.

Category	Method	Refs.
Argumentative	Bayesian belief network (BBN)	(Hall et al., 2018)
	Causal loop diagram (CLD)	(Zhang et al., 2016)
	Cross-impact matrix (CI matrix)	(Allen et al., 2019a; Dawes, 2020; Kumar et al., 2018; Weitz et al., 2018; Zaini and Akhtar, 2019; Zelinka and Amadei, 2017)
	Structured elicitation of expert information (Expert)	(Allen et al., 2019a; Bhaduri et al., 2016; Hall et al., 2018; Hazarika and Jandl, 2019; Jaramillo et al., 2019; Waage et al., 2015; Wieser et al., 2019)
	Nilsson scale (N Scale)	(Allen et al., 2019a; Fader et al., 2018; Fuso Nerini et al., 2019; Hall et al., 2017; Hazarika and Jandl, 2019; Jaramillo et al., 2019; McCollum et al., 2018; Nilsson et al., 2016; Singh et al., 2018; Weitz et al., 2018; Zelinka and Amadei, 2017)
Literature	Non-systematic literature review (Non-syst)	(Alcamo, 2019; Bringezu, 2018; Fisher et al., 2017; Haines et al., 2017; Hazarika and Jandl, 2019; Manandhar et al., 2018; Morton et al., 2017; Pandey and Kumar, 2018; Recuero Virto, 2018; Swamy et al., 2018; Wydra et al., 2019)
	Semi-systematic literature review (Semi-syst)	(Bangert et al., 2017; De Paiva Seröa Da Motta, 2019; Engström et al., 2018; Fuso Nerini et al., 2019, 2018; Hanjra et al., 2016; Hepp et al., 2019; Schroeder et al., 2019)
	Systematic literature review (Syst)	(Alcamo, 2019; Blicharska et al., 2019; Davide et al., 2019)
	Review of case studies (Case studies)	(Alcamo, 2019; Velis et al., 2017)
Linguistic	Keyword analysis (KWA)	(De Paiva Seröa Da Motta, 2019; Le Blanc, 2015; Nugent et al., 2018)
Simulation	Agent based modelling (ABM)	(Wang et al., 2019)
	Computable general equilibrium models (CGE)	(Banerjee et al., 2019; Campagnolo and Davide, 2019; Doelman et al., 2019; Lucas et al., 2019; Matsumoto et al., 2019; Schütze et al., 2017)
	Energy system models (ESM)	(Engström et al., 2019; Vandyck et al., 2018)
	Integrated assessment models (IAM)	(Doelman et al., 2019; Fujimori et al., 2019; Gao and Bryan, 2017; Heck et al., 2018; Hutton et al., 2018; Lucas et al., 2019; Matsumoto et al., 2019; Obersteiner et al., 2016; Rao et al., 2016; von Stechow et al., 2016; Zhang et al., 2019)
	System dynamics modelling (SD)	(Allen et al., 2019b; Collste et al., 2017; Dawes, 2020; Pedercini et al., 2019, 2018; Spaiser et al., 2017)
Other quantitative	Accounting framework (Account)	(Engström et al., 2018)
	Network analysis (NWA)	(Allen et al., 2019a; Dörgő et al., 2018; Feng et al., 2019; Jaramillo et al., 2019; Jiménez-Aceituno et al., 2020; Kunčič, 2019; Le Blanc, 2015; Lim et al., 2018; Lusseau and Mancini, 2019; Mainali et al., 2018; McGowan et al., 2019; Nugent et al., 2018; Sebestyén et al., 2019a, 2019b; Weitz et al., 2018; Zelinka and Amadei, 2017)
	Environmentally-extended multi-regional input-output models (IO)	(Hubacek et al., 2017; Scherer et al., 2018)
Statistical	Advanced sustainability analysis (ASA)	(Mainali et al., 2018)
	Autoregressive distributive lag bounds test (ARDL)	(Ngarava et al., 2019)
	Correlation analysis (Corr)	(Brecha, 2019; Donaires et al., 2019; Kroll et al., 2019; Mainali et al., 2018; Ngarava et al., 2019; Pradhan et al., 2017; Sebestyén et al., 2019a, 2019b)
	Cox proportional hazards models (CPH)	(Akinyemi et al., 2018)
	Descriptive statistics (Descr)	(Howden-Chapman et al., 2020)
	Generalised method of moments (GMM)	(Matthew et al., 2019; Shahbaz et al., 2019)
	Joint correspondence analysis (JCA)	(Ulman et al., 2018)
	Linear mixed effect models (LMM)	(Lusseau and Mancini, 2019)
	Pairwise granger causality test (PGC)	(Ngarava et al., 2019)
	Principal component analysis and Factor analysis (PCA&FA)	(Donaires et al., 2019; Feng et al., 2019; Sen and Ongsakul, 2018; Spaiser et al., 2017)
	Quantile regression, bootstrapped (Q Reg)	(Sinha et al., 2020)
	Regression analysis (Reg)	(Buonocore et al., 2019; Cluver et al., 2016; Hall et al., 2017; Malerba, 2019; Obersteiner et al., 2016; Ramos et al., 2018; Ulman et al., 2018)

Figure 4.1: Source: Horvath et al. (2022)

CONCLUSION

Data-Driven Approach

Needed to integrate various data sources and need this approach to handle data quality issues

Future Research Directions

System dynamic approach, proxy indicator, stock flow diagram will be used.

Utilizing Large-Scale Databases

- *Industrial Ecology Data Commons (IEDC)*
- *GDELT (Global Database of Events, Language, and Tone)*

Balancing Synergies & Trade-Offs

Integrating **economic, environmental, and social factors** for sustainable SDG progress.

Thank you for listening!

Do you have any questions?