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**Dipartimento di Scienze Aziendali-
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Corso di Dottorato di Ricerca in
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Developing an Innovative Blockchain-Based Model to Contribute to the Implementation of the 2030 Agenda in Italy

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« A scientist is a person who, from his studies and experiences, makes conjectures and analogies that have permanent and fixed relations in terms of techniques (sensory events).»

(Andre Morova)

« If the facts are not in line with theories, change the facts.»

(Einstein)

Chapter 1
Introduction

1.1 Abstract

One of the most crucial collective efforts in history for improving the lives of billions of people is Sustainable Development Goals (SDGs). The aim of the seventeen (SDGs) s included in the 2030 agenda represents the global action plan of the United Nations to eradicate poverty, protect the planet, and make certain prosperity for all. Although it has been five years since the adoption of the 2030 Agenda, the assessment of the implementation of the SDGs in Italy demonstrates that, overall, Italian cities have achieved 53% of the implementation of the SDGs from 100 percent full achievement. In many situations, the investigation verifies the gap between the country's north and south. Given that the use of the transformational power of blockchain to achieve the SDGs looks promising, the goal of this study is to explore how blockchain may improve the implementation of the 2030 Agenda in Italy. In this regard, we proposed an innovative Ethereum Blockchain platform for improved implementation of the SDGs. The framework of the platform includes three basic modules (data module, sustainability module, and governance module) derived from the novel ICT framework to implement the 2030 Agenda by Kostoska and Kocarev in 2019. Based on the layers of the Saunders research onion (Saunders et al., 2009), the type of researcher's view in this research is the interpretive view of phenomena. In this research, a qualitative approach and the strategy of the systematic literature review and thematic analysis have been

adopted. For collecting and analyzing research data, the semi-structured interview method has been used. The statistical population of this research is in the stage of systematic literature review, studies from 2015 to 2020 in the field of blockchain and its applications according to the seven stages of a systematic review of Scaringella & Radziwon (2018), and in the field of content analysis, the statistical community consists of experts and university professors, and administrators who have a background of study or implementation in the field of understanding blockchain theories and models and their applications, especially in the field of sustainability. In the thematic analysis stage, relying on the purposeful snowball sampling method, finally, eight of the mentioned experts have been selected and interviewed. After studying the reviewed articles, first, all the applications of blockchain obtained in the articles have been extracted according to the three modules of data, governance, and sustainability by textual content analysis method and relying on the researcher's knowledge of the mentioned applications. In this research, the six-step method of Braun & Clarke (2006) has been used for the thematic analysis method, and after extracting the basic, organizer, and global themes from the interviews the thematic network has been drawn, and the results from the thematic analysis have been Integrated with the systematic literature review results. The final set of the blockchain use cases proposed in this research for the improved implementation of the three modules (data, sustainability, and governance) could be written in Solidity language on the Ethereum blockchain. and in accordance with the development challenges in the Italian cities to be customized and implemented through smart contracts. The originality of the dissertation consists of developing an innovative Ethereum

blockchain platform to adopt the potential of blockchain technology to implement the 2030 Agenda considering existing discussions in governance science, sustainability science, and data science. Consequentially, due to its comprehensive and structured nature, superior to existing approaches. The dissertation findings offer insights to the policymakers and authorities at the regional and national levels on how to implement the 2030 Agenda through blockchain-based innovative solutions in Italy to reduce territorial inequalities between places in Italy. and provides support knowledge to define Italy's sustainable development strategy towards achieving the 2030 Agenda in Italy.

Keywords: The 2030 Agenda, Blockchain Technology, Sustainable Development Goals, Italy

1.2 Introduction

The 2030 Agenda for Sustainable Development was adopted by the United Nations General Assembly in September 2015, outlining guidelines for international activities over the next 15 years. The 2030 Agenda lays out seventeen Sustainable Development Goals (SDGs) that discuss the economic, social, and environmental pillars of development, with the goal of achieving a sustainable future by 2030 that balances equitable prosperity within global boundaries. The Sustainable Development Goals (SDGs) are the world's largest collective initiative, creating quantitative goals and targets to guide evidence-based policies and improve the health of individuals and communities (Courtney et al, 2016). The Sustainable Development Goals (SDGs) are a set of objectives that aim to put the universe on a road toward a more prosperous, inclusive, and environmentally sustainable future. Growing worries about environmental and climate change, as well as poverty and inequality, have pushed sustainable development into the forefront in recent years. While sustainable development is vital for humanity's future, assessing and managing sustainability has become a major challenge for our civilization (Kostoska and Kocarev, 2019). To ensure that the SDGs are achieved, the heads of governments ask that the UN Secretary- General continue to involve the stakeholders to generate new solutions and put in the light the best experiences in the promotion of SDGs (AsviS, 2019). As Chaturvedi et al. (2019) point out, science, technology, and innovation (STI) play a critical role in providing innovative solutions to address sustainability concerns. Meanwhile, digitalization is widely accepted as a necessary component of accomplishing long-term development goals. The United Nations' Broadband for Sustainable Development initiative has highlighted the critical role that information and communication technology (ICT) can play in delivering integrated, creative, and cross-sectoral sustainable development outcomes (Kostoska and Kocarev, 2019). Emerging opportunities including the adoption of blockchain technology and other digital technologies can make a positive impact to meet the SDGs challenges. However, as stated by Chaturvedi et al. in 2019, there is a need to assess how emerging applications including the adoption of blockchain technology can be synergized with the SDGs. Blockchain technology, as a breakthrough technology, will usher in the next generation of (ICT) (Kogure, 2017), and blockchain growth seems to be a feasible accelerator for reaching global sustainable development goals (Kewell, 2017). The belief is that the field of information and communication technologies for development (ICT4D) can help people all around the world progress and improve their lives. Medaglia and Damsgaard (2020) investigated the Sustainable Development Goals and their great traction in the revitalized global discourse on sustainability, claiming that digital technologies play a significant role. Digital technologies are considered as enablers of social inclusion, equity, and sustainability. However, more research is needed on how digital innovations will affect humanity's future in the coming decades, and there is a pressing necessity to combine interdisciplinary studies on digital economy and sustainable development to address existing research gaps and examine how digital alternatives can navigate sustainability challenges (A. Schulz et al, 2020).

1.3 Research Problem Statement

In Italy, while five years have passed since the signing of the 2030 Agenda, although Italy much has been done in these years nevertheless, much remains to be done (SDSN Italia, 2019). Based on the updated of composite indicators relating to the 17 sustainable development goals (SDGs) between 2018 and 2019, published by the Italy National Statistics Institute (ISTAT) Italy showed: - A significant improvement for six Goals: poverty; sustainable food, and agriculture; energy system; innovation; sustainable models of production and consumption; quality of governance, peace, justice, and solid institutions. - A slight advance for five other Goals: health; inequalities; city conditions; fight against climate change; conditions of marine ecosystems. - A slight deterioration in education and economic and employment conditions. - A significant deterioration for four objectives: gender equality; water and sanitation; conditions of terrestrial ecosystems; international cooperation. There are concerning delays and a lack of a clear implementation strategy for the 2030 Agenda in Italy; however, there are encouraging signs, such as the new government's commitment to include the principle of sustainable development in the Constitution, to establish an Urban Agenda for Sustainable Development, and to guide policies in favor of the green economy, circular economy. The SDGs city score from SDSN Italia shows that, on average, Italian cities have achieved 53% of the international targets for the SDGs by establishing 100% full achievement of the international targets. According to the report, none of the 101 cities studied had achieved more than 80% of the overall SDG accomplishment (SDSN Italia, 2018). In 2019, Farnia and colleagues1 created the Italian Cities Sustainable Development Goals (SDGs) Composite Index as a methodological approach to measuring Agenda 2030 at an urban level in Italy, and Italian cities were rated for each of the SDGs based on these indices (SDGs). The findings support the divide between the country's north and south in many situations, but they also show that a city might perform admirably in certain Goals while falling short in others. Individual ranks show a significant degree of variety, implying a high degree of heterogeneity among Italian municipalities. These findings could be valuable in Italy for policymakers and sustainable development authorities at the local level (Farnia et al, 2019).

Figure.1- Italian cities have achieved an overall, 53 percent of the implementation of the SDGs from 100 percent full achievement (The SDSN Italia SDGs city index)

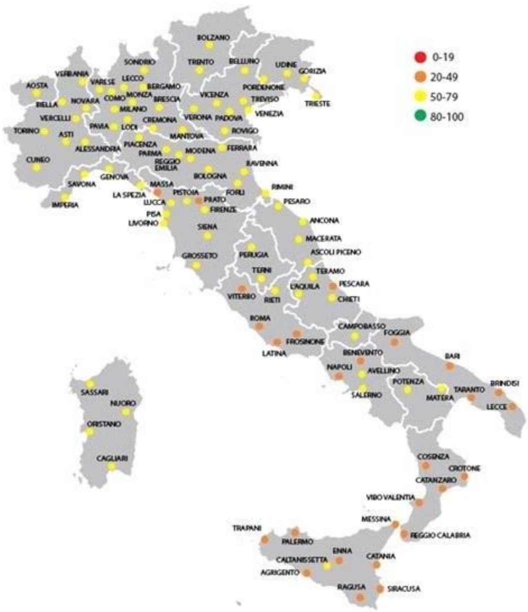


Table.1- List of indicators considered (Farnia et al, 2019)

Indicator	Source	Year	SDGs	Polarity
Elderly people dependence index	ISTAT	2017	1	negative
Economic distress	MEF	2013	1	negative
Individuals in low-working intensity families	ISTAT	2011	1	negative
Urban bio gardens	URBES	2013	2	positive
Obesity rate	ISS	2016	2	negative
Healthy life expectancy at birth	ISTAT	2016	3	positive
Healthy life expectancy at 65 years	ISTAT	2016	3	positive
Deaths and injuries in road accidents	ISTAT	2016	3	negative
Support to elderly people	ISTAT	2015	3	positive
Suicide rate	URBES	2011	3	negative
Infant mortality rate	URBES	2011	3	negative
Nursery services for children aged 0–36	ISTAT	2013	4	positive
Student literary competence	URBES	2013/14	4	positive
Student numerical competence	URBES	2013/14	4	positive
People with university degree	ISTAT	2011	4	positive
Population with low school license (isced 3)	ISTAT	2011	4	positive
Enrolled population at school aged 0–16	ISTAT	2011	4	positive
Schools with ramps for people with disabilities	URBES	2013	4	positive
School with technologies	MIUR	2015	4	positive

Table. 2- Fifteen municipalities with the maximum and minimum achievement (Sustainability Index to Goal 5) (Farnia et al, 2019)

Municipality	S.I.	Municipality	Goal_1	Municipality	Goal_2	Municipality	Goal_3	Municipality	Goal_4	Municipality	Goal_5
Trento	2.30	Bolzano	1.83	Torino	5.61	Terni	1.91	Cremona	1.96	Roma	2.46
Cremona	1.51	Treviso	1.64	Parma	1.93	Treviso	1.89	Padova	1.85	Lodi	2.16
Bolzano	1.43	Pavia	1.27	Ferrara	1.43	Mantova	1.57	Trento	1.59	Torino	2.12
Padova	1.42	Rieti	1.16	Ravenna	1.18	Rimini	1.51	Udine	1.53	Ancona	2.06
Lodi	1.39	Padova	1.15	Pordenone	0.95	Forli'	1.49	Rovigo	1.51	Piacenza	1.87
Macerata	1.37	Brescia	1.15	Bologna	0.94	Siena	1.38	Bologna	1.44	Savona	1.76
Verbania	1.23	Trieste	1.14	Trento	0.91	Pordenone	1.38	Belluno	1.39	Vercelli	1.70
Forli'	1.21	Varese	1.13	Cremona	0.90	Perugia	1.37	Sondrio	1.35	Verbania	1.64
Mantova	1.18	Cremona	1.13	Belluno	0.90	Sondrio	1.29	Parma	1.33	Bologna	1.50
Verona	1.12	Lodi	1.05	Bolzano	0.87	Trento	1.23	Ancona	1.21	Alessandria	1.48
Ferrara	1.11	Firenze	1.05	Como	0.86	Macerata	1.23	Bergamo	1.20	Pavia	1.47
Bologna	1.10	Novara	0.99	Padova	0.85	Pistoia	1.23	Forli'	1.16	Pisa	1.35
Modena	1.02	Modena	0.98	Modena	0.83	Teramo	1.22	Pavia	1.15	Siena	1.17
Parma	0.99	Matera	0.96	Sondrio	0.82	Campobasso	1.20	Gorizia	1.11	Milano	1.06
Siena	0.93	Siena	0.95	Lecco	0.81	Pesaro	1.16	Macerata	1.11	Firenze	0.92
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
Catanzaro	−0.87	Alessandria	−0.99	Trapani	−0.97	Cremona	−0.91	Torino	−1.01	Messina	−0.97
Massa	−1.08	Lecce	−0.99	Agrigento	−0.97	Alessandria	−0.99	Caltanissetta	−1.13	Massa	−1.00
Brindisi	−1.12	Roma	−0.99	Messina	−0.97	Milano	−1.20	Brindisi	−1.18	Bari	−1.09
Caltanissetta	−1.15	Cosenza	−1.08	Matera	−0.98	Genova	−1.25	Alessandria	−1.18	Ragusa	−1.15
Frosinone	−1.32	Taranto	−1.19	Potenza	−0.98	Palermo	−1.35	Prato	−1.21	Enna	−1.23
Taranto	−1.33	Vibo valentia	−1.19	Campobasso	−1.41	Enna	−1.41	Massa	−1.30	Agrigento	−1.49
Benevento	−1.34	Crotone	−1.20	Reggio di Calabria	−1.52	Catania	−1.49	Agrigento	−1.44	Taranto	−1.56
Agrigento	−1.51	Frosinone	−1.21	Catanzaro	−1.52	Messina	−1.55	Oristano	−1.44	Caltanissetta	−1.72
Vibo valentia	−1.56	Catania	−1.34	Cosenza	−1.52	Agrigento	−1.59	Taranto	−1.47	Palermo	−1.73
Palermo	−1.57	Sondrio	−1.51	Vibo valentia	−1.52	Pavia	−1.63	Trapani	−1.61	Catania	−1.80
Crotone	−2.14	Trapani	−1.60	Crotone	−1.52	Massa	−1.68	Messina	−1.70	Brindisi	−1.88
Messina	−2.19	Napoli	−1.69	Napoli	−1.75	Caltanissetta	−1.84	Crotone	−2.05	Foggia	−2.01
Trapani	−2.38	Palermo	−1.77	Salerno	−1.77	Roma	−2.20	Catania	−2.09	Napoli	−2.05
Napoli	−2.44	Agrigento	−4.01	Avellino	−1.77	Napoli	−2.87	Palermo	−2.47	Crotone	−2.06
Catania	−2.54	Messina	−4.55	Benevento	−1.77	Trapani	−3.12	Napoli	−2.91	Trapani	−2.10

Figure. 2- Sustainability Index: Map visualization of the municipality's achievements on Goals 1 through Goal 5 (Farnia et al, 2019)

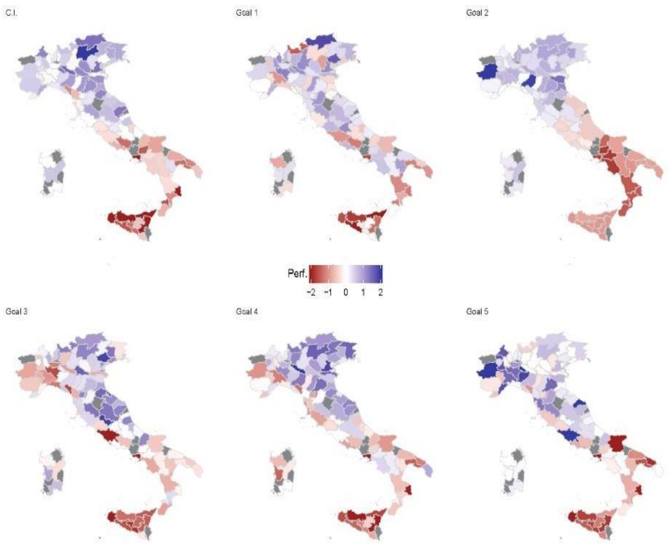


Table. 3- Fifteen municipalities with the maximum and minimum achievement (Goal 6 to Goal 11) (Farnia et al, 2019)

Municipality	Goal_6	Municipality	Goal_7	Municipality	Goal_8	Municipality	Goal_9	Municipality	Goal_10	Municipality	Goal_11
Mantova	1.07	Padova	3.96	Milano	1.80	Milano	2.78	Vercelli	1.63	Bolzano	2.07
Milano	1.02	Macerata	3.66	Pavia	1.65	Trieste	2.19	La Spezia	1.60	Oristano	2.03
Sondrio	1.01	Pesaro	3.56	Siena	1.64	Venezia	1.94	Pistoia	1.59	Verbania	1.73
Livorno	0.93	Verona	3.32	Padova	1.52	Treviso	1.58	Rieti	1.48	Pesaro	1.51
Torino	0.92	Oristano	2.27	Bergamo	1.47	Siena	1.57	Alessandria	1.48	Ravenna	1.44
Vercelli	0.92	Cosenza	2.16	Belluno	1.44	Cremona	1.52	Forli'	1.46	Sondrio	1.41
Teramo	0.91	Lodi	1.95	Treviso	1.20	Bologna	1.47	Terni	1.35	Ferrara	1.31
Genova	0.91	Pordenone	1.52	Trento	1.18	Genova	1.24	Ravenna	1.34	Mantova	1.30
Lecco	0.89	Trento	1.47	Parma	1.11	Trento	1.23	Nuoro	1.33	Lecce	1.19
Cremona	0.86	Como	1.02	Bologna	1.09	Parma	1.23	Asti	1.28	Forli'	1.17
Foggia	0.85	Cremona	0.92	L'Aquila	1.07	Brescia	1.19	Taranto	1.28	Cremona	1.02
Varese	0.84	Bergamo	0.84	Varese	1.03	Mantova	1.19	Savona	1.22	Modena	1.00
Piacenza	0.82	Vicenza	0.82	Bolzano	1.02	Bergamo	1.06	Rovigo	1.21	Pistoia	0.99
Trento	0.81	Verbania	0.79	Lodi	0.98	Ancona	1.05	Livorno	1.20	Matera	0.89
Modena	0.81	Biella	0.73	Lecco	0.90	Firenze	1.00	Massa	1.18	Sassari	0.87
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
Taranto	−0.57	Vibo valentia	−0.70	Ragusa	−0.96	Macerata	−1.08	Firenze	−1.00	Asti	−1.06
Rieti	−0.62	Reggio di Calabria	−0.72	Cosenza	−0.99	Teramo	−1.08	Pescara	−1.01	Biella	−1.07
Verona	−0.79	Campobasso	−0.72	Bari	−0.99	Grosseto	−1.08	Cagliari	−1.12	Vibo valentia	−1.09
Frosinone	−0.86	Napoli	−0.75	Agrigento	−1.02	Rovigo	−1.10	Catania	−1.13	Rovigo	−1.19
Campobasso	−1.06	Trieste	−0.75	Sassari	−1.04	Biella	−1.13	Palermo	−1.17	Varese	−1.19
Potenza	−1.15	Rovigo	−0.76	Foggia	−1.47	Salerno	−1.14	Como	−1.24	Benevento	−1.28
Pistoia	−1.17	Torino	−0.77	Caltanissetta	−1.59	Nuoro	−1.17	Varese	−1.27	Lucca	−1.33
Catanzaro	−1.26	Nuoro	−0.77	Brindisi	−1.70	Massa	−1.20	Brescia	−1.34	Terni	−1.35
Palermo	−1.47	Viterbo	−0.78	Messina	−1.80	Ragusa	−1.38	Treviso	−1.62	Como	−1.46
Lucca	−1.68	Varese	−0.78	Taranto	−1.86	Frosinone	−1.60	Padova	−1.79	Napoli	−1.85
Venezia	−1.93	Latina	−0.79	Crotone	−1.95	Caltanissetta	−1.74	Lecce	−1.82	Milano	−2.05
Pordenone	−1.95	Palermo	−0.80	Trapani	−2.41	Crotone	−1.81	Napoli	−1.82	Lecco	−2.44
Benevento	−3.02	Lucca	−0.81	Palermo	−2.52	Trapani	−1.87	Roma	−2.15	Torino	−2.64
Treviso	−4.20	Enna	−0.83	Napoli	−2.87	Enna	−1.87	Bergamo	−2.49	Reggio nell'Emilia	−2.66
Catania	−4.85	Taranto	−0.83	Catania	−3.15	Vibo valentia	−1.89	Milano	−3.93	Messina	−3.07

Figure. 3 - Sustainability Index: Map visualization of the municipality's achievements on Goal 6 through Goal 11 (Farnia et al, 2019)

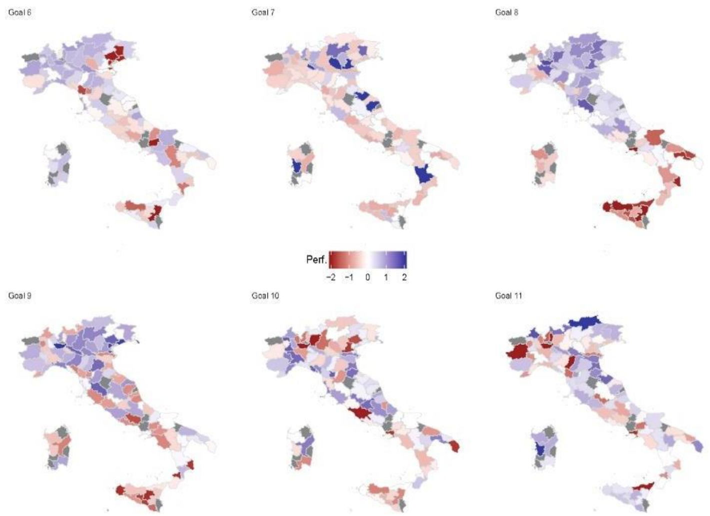


Table. 4- Fifteen municipalities with the maximum and minimum achievement (Goal 12 to Goal 17) (Farnia et al, 2019)

Iunicipality	Goal_12	Municipality	Goal_13	Municipality	Goal_15	Municipality	Goal_16	Municipality	Goal_17
Belluno	1.68	Venezia	4.33	Matera	5.04	Enna	3.05	Roma	2.67
Treviso	1.68	Milano	3.75	Nuoro	1.76	Ferrara	2.45	Firenze	2.35
Trento	1.53	Roma	2.17	Trento	1.70	Prato	1.70	Padova	2.26
Novara	1.42	Bologna	2.00	Potenza	1.68	Ravenna	1.54	Modena	2.10
Pordenone	1.35	Trieste	2.00	Oristano	1.66	Livorno	1.42	Bolzano	2.02
Nuoro	1.31	Siena	1.48	Sondrio	1.60	Trento	1.38	Venezia	1.94
Macerata	1.28	Firenze	1.45	Enna	1.24	Rimini	1.37	Trento	1.89
Lodi	1.26	Brescia	1.42	Sassari	1.24	Pescara	1.36	Siena	1.89
Teramo	1.22	Genova	1.39	Ragusa	1.08	Mantova	1.21	Potenza	1.12
Chieti	1.21	Torino	1.35	Verbania	1.02	Cuneo	1.20	Cagliari	1.10
Mantova	1.18	Cagliari	1.34	Caltanissetta	0.94	Verona	1.17	Udine	1.03
Benevento	1.15	Trento	1.21	Cuneo	0.86	Verbania	1.13	Salerno	0.96
Gorizia	1.09	Parma	1.06	Cagliari	0.85	Bolzano	1.13	Cremona	0.94
Asti	1.07	Rimini	0.90	Agrigento	0.80	Milano	1.11	Milano	0.93
Cuneo	1.07	Verona	0.89	Gorizia	0.74	Torino	1.10	Como	0.88
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
Potenza	−0.99	Sondrio	−0.76	Cosenza	−0.79	Ragusa	−1.01	Frosinone	−0.96
Avellino	−1.17	Lucca	−0.76	Verona	−0.81	Foggia	−1.03	Vercelli	−0.99
Brindisi	−1.32	Massa	−0.80	Parma	−1.04	Bari	−1.13	Ragusa	−1.10
Massa	−1.32	Lecco	−0.82	Modena	−1.06	Brindisi	−1.13	Brindisi	−1.24
Foggia	−1.44	Nuoro	−0.85	Udine	−1.08	Catanzaro	−1.21	Imperia	−1.33
ibo valentia	−1.45	Catanzaro	−0.89	Brescia	−1.31	Taranto	−1.22	Enna	−1.37
Grosseto	−1.48	Taranto	−0.99	Roma	−1.35	Cagliari	−1.31	Catania	−1.39
Brescia	−1.54	Vercelli	−1.07	Napoli	−1.41	Napoli	−1.32	Catanzaro	−1.51
Cagliari	−1.61	Benevento	−1.08	Bari	−1.43	Trapani	−1.39	Massa	−1.54
Crotone	−1.70	Oristano	−1.16	Bologna	−1.71	Agrigento	−1.62	Vibo valentia	−1.58
Siena	−1.73	Lodi	−1.19	Torino	−1.78	Reggio di Calabria	−1.63	Agrigento	−1.88
Pisa	−2.03	Rovigo	−1.31	Pescara	−1.81	Matera	−1.79	Taranto	−1.97
Trapani	−2.09	Gorizia	−1.36	Firenze	−2.03	Cosenza	−1.79	Crotone	−2.00
Catania	−2.57	L'Aquila	−1.64	Milano	−2.38	Oristano	−2.21	Trapani	−2.34

Figure. 4- Sustainability Index: Map visualization of the municipality's achievements on goals 12 through 17 (Farnia et al, 2019)

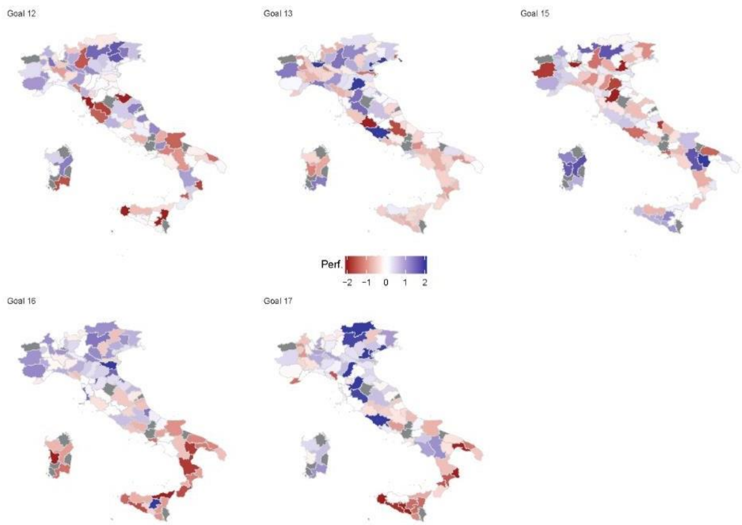
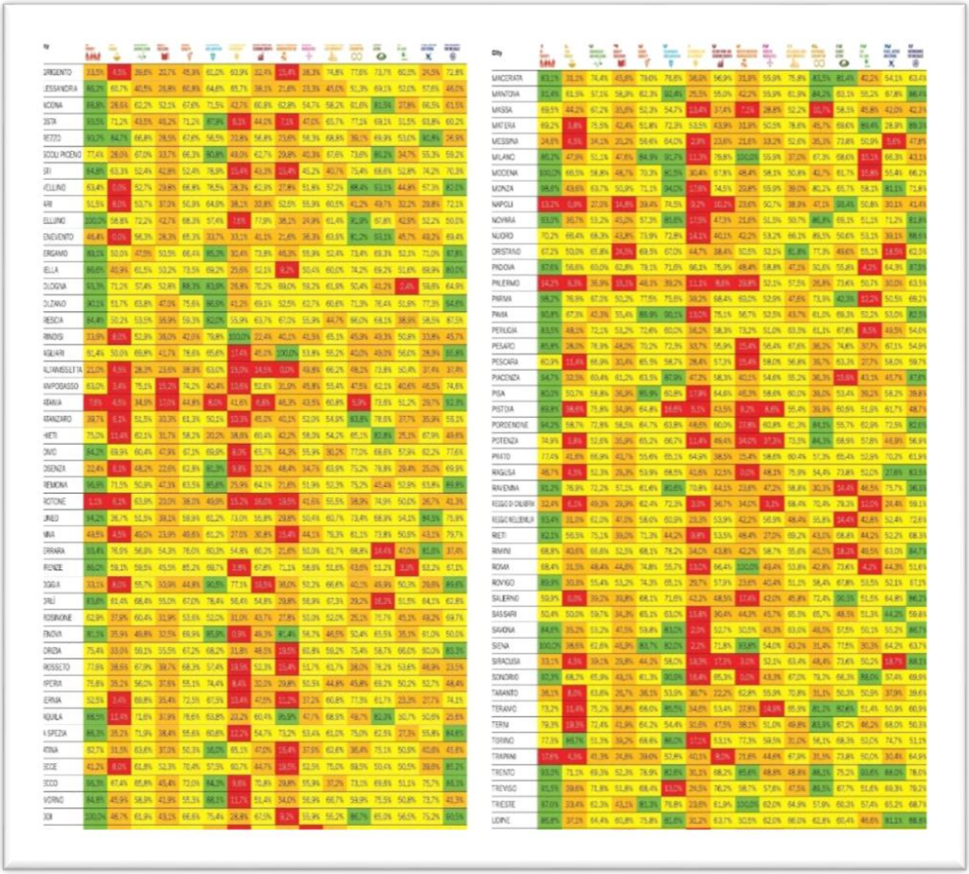


Figure. 5- SDSN Italia SDGs City Index (percentages of achievement of the SDGs)



1.4 Research Contributions to Meet the Problems

Despite the support and assistance of international organizations, the UN Resolution specifies that the effective completion of the SGD is a national responsibility. Because each country faces a unique set of issues, mapping SDGs based on local needs is necessary (Katramiz et al.2020). In the corporate sector, academia, and under the auspices of the United Nations (UN), novel stakeholder alliances and organizations with a particular emphasis on blockchain technologies are forming. The UN, for example, is constantly working to establish blockchain's aptitude for attaining SDGs like identity verification and wealth creation (Medaglia and Damsgaard, 2020). The European Union Blockchain Forum, Stanford University's, Massachusetts Institute of technologies, and Oxford Internet Institute's research centers, as well as the UN'Climate Chain Coalition' are all examples (CCC) (A. Schulz et al, 2020). In addition, the European Union committed to increasing qualification and experience in digital technologies such as the Internet of Things, cyber-security, and blockchain through its Action Plan by focusing on a series of initiatives targeted at enhancing the impact of digital technologies in Europe's long-term growth (Cioacă et al 2020).

In the drafting of the national strategy for blockchain and distributed ledgers proposed by the Ministry of Economic Development of Italy, has been emphasized to use the technology to facilitate the transition to circular economy models in line with the 2030 Agenda for sustainable development (Ministry of Economic Development, 2020). Given that the use of the transformational power of blockchain to achieving the SDGs looks promising, this research aims to explore the contribution of blockchain to improved implementation of the 2030 Agenda in Italy. In this regard, we proposed an innovative Ethereum Blockchain platform for improved implementation of the SDGs. The framework of the platform includes three basic modules (data module, sustainability module, and governance module) derived from the novel ICT framework to implement the 2030 Agenda by Kostoska and Kocarev in 2019.

In this study, due to the adoption of a comprehensive approach to "Developing an innovative platform based on the Ethereum Blockchain to implement the 2030 agenda in Italy", it is necessary to try to understand how to explain the phenomenon in the real context. Based on the layers of the research onion (Saunders et al., 2009), the type of researcher's view in this research is the interpretive view of phenomena. Since the results of this research are based on a developed model, located in the world, and used for the case study of the research, so this research is developmental research. In this research, a qualitative approach has been used. the researcher has used the field study and library method for each stage of theoretical studies and text analysis. The strategy adopted in this research has been a systematic review and theme analysis. and the researcher has used exploration and understanding in this research. For collecting and analyzing research data, in this study, the semi-structured interview method has been used. The statistical population of this research is in the stage of systematic literature review, studies from 2015 to 2020 in the field of blockchain and its applications according to the seven stages of a systematic review of Scaringella & Radziwon (2018), and in the field of content analysis, the statistical community consists of experts and university professors, and administrators who have a history of study or implementation in the field of understanding blockchain theories and models and their applications, especially in the field of sustainability. In the thematic analysis stage, the purposive sampling method is used to select the sample. Relying on the purposeful snowball sampling method, finally, eight of the mentioned experts have been selected and interviewed. After studying the reviewed articles, first, all the applications of blockchain obtained in the articles have been extracted according to the three modules of data, governance, and sustainability by textual content analysis method and relying on the researcher's knowledge of the mentioned applications. and has been organized as extracted codes from the articles reviewed. In this research, the six-step method of Braun & Clarke (2006) has been used for the thematic analysis method, and after extracting the basic, organizer, and global themes from the interviews the thematic network has been drawn, and the results from the thematic analysis have been Integrated with the systematic literature review results. The final set of the blockchain use cases proposed in this research for the improved implementation of the three modules (data, sustainability, and governance) could be written in Solidity language and customized in accordance with the development challenges in the Italian cities, by the developers, and through the smart contracts could be implemented on the Ethereum blockchain.

Since the uniqueness of issues in every country demands mapping SDGs based on regional requirements (Katramiz et al, 2020), as well as every municipality will need to adjust SDGs and implementation strategies to their circumstance, (Kanuri et al, 2016), We propose that for providing the inputs data for the proposed platform will be used from the full variety of local stakeholders. In this regard, Kanuri et al. (2016) have identified key stakeholder groups in urban and local development and their potential roles in SDG implementation, which includes Local Authorities, National and regional governments, Parliamentarians, Non-governmental organizations, and civil society groups (NGOs and CSOs), Businesses and Industry, Universities, Professionals, Faith-based institutions, financial institutions, international organizations, and City networks. All the integrative interactions among the three modules and various stakeholders within the proposed platform develop through the processes of the Ethereum blockchain, smart contracts, and consensus protocol. In this regard, the Ethereum blockchain could be a powerful lever to bring together the stakeholders involved in achieving the 2030 Agenda at the local level. Blockchain can be updated through consensus protocol. The consensus is indeed a method used by members of a network to reach an agreement. As the most important concept of blockchain, the distributed consensus process, has been used in our proposed platform to create integrity among all the stakeholders. The stakeholder groups could share data pertaining to the interests of any SDG project across our proposed platform, and through a consensus protocol make decisions. Hence, SDGs' priorities for implementation determine based on local community values and needs and key stakeholders contribute to influence and shape decisions. The accurate use of the consensus feature of blockchain in the proposed platform helps stakeholders to reach an agreement through Ethereum Consensus Algorithm. Ethereum is the representative second-generation blockchain platform, and is an implementation of blockchain, and is an open-source, public, and decentralized computing platform. With Ethereum, writing complex smart contracts and utilizing the blockchain use cases becomes easy. Different programming languages can be used to write smart contracts. Solidity is a high-level language for smart contracts, which has been written for EVM. Ethereum platform has provided the field for designing and customization of various smart contracts regarding the need of each system. The smart contract can be designed to create a variety of functions desired. and provide many advantages such as user's ease of use, preventing of violations, automatic execution of operations, avoiding bureaucratic processes that are energy- and time-consuming. Smart contracts are deployed on the Ethereum blockchain under decentralized applications (DApps).

Our proposed platform will be executed by general nodes of the Ethereum blockchain network. The Ethereum nodes can participate in various public networks. The Ethereum client can be a desktop/mobile/web page. (Packt, 2020). With Ethereum, servers and clouds are replaced by many “nodes” run by volunteers from across the globe. (Techsophy, 2020). All operations existing in the platform include stakeholder register, recording the initial data, consensus protocols documents by using Ethereum smart contracts and distributed IPFS (InterPlanetary File System) on the blockchain. The procedure of chain begins when stakeholders register in the system. The stakeholder groups can join the platform by providing initial information and after registry can enter their user account. They indeed have signed the membership in the smart contract through this registry. The proposed platform could be implemented with smart contracts so that the full potential of the blockchain's different properties can be used. The final set of the blockchain use cases proposed in this research for the improved implementation of the three modules (data, sustainability, and governance) can be written in Solidity language and could be customized in accordance with the development challenges in the Italian cities, by the developers through the smart contracts be implemented on the Ethereum blockchain.

The originality of the dissertation consists of developing an innovative Ethereum blockchain platform to adopt the potential of blockchain technology to the improvement implement the 2030 Agenda considering existing discussions in governance science, sustainability science, and data science. As a result of its comprehensive and structured nature, it outperforms earlier possibilities. The thesis findings offer insights to the policymakers and local authorities at national and regional levels on how to implement the 2030 Agenda through blockchain-based innovative solutions in Italy to reduce territorial inequalities between places in Italy. In addition, could provide support knowledge to define Italy's sustainable development strategy towards achieving the 2030 Agenda in Italy.

1.5 Research Questions Development

In Italy, drafting of the strategy for the blockchain and distributed ledgers is an important step for this technology to become central for the economic and social development of the country, as well as constituting the Italian contribution to a synergistic action between EU member countries. The Italian three-year plan for IT in Public Administration 2019-2021 has emphasized the adoption of emerging technologies, such as blockchain technology and artificial intelligence at the national level (AGID, 2019).

Furthermore, Italy's Ministry of Economic Development stated that the country's top goal is to "understand, develop, and solve the situation of distributed ledger technology (DLT) and blockchain, as well as raise infrastructure investment in this regard." In this regard, the Ministry of Economic Development announced a list of 30 specialists in 2019 to build the country's blockchain strategy, with the goal of identifying possible use cases for blockchain in public and private sectors, according to the ministry's statement. In the drafting of the national strategy for blockchain and distributed ledgers proposed by the Ministry of Economic Development of Italy, has been emphasized to use of the technology to enhance the conversion to circular economy models in line with the 2030 Agenda for sustainable development (Ministry of Economic Development, 2020). In the current thesis as described in the above sections, we aim to develop an innovative Ethereum blockchain platform to adopt the potential of blockchain technology to improve implement the 2030 Agenda in Italy considering existing discussions in governance science, sustainability science, and data science. As a result, the following is our primary research question:

How can blockchain contribute to the improved implementation of the 2030 Agenda in Italy, considering existing discussions in Data science, Governance science, and sustainability science?

We separated the main research question into the following due to the complexity of the research topic :

RQ.1 How can blockchain contribute to the improved implementation of the Data Module?

RQ.2 How can blockchain contribute to the improved implementation of the Governance Module?

RQ.3 How can blockchain contribute to the improved implementation of the Sustainability Module? The framework of our proposed platform includes three basic modules (data module, sustainability module, and governance module) derived from the novel ICT framework to implement the 2030 Agenda provided by Kostoska and Kocarev in 2019. They have provided a novel ICT framework to offer an extraordinary platform to address the complexity of the 2030 Agenda.

Their suggested scheme comprises a series of principles organized into three modules (database, sustainability, and governance) that could serve as a foundation for better SDG implementation. The data module analyzes information and offers input data for the other two modules to work with. information might be gathered from a spread of sources, so as to be divided into 3 categories: (1) Statistical information (facts from countrywide and EU statistical agencies, statistics from other governmental and non-governmental businesses, various open-statistics available in periodical reviews or in non-stop mode), (2) Sensor data (records from sensors owned by using governmental organizations in addition to from sensors owned by using various providers, and facts from citizens' sensors consisting of wearable sensors, mobile smart-phones, in-automobile sensors, and so on.), and

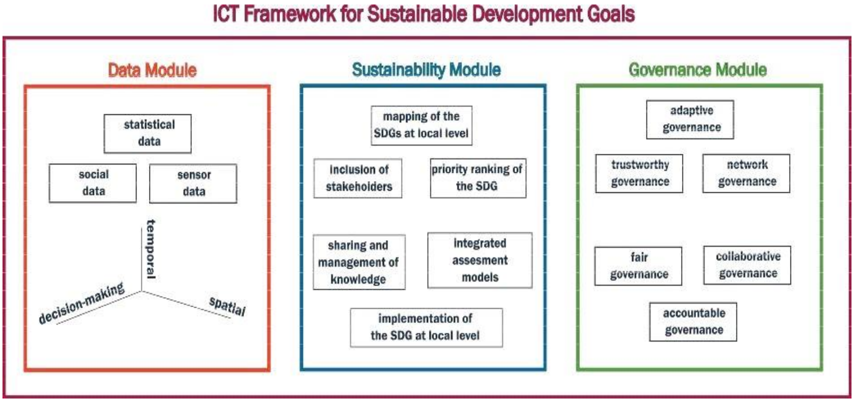
(3) Social facts (records from social networks, blogs, and facts from newspapers or information aggregating portals). The sustainability

module implements SDGs at the level of municipality/city, guarantees to rate of regionally converted SDGs to set up them in keeping with the values and wishes of the local communities, and proposes an included approach in modeling the social-ecological systems. governance module included six submodules, adaptive governance, honest governance, network governance, collaborative governance, responsible governance, and truthful Governance. The governance module allows for effective citizen involvement in the governance of SDGs by using governance theories. Kostoska and Kocarev (2019) said that this framework is really the primary try to conceptualize the SDGs (as an ICT-supported phenomenon) within the mild of current discussions in governance science, sustainability technology, and statistics technology, and could provide a supporting understanding for building an ICT platform. They believe that, to strengthen and apply this sort of platform in practice, the three modules of the ICT framework should be linked in a network of local organizations to ensure that global concerns are addressed holistically.

Figure. 6- Three building blocks of the ICT framework

(Kostoska and Kocarev, 2019)

Based on the layers of the research onion (Saunders et al., 2009),



the type of researcher's view in this research is the interpretive view of phenomena. In this research, a qualitative approach and the strategy of the systematic literature review and theme analysis have been adopted. For collecting and analyzing research data, the semi-structured interview method has been used. The statistical population of this research is in the stage of systematic literature review, studies from 2015 to 2020 in the field of blockchain and its applications according to the seven stages of a systematic review of Scaringella & Radziwon (2018), and in the field of content analysis, the statistical community consists of experts and university professors, and administrators who have a history of study or implementation in the field of understanding blockchain theories and models and their applications, especially in the field of sustainability. In the thematic analysis stage, relying on the purposeful snowball sampling method, finally, eight of the mentioned people have been selected and interviewed. After studying the reviewed articles, first, all the applications of blockchain obtained in the articles have been extracted according to the three modules of data, governance, and sustainability by textual content analysis method and relying on the researcher's knowledge of the mentioned applications. In this research, the six-step method of Braun & Clarke (2006) has been used for the thematic analysis method, and after extracting the basic, organizer, and global themes from the interviews the thematic network has been drawn, and the results from the thematic analysis have been Integrated with the systematic literature review results. The final set of the blockchain use cases proposed in this research for the improved implementation of the three modules (data, sustainability, and governance) could be written in Solidity language on the Ethereum blockchain. and in accordance with the development challenges in the Italian cities to be customized and implement through smart contracts. The originality of the dissertation consists of developing an innovative Ethereum blockchain platform to adopt the potential of blockchain technology to implement the 2030 Agenda considering existing discussions in governance science, sustainability science, and data science. Consequentially, due to its comprehensive and structured nature, superior to existing approaches. The thesis findings offer insights to the policymakers and authorities at the regional and national levels on how to implement the 2030 Agenda through blockchain-based innovative solutions in Italy to reduce territorial inequalities between places in Italy. and provides support knowledge to define Italy's sustainable development strategy towards achieving the 2030 Agenda in Italy.

Chapter 2
Literature Review

The current chapter presents the contemporary literature regarding blockchain technology, blockchain features and applications, consensus mechanisms, smart contracts, The 2030 Agenda, sustainable developments goals, and previous research on blockchain and sustainable developments goals. This chapter is also advantageous to understand the context of the blockchain domain and its applications in a variety of areas.

2.1 Blockchain Technology

Bitcoin, which was originally used for historical recording, put blockchain technology into practice with the goal of making reliable, verifiable, distributed, efficient, and low-cost transactions (Nakamoto, 2019). With the advancement of cryptography, the blockchain's core technology was detached from bitcoin and developed as a technology related to existing technologies such as cryptography. There are three forms of blockchain: public, private, and combination. Each one has its own set of benefits and drawbacks, allowing them to cater to a variety of requirements and applications in this industry (Guegan, 2017, Shahzad and Crowcroft, 2019). The advantages of using blockchain technology can be summarized as follows: A high volume of data can be easily managed. 2. The cost of managing and reporting domestic and international financial transactions is reduced. 3. It is impossible to create disorder and theft in information by encryption and consensus algorithm. Penetration into part of the system will be completely prevented by decentralized technology. There is no need for maintenance by the bank. 5. It is almost free cost (Golosova, and Romanovs, 2018). To understand the notion of blockchain, think of it as an account ledger in which all evidence (in the case of Bitcoin, transactions) is recorded. If the ledger was kept by a single person, it could be altered to suit his or her own needs. To avoid this, the ledger is shared and maintained by several persons or organizations. As a result, if a user submits a modified form of the ledger, the entire group can evaluate or audit it and reject the corrupted ledger. As a data format, blockchain ensures data integrity while also providing a historical record of the data (Palacio 2018). The blockchain system would be a decentralized transactional database that allows for the execution of validated, tamper-resistant transactions throughout a high variety of network subscribers, known as nodes. Due to its decentralized and tamper-resistant nature, blockchain technology has the potential to address concerns about credibility, decentralization, and transparency across a wide variety of people, corporations, and authorities all over society. Initially established and focused solely on the phenomenon of cryptocurrencies, blockchain research is increasingly expanding to incorporate a broader range of applications, such as supply chain management, verification, and smart city schemes. Blockchain has begun to be positioned at the heart of research agendas in a wide spectrum of disciplines fields due to its qualities in relation to sustainable development. Most of the programs of blockchain generation, in truth, could evidently fall in the scope of sustainable development initiatives.

For example, blockchain technology can improve supply chain transparency, enable circular economies, and eliminate resource management information asymmetry (Medaglia and Damsgaard, 2020). "An open, decentralized ledger that can document transactions between two parties effectively, verifiably, and permanently" is how blockchain is defined. It rose to prominence in 2009 because of its use in BitCoin, the first open-source, peer-to-peer, digital, decentralized cryptocurrency. However, blockchain's implications extend beyond digital currency, touching various aspects of our daily lives. Energy applications have been getting popular, with research leading to demonstration projects by start-ups that have attracted the interest of traditional electrical sector players. Permissioned or private blockchains must be distinguished from permissionless or public blockchains, and private blockchains are frequently referred to as "distributed ledgers." One path ahead could be the development of new private blockchain verification algorithms that employ pre-selected trusted validators. Furthermore, the convergence of the Internet of Things and blockchain applications is gaining traction. In microgrids, appropriate sensors, actuators, and gadgets could be used as blockchain nodes. Microgrid implementation in underdeveloped countries can be aided by digital technology applications such as blockchains, which can help achieve the 2030 SDG of universal energy access. The future appears bright (Kyriakarakos and Papadakis, 2018). Blockchain consists of two parts, block, and chain. The blockchain platform has a feature called "Hash". hash, which is interpreted as a signature, and in fact, the blocks are encrypted by this hash. A hash is a string of characters formed of specific mathematical functions (Di Pierro,2017, Gupta, 2017). In the blockchain, the next hash block will contain the previous block hash. The smallest change in a block's information changes the hash generally.

Figure. 7- Schematic design of digital information stored in a blockchain

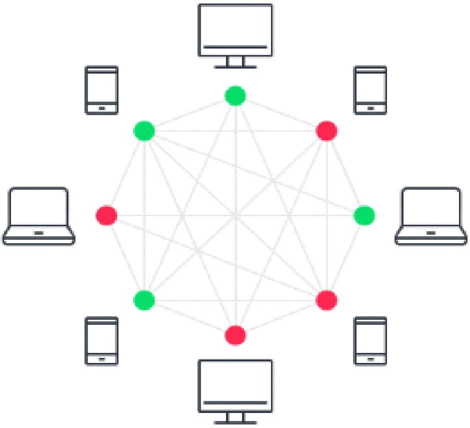


Figure. 8- A simple blockchain network topology in which all nodes have the same ledge (Palacio 2018)

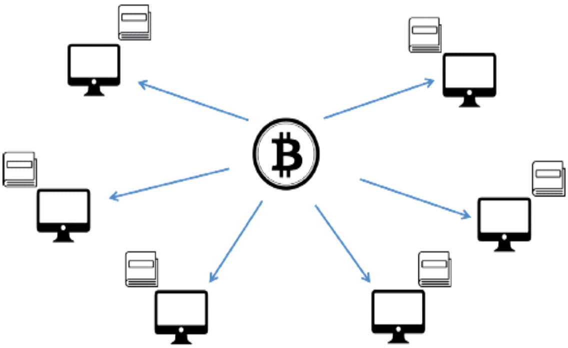


Table. 5- Differences between permissioned and permissionless blockchains (Palacio 2018)

	Permissioned or Private Blockchain	Permissionless or Public Blockchain
Network access	Authorized access	Open access
Approach in relation to laws and regulations	Able to comply with "Know Your Client (KYC)" and "Anti Money Laundering (AML)" banking regulations	Aims to create censorship resistant anonymous transactions outside of the current legal and regulatory framework
Validator approach	Pre-selected trusted validators	Anonymous, fully decentralized validators

Currently, the study of the dimensions of using this technology is on the agenda of many national policy institutions in different countries. In general, companies and governments that can quickly embark on new technology waves have implemented blockchain more than others. For example, Dubai has recently announced that it wants to be the first capable state with blockchain in the world by 2020. In addition, the use of blockchain technology and its advancement has been investigated in governmental policy-making institutions in many countries. For example, it can include the US Congress and Senate, the European Parliament, the Central Bank of China, the Russian National Institutions and the State Working Group of the Russian Bloc Chain, the French Parliament, South Korea, Canada, etc. In addition, many international organizations, such as the United Nations and the World Trade Organization, are investigating the use of this technology in various areas under their control. In the area of protection of intellectual property rights, the Director-General of the World Intellectual Property Organization (WIPO) cited blockchain technology as an opportunity to protect intellectual property rights and predicted that the operation of the technology can solve many problems related to the protection of intellectual property rights provided comprehensive attention (Sacha, 2019).

2.2 Consensus Mechanisms

Despite PoW currently being the most adopted way of reaching consensus on the blockchain, there are other consensus mechanisms as well been implemented. This is due to scalability issues of PoW, leading to latencies on the order of an hour for a single transaction and high energy costs Vukolic (2016). PoW is also considered rather slow at the time of writing only processing approximately seven transactions/second on the Bitcoin blockchain. In comparison, Visa processes around 2.000 transactions per second (Narayanan et al., 2016). The 4 other most important alternatives to PoW are currently Proof-of-Stake and its derivatives, (Delegated and Federated) Byzantine fault tolerance, Federated Byzantine Agreement, and Proof-of elapsed time (Baliga, 2017). Currently, the most important alternative to PoW is Proof-of-Stake (PoS). The main advantages PoS has over PoW are the high energy costs of PoW and scalability. PoS completely replaces the mining operation with a voting mechanism based on staking cryptocurrency. The PoS algorithm pseudo-randomly selects validators for the creation of a new block. Should the node vote for an invalid transaction the stake of the node is burned. This tackles the Nothing-at-Stake problem in which nodes can vote for multiple forks of the blockchain with nothing at stake. In addition to losing their stake as an incentive to act honestly, nodes receive a dividend based on the size of their stake as a reward for rightful voting. The NXT blockchain currently utilizes this concept and the Ethereum blockchain will shift from PoW to PoS in 2018 (Prisco, 2017). To comprehend the alternative consensus models, it is necessary to first realize that Blockchain platforms can be divided into three types: public, consortium, and private (Buterin, 2015).

In a public blockchain everyone can participate as a node in the network to take part in the consensus process in addition to reading and writing transactions. These blockchains are generally considered to be fully decentralized. Bitcoin and Ethereum are prime examples of this. ‘Permissionless’ is another term commonly used to refer to public blockchains (Perretta, 2017). In a private blockchain, permissions are restricted to one organization. Likely examples of the application of private blockchains include database management internal auditing, etc. These blockchains are considered centralized and are often referred to as ‘Permissioned’ blockchains. Consortium blockchains are blockchains where the consensus process is controlled by a preselected set of nodes which are semi-trusted and verified members. An example of a consortium blockchain is a group of financial institutions, each of which operates a node. To reach a consensus on the validity of a block for example 10 out of the 12 nodes must approve it. Consortium blockchains are a hybrid between public and private blockchains but in practice often require permission before a party can participate in the network. The Byzantine Generals problem is solved via a consensus technique called Practical Byzantine Fault Tolerance (PBFT) (Lamport, Shostak, and Pease, 1982). The Byzantine Generals problem boils down to how to reach consensus when faced with untrustworthy and malfunctioning actors that threaten to destabilize the network. PBFT is used in the Hyperledger Fabric blockchain, which is a consortium blockchain developed by the Linux Foundation (Cachin, 2016). Delegated Byzantine Fault Tolerance (DBFT) solves the Byzantine Generals problem by querying a random node in the network about the state of the network until >66 percent of the network agrees with that random node. This implies that dBFT assumes at least two-thirds of the network operates not maliciously. Currently, the public NEO blockchain utilizes this consensus mechanism (NEO-Foundation, 2017). Federated Byzantine Agreement (FBA) is utilized by the public Ripple and Stellar blockchains to tackle the Byzantine Generals problem (Mazieres and Stellar- Development Foundation, 2016). Both are real-time gross settlement systems aimed at supporting financial institutions completing a high amount of transactions/sec. The instantiation of the FBA in Ripple works in an iterative way. A batch of transactions first must be approved by at least 50 percent of the nodes to become a candidate set. After this, it is pushed further for higher approval ratings until 80 percent (super-majority) of the nodes approve of the specific candidate set.

2.3 Smart Contracts

Smart contracts are a significant step forward for blockchain technology. A smart contract was proposed in the 1990s as a computerized transaction protocol for carrying out an agreement's contractual provisions. When a specific condition is met, contractual clauses encoded in smart contracts will be automatically executed (e.g., If one of the parties breaks the contract, they would be instantly penalised). Smart contracts are made possible by blockchains. In essence, smart contracts are built on top of blockchains. Contractual terms that have been authorized are turned into computer programs that can be executed. In the form of logical flows in programs, the logical linkages among contractual provisions have also been retained (e.g., the if-else-if statement). Every contract statement's completion is added to the blockchain as an unchangeable transaction. Smart contracts ensure that proper access control and contract enforcement are in place. Figure.10 shows an example of the source code for a smart contract created in the Solidity programming language. Smart contracts can be written in a variety of languages, including Java, Golang, Javascript, C++, Python, and.NET (Rosic, 2017). Developers can set access permissions for each contract function. When a smart contract's conditions are met, the prompted declaration will run the relevant function in a predictable way. Alice and Bob, for example, agree on the punishment for breaching the contract. If Bob breaks the contract, the punishment (as stipulated in the contract) will be removed from Bob's deposit automatically (Zheng et al, 2020).

Figure. 9- Smart Contract implementation (Zheng et al, 2020)

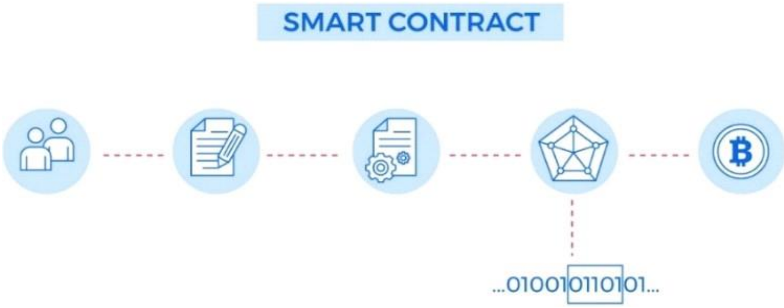


Figure. 10- Example of the source-code of a smart-contract written in Solidity

```
contract MetaCoin {
  mapping (address => uint) balances;

  function MetaCoin() {
    balances[tx.origin] = 10000;
  }

  function sendCoin(address receiver, uint amount) returns(bool sufficient) {
    if (balances[msg.sender] < amount) return false;
    balances[msg.sender] -= amount;
    balances[receiver] += amount;
    return true;
  }

  function getBalance(address addr) returns(uint) {
    return balances[addr];
  }
}
```

2.4 Blockchain Technology Applications

The distributed ledger network (Blockchain) has recently piqued the interest of a wide range of industries, including industry, financial institutions, academics, the online community, and entrepreneurs, owing to the vast range of problems blockchain may answer. Institutional transparency, business decentralization, trackable information, and democratizing work rewards across all users of the network by removing any need for a single authority with ultimate control are some of the most prominent examples (Palacio 2018).

There is a potential program to use this unique feature of the blockchain. One of the most common current uses of blockchain technology is digital currencies. The ways to use the blockchain and the benefits of using it are expanding and developing. Tracking of goods, protection of intellectual property rights, smart contracts (Karamitsos et al, 2018), protection of artistic works, registration of trademarks and patents (Drobyazko, 2019), and authentication and ownership are other applications of blockchain technology (Blue et al, 2018). Authentication and ownership can include passports, medical records, birth certificates, marriage certificates, ownership documents, and IDs, without the possibility of manipulating records. Blockchain technology can also be used in smart contracts; So that contracts can be automatically approved and signed and save time and cost of companies, especially large companies with high transaction volume. Smart contracts include all information about the terms of the contract, and all clauses of the contract are executed automatically. This contract is the computer code stored on the blockchain platform. These smart contracts will be able to remove the obligation to enforce the law from administrative officials and assign them to computers (Sacha, 2019, Cheng, 2019).

Numerous studies in the field of blockchain have been published in journals, conferences, and patent registration by researchers and scientists around the world, and the number of these articles is expanding every day. According to Figure 11., the number of articles published by 2020 in relation to the blockchain reaches 6,000 articles and it is growing exponentially.

Blockchain as a Consensus Technology

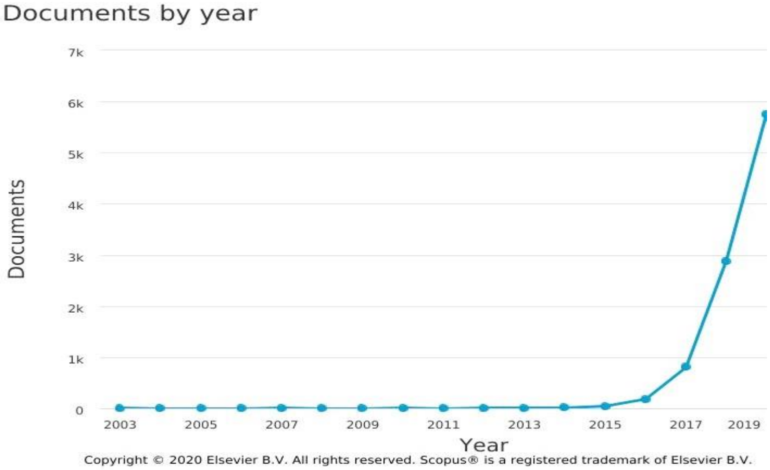
Consensus is necessary to assure decisions for the group that should be accurate and trustworthy. Consensus building is a strategy for boosting the likelihood of equitable decision- making among stakeholders (Chamberlain, 2019). A key feature of the blockchain is that it has a consensus protocol built in. This means that the blockchain could replace third-party entities as a consensus mechanism and transaction ledger (Ammous, 2015).

A smart contract is a digital contract that is kept on the blockchain, and it is "smart" because that incorporates programming logic that can automatically carry out the contract's terms. Smart contracts work without the need for a middleman to interpret contract requirements and deal with unexpected events (Chamberlain, 2019). Decentralization, clarity, immutability, and accessibility are among the core operational concepts of blockchain technology that could stimulate, enable, and promote productivity and science. In relation to the following domains and concerns, blockchain has the responsibility to empower the research cycle in a holistic manner. The following domains and concerns are examples of how blockchain could potentially inform the research cycle in a comprehensive manner (Rachovitsa, 2108).

DLT applications are also being investigated in the strength marketplace, both as a system that permits proprietors to sell extra solar-generated energy to each other while not having to go through 1/3 parties (including PowerLedger and TransActive) and as a marketplace infrastructure for carbon trading, that is an unbiased ledger of the authorizations to generate Earth's allowance of greenhouse gases (Kewell et al, 2017).

Decentralization, transparency, equality, and accountability are among the key operational concepts of the blockchain. The personal blockchain is a subcategory of the permissioned blockchain, wherein best a restrained quantity of authenticated persons has got right of entry to to the database, together with for analyzing or writing; these normally reside at the back of a few organizational firewalls however provide within-institution transparency, privateness, and govern for a described set of users. The permissioned blockchain can aid in the implementation of the SDG agenda (Kewell et al, 2017). The emergence of use instances for inter-organizational and consortiaprimarily based blockchain deployment (as dispensed ledger technologies and permissioned ledgers) indicates that it might not be lengthy earlier than companies start to see blockchains as alternate agents (Kewell et al, 2017).

Figure. 11- shows the number of articles published in the blockchain by year, from 2000 to the present (Research findings)



Statistical review of articles published in this field is shown in Figure.12 according to the countries active in this field. According to Figure.12, the leading countries in this field are China, the United States, and India, respectively. The subject and scope of researchers' application and activity in the use of blockchain technology are diverse.

Figure. 12- Bar chart of leading countries in the field of blockchain based on international publications (research findings)

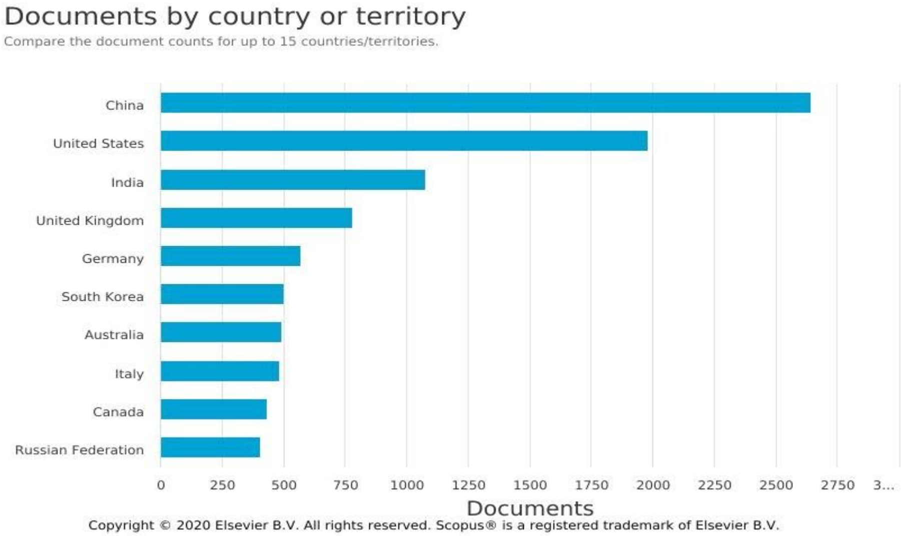
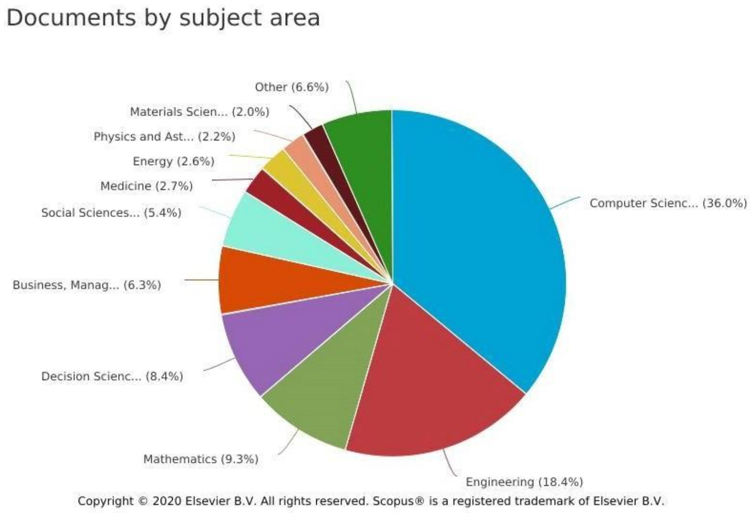


Figure. 13 shows the share and percentage of different fields in blockchain technology, based on the result of research published in scientific circles since 2000. Based on the results shown in Figure. 13, most of the blockchain articles published were computer science 36%, engineering sciences 18.4%, mathematics 9.4%, and topics such as communication, decision making, energy, medicine, commerce, etc. allocated another percentage.

Figure. 13-Comparison of the share of the public and various positions in the use of blockchain technology (research findings)



The increasing expansion of blockchain technology led to the expansion of new areas combined with blockchain, each of which has its own unique benefits. In fact, this technology led to an improvement in the level of these areas. For example, using the blockchain in the government with adaptive governance, blockchain with a trustworthy governance approach (Alcarria, 2018, Feng and Yan, 2019) blockchain with a network governance approach (Bousfield, 2019, Atzori, 2017) blockchain with fair governance approach, blockchain with collaborative governance approach, blockchain with accountable governance approach (Kundu et al, 2018, Maupin, 2017), blockchain in using statistical data (Anghel, 2019, Ghadamyari and Samet, 2019), blockchain in using social data (Albrecht et al, 2019, Xu et al, 2020), blockchain in the use of sensor data (Chanson et al, 2019, Wang et al, 2018) and the role of blockchain in decision making (Laskowski, 2017).

2.5 Sustainable Development Goals and the 2030 Agenda

The co-optimization of dynamic and inventive efforts to meet market needs, reduce resource depletion, and assure the achievement of full human potential has been described as sustainability (Ashford and Hall, 2011). In the future, sustainable development is a paradigm that balances economic growth and environmental protection. As a result, meeting present and future requirements has the goal of improving and developing living quality. Sustainable development is a concept that envisions a future that balances economic progress and environmental protection. As a result, meeting present and future needs is intended to enhance and develop living quality (Cioaca et al 2020). The Sustainable Development Goals (SDGs) are the world's largest collective enterprise to enhance the lives of billions of human beings with the aid of setting up quantitative goals and outcomes to guide evidence-primarily based policymaking (Courtney et al, 2016).

Sustainable development isn't a new notion. Frequently referred to as “improvement that meets the needs of the modern technology without compromising the ability of future eras to meet their very own desires” as described in a milestone file posted in 1987, the modern-day conceptualization of sustainable improvement has prolonged its authentic recognition on the character of monetary growth best, to greater extensively embody the wider discourse on how solutions to needs of society can be not handiest economically viable, but additionally environmentally bearable, and socially equitable at the identical time (Medaglia and Damsgaard,2020).

Furthering monetary and social development while making sure that it meets the wishes of the prevailing without compromising the capability of destiny generations to fulfill their own desires. Advancing economic and social progress while guaranteeing that it serves current needs without jeopardizing future generations' abilities to fulfill their own. The framework for the political implementation of sustainable development and the presentation of Agenda 21, the action plan for the twenty-first century, was laid as early as 1992 at the World Summit in Rio. Commitments to sustainable development were reinforced in 2012 at the Rio + 20 Conference, and the essential actions were outlined in the manifesto "The Future We Want." The United Nations General Assembly adopted the 2030 Agenda for Sustainable Development on September 25, 2015, in line with the Millennium Development Goals. The 2030 Agenda lays out the framework for international activities for the next 15 years.

The 17 Sustainable Development Goals of the 2030 Agenda are the United Nations' worldwide action plan to end poverty, safeguard the environment, and promote prosperity for all. These desires consist of numerous troubles, which are essential elements of sustainability, which includes poverty, discrimination, climate alternate, safety of the herbal environment, training, and labor problems to eliminate poverty and starvation anywhere; to fight inequalities within and amongst countries; to construct non-violent, just, and inclusive societies; to shield human rights and sell gender equality and the empowerment of ladies and ladies, and to ensure the lasting safety of the planet and its herbal sources.

The 2030 Agenda is a plan of action for people, the planet, and prosperity that aims to expand on and complete the Millennium Development Goals (UN, 2015). This strategy will be implemented by all countries and stakeholders in collaborative partnerships, ensuring that no one is left aside. The 2030 Agenda includes 17 Sustainable Development Goals (SDGs) that address the economic, social, and environmental pillars of development, with the goal of achieving a sustainable future by 2030 that balances equal prosperity within global boundaries (Table.6).

Table. 6- Sustainable Development Goals

(United Nations, 2015)

Goal. 1	End poverty in all its manifestations around the world.
Goal. 2	End hunger, improve meals security and vitamins and promote sustainable agriculture.
Goal. 3	Good health and well-being. ensure that every person of all ages has healthful life and well-being.
Goal. 4	Quality education and ensure inclusive and equitable education for all.
Goal. 5	Achieve gender equality and the empowerment of all girls and women.
Goal. 6	Ensure sustainable access to water.
Goal. 7	Ensure that all people have access to affordable, dependable, efficient, and modern energy.
Goal. 8	Ensure long-term, comprehensive, and sustainable economic growth and decent work for all.
Goal. 9	Develop resiliency in infrastructure, promote equitable and sustainable industrialization, and encourage innovation.
Goal. 10	Reduce intra- and inter-country inequalities.
Goal.11	Create inclusive, secure, adaptable, and sustainable cities and human habitation.
Goal. 12	Ensure that manufacturing and consumption processes are sustainable.
Goal. 13	Take immediate action to address climate change and its consequences.
Goal. 14	Protect the oceans, seas, and marine resources and utilize them responsibly for sustainable development.
Goal. 15	Preserve, regenerate, and stimulate the appropriate use of terrestrial ecosystems, as well as sustainably manage natural resources, combat desertification, and land degradation, and biodiversity loss.
Goal. 16	For sustainable development, create peaceful and inclusive societies, offer universal access to justice, and construct effective, responsible, and inclusive institutions at all levels.
Goal. 17	Strengthen and renew the Global Partnership for Sustainable Development's implementation mechanisms.

Figure 14. Sustainable De

Figure. 14- Sustainable Development Goals
(United Nations, 2015)

The Sustainable Development Goals and Agenda 2030 were agreed upon by world leaders in September 2015, placing the world on a path to a wealthy, equitable, and environmentally sustainable future. The Sustainable Development Targets (SDGs) are a collection of measurable goals that can be used as a platform for local and national governments to work together. The transition to sustainable advancement provides a chance for cities and local governments to move away from traditional growth paths and toward more inclusive, environmentally sustainable, and economically viable ones. The agenda is a set of goals for people, the environment, and economic prosperity. This plan (Agenda 2030) will be implemented by all nations and stakeholders in a collaborative partnership, and the 2030 Agenda for Sustainable Development offers a rare chance to reconsider public administration and local development (Dieuwke, 2018). Worries about environmental and climate change, as well as issues of poverty and inequality, have pushed sustainable development to the forefront in recent years. While sustainable development is vital for humanity's future, assessing and managing sustainability has become a major challenge for our civilization (Kostoska and Kocarev, 2019). Using blockchain-enabled solutions to achieve true longevity is still a matter of public governance (Sulkowski, 2018). The 2030 Agenda tackles environmental, social, and economic challenges holistically, with the goal of transforming our society's primarily economic model of success into an integrated and sustainable model of wealth. However, the 2030 Agenda's success will be determined by how well it is implemented. The methods for implementation have been detailed, with the emphasis on the need for "quality, available, timely, and accurate disaggregated data" "to assist with progress measurement and to guarantee that no one is left behind" (The 2030 Agenda). With the goal of increasing company openness and responsibility on social and environmental issues, Europe introduced the pioneering EU Directive on the disclosure of non-financial and diversity information (Directive 2014/95/EU), which emphasized the importance of sustainability reporting (Semen Son-Turan, 2019).

2.6 ICT and Sustainable Development Goals

The belief is that the discipline of information and communication technologies for improvement (ICT4D) may be used to help people all over the world progress and improve their lives (Rothe 2020). Programs to undertake extensive cost-benefit, life cycle, or risk evaluations, as well as other forms of utility analysis and attribute aggregation, could be included in the utilization of ICT in the development cooperation sector, often known as ICT for development (Chamberlain, 2019). Geospatial information system (GIS) tools are also being used to analyze and evaluate humanitarian disaster response techniques on the ground, as part of data-for-development programs. The Ushahidi online disaster response platform is an illustration of this, as it enables users to geo-cache occurrences such as leaking water pipes or violations of human rights (Chamberlain, 2019). The United Nations Commission on Broadband for Sustainable Development has emphasized the important function that ICT can perform in delivering integrated, creative, and cross-sectoral sustainable development outcomes. While private sector ICT applications have advanced, many of the difficulties of sustainable development (education, health, infrastructure, and environmental sustainability) necessitate a significant contribution from the public sector and policymakers (Kostoska and Kocarev, 2019). Meanwhile, there is a considerable amount of research demonstrating the ability of ICTs to promote different aspects of sustainable development, such as economic empowerment, e-governance, and environmental sustainability (Rothe 2020). For example, Ziemba (2018) has studied the relationship between home ICT adoption and sustainability from both a theoretical and empirical standpoint. According to the regression analysis, information culture, information technology management, and information technology quality all have a significant and beneficial impact on sustainability.

2.7 The novel ICT framework for Sustainable Development Goals

In 2019, Kostoska and Kocarev created a unique ICT framework to give an exceptional platform for addressing the complexity of sustainable development goals (SDGs). Their suggested scheme consists of several different concepts organized into three modules (data, sustainability, and governance), which could serve as a foundation for better SDG implementation. The data module combines data from a variety of sources, processes it, infers knowledge, and transforms it into intelligible data and knowledge. The sustainability module implements SDGs at the municipal/city level, guaranteeing that locally customized SDGs are prioritized and organized in accordance with local communities' values and requirements, and gives an integrated approach to modeling social-ecological systems. In 2019, Kostoska and Kocarev presented a revolutionary ICT framework for addressing the Sustainable Development Goals. The framework is made up of three modules: knowledge, sustainability, and administration, and it has both nationally and internationally consequences in the economical, ecological, and social components of sustainable development. The data module combines data from a variety of sources, analyses it, infers knowledge, and transforms it into usable information and knowledge. The sustainability module implements SDGs at the municipal/city level, guarantees that locally modified SDGs are ranked to arrange them in accordance with the values and requirements of local populations, and presents an integrated approach to modeling social-ecological systems. The governance module allows for successful public engagement in SDG governance by putting governance theory into practice. Following the four concepts, Kostoska and Kocarev (2019) developed a framework to design and implement an ICT platform to address the SDGs.

(1) Three fields should shape the performance of the SDGs: governance science, sustainability science, and data science. The framework's main building components are shaped by the first principle: data, sustainability, and governance modules.

(2) Multiple players at various geographical, temporal, and decision-making scales (e.g., farm, local, region, state, national, international), temporal scales (e.g., daily, monthly, annual), and decision- making scales (e.g., national, international) should be triggered to implement the SDGs (e.g.,

individual, group, institution). The second concept entails the collaboration of all active subjects, including individuals, groups, governments, and multilateral organizations.

(3) Diverse governance theories activating activities at multiple levels and involving participants from various sectors should be addressed when it comes to SDG governance. The framework's third premise allows for the adoption of diverse governance ideas.

(4) Human behavior should have an impact on SDG implementation. Individuals are encouraged and motivated to engage in decision-making processes by the fourth principle.

Data module collects, prepares, analyzes (computes and transforms), visualizes, manages, and preserves data from three sources: statistical, sensor, and social data at three levels of granularity: spatial, temporal, and decision-making.

The Sustainable Development Goals (SDGs) module seeks to map SDGs at the local level, promote stakeholder inclusion, give priority ranking of SDGs, implement SDGs at the local level, and exchange and manage knowledge. Adaptive, networked, collaborative, fair, and trustworthy governance is the goal of the governance module. The suggested paradigm, according to Kostoska and Kocarev (2019), is the first attempt to conceptualize the SDGs as an ICT-enabled phenomenon in light of existing discourse in governance science, sustainability science, and data science. The advantages of employing this framework, according to them, include the following innovative features: The New ICT Framework's Key Features for addressing the 2030 Agenda (Kostoska and Kocarev, 2019).

1. Holistic approach: A holistic approach is one that combines three disciplines—governance science, sustainability science, and data science—all of which are intertwined with the concept of digital democracy.

2. Increased-consciousness strategy: A method focused on better understanding that contributes to nationally and internationally SDG governance.

3. Data-intensive strategy: A data-intensive approach wherein SDGs are applied at various spatial, temporal, and decision-making scales utilizing state-of-the-art machine learning technologies.

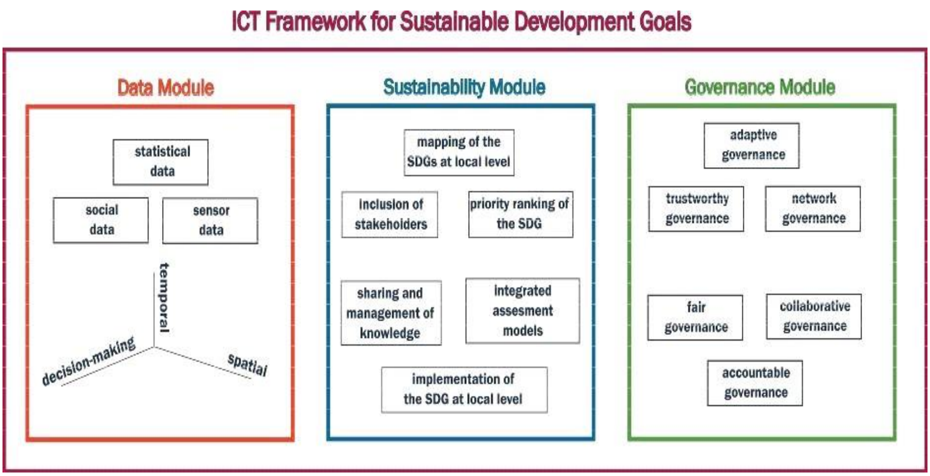
4. Adaptive governance, network governance, collaborative

governance, responsible governance, fair governance, and trustworthy governance are all examples of governance-enhanced approaches in which SDGs are achieved using various governance theories.

5. Two-way approach: A two-way method that ensures successful citizen engagement in achieving the SDGs by ensuring communication between the government and the people.

6. Responsible approach: A responsible strategy that has a real impact on the SDGs by encouraging citizens to get involved in addressing the goals and allowing those in positions of power to endorse the framework.

Figure 15. Three building blocks of the ICT framework (Kostoska and Kocarev, 2019)



2.8 Blockchain Technology and Sustainable Development

Blockchain research is quickly developing and maturing. Conceptualizations of blockchain, as well as preliminary empirical research in IS, have begun to go beyond the original narrow focus on blockchain's applications in the financial sector, and have begun to foresee its possibilities in a much broader range of domains. The focus on blockchain and sustainability could be one of these topics. Circular economies, removing asymmetric information in resource management, giving access to finance, increasing monitoring, boosting disaster preparedness, and facilitating geospatial platforms are all examples of how blockchain is seen to promote sustainability. When it comes to blockchain research, sustainability is usually only discussed in terms of the technology's ecological footprint – that is, the high energy consumption required by the computing-intensive processes that characterize blockchain technology, such as the blockchain proof-of-work consensus mechanism (Medaglia and Damsgaard,2020). Autonomous objects, augmented analytics, AI-driven development, edge and fog computing, digital twins, digital lakes, and immersive technologies are examples of cutting-edge ICTs that have yet to be completely developed and used for the SDGs (Kostoska and Kocarev, 2019). Both scholars and practitioners increasingly think that blockchain could have a game-changing impact on society, based on an expanding number of alternatives. However, opinions on the virtues of blockchain differ. While some businesses are concerned about the consequences, others see it as a promising IT infrastructure. While this ambiguity necessitates the development of rules for evaluating blockchain's effectiveness, most research is currently focused on its theoretical basis and technological aspects. As a result, organizations are taking a closer look at blockchain technology and building multi-functional teams to assess the technology and its implications for their operations. Evaluation standards and criteria, on the other hand, are only accessible for a limited number of applications in the financial sector, cryptocurrency security, social companies (such as crowdlending), logistics, and the evaluation of smart data initiatives (Fridgen et al, 2018).

As part of the fourth industrial revolution, blockchain technology has been one of the technologies altering governments (Zein and Twinomurinzi, 2019). Blockchain technology appears to be the viable driver for achieving global sustainability objectives, and it is already being employed in ways that might make this noble ambition a reality (Kewell et al, 2017). Using affordance theory, Kewell et al. (2017) consider innovative blockchain projects such as blockchain mining, the Internet of Value, supply chain, governance innovations, sharing economy, and financial inclusion that could help deliver socially and environmentally beneficial outcomes by challenging existing business models and providing new opportunities. Furthermore, Wu and Tran (2018) reviewed blockchain applications in a sustainable energy system and concluded that it presents a good opportunity for the development of the energy internet because it can solve many of the issues that currently impede its development, such as the control and management of distributed sustainable energy forms. Adams et al (2018) feel that DLT projects designed for the public benefit might theoretically aspire to achieve the United Nations' existing sustainable development objectives; nevertheless, they emphasize that further research is needed to determine which sort of DLT can offer sustainability the most effectively. However, there has been a minimal study too far on novel blockchain applications that could assist produce socially and environmentally positive outcomes, as defined by the United Nations' Sustainable Development Goals. Blockchain is actively investigating certain solutions for long-term viability.

Cryptographic purpose-driven tokens, for example, can be used to achieve societal goals or motivate institutions to operate sustainably when issued through smart contracts. The Solar Coin Foundation, for example, rewards solar energy providers with blockchain-based digital tokens if they can demonstrate a reduction in carbon impact. Furthermore, there are other potential benefits of blockchain in terms of sustainability, according to the literature. Lowered costs, for example. Banks may be able to save money by implementing blockchain technology, and these advantages could subsequently be utilized to accelerate the development of renewable technology and stimulate economic growth (Cocco et al., 2017). When it comes to collective action challenges in managing the global commons, adopting blockchain to accomplish sustainable development goals offers an acceptable level of demonstration as a component of efficiency (Chamberlain, 2019). Several government projects are already utilizing blockchain technology to advance Agenda 2030 goals. For example, as Son-Turan (2019) points out, the World Food Programmer's "Blockchain for Zero Hunger" initiative is taking the first steps toward leveraging blockchain technology to improve their ability to provide effective and efficient assistance to the people they serve. In addition, experimental programs with Syrian refugees in Pakistan have been effective, with blockchain being used to record every transaction that takes place at a certain merchant. As a result, there were fewer transactions, and the refugees had more security and privacy. It is critical that the information be of high quality. Because costly approaches are wasteful and unsustainable, information asymmetries enhance expenses and can have a detrimental impact on development outcomes (Hilbert, 2016).

In this regard, to decrease information asymmetries and reduce inefficiencies in global collaborations the blockchain uses cases looks promising. One of the first majors, successful blockchain-for-development projects is to provide humanitarian relief and aid. Blockchain through departs from the multilateral intermediaries, facilitates global development transactions.

The United Nations, for example, has launched programs to promote cash transfers to refugees around the world (Coppi & Fast, 2019). A few illustrations could show how significant blockchain's potential impact on development practice could be. The Republic of Ghana is using a land titling registry to allow citizens to prove legal property ownership using blockchains, while the analog ledger method was unstable and easily influenced before blockchain (Zwitter & Herman, 2018). Furthermore, considering blockchain is supposed to be decentralized, it may open up more chances for peer-to-peer transactions in a variety of market activities, such as microlending and healthcare, enhancing a citizen's autonomy (Chamberlain, 2019). Furthermore, within the public sector, blockchain is being used to optimize the humanitarian assistance supply chain, provide digital identity for refugees, enable women's empowerment by market participation, and reduce inequality, to name a few (Zwitter and Boisse- Despiaux, 2018). Multilateral organizations, such as the United Nations, are using blockchain technology in sustainable development projects. Securing digital identities, trying to improve land or property rights documents, boosting gender equality, empowering equal access to finance and markets, achieving international peace and democracy, and empowering a targeted dispersal of humanitarian aid funds are some of the Global Goals that blockchain projects are aiming to address. There are also several active global efforts, with more being established. Table. 7 shows how some of the major assistance groups have effectively established the following operational initiatives (Chamberlain, 2019).

Table 7. Blockchain Technology and Sustainable Development Goals initiatives (Chamberlain, 2019)

1.	The World Food Programme is leveraging blockchain technology to help Syrian refugees in Jordan redeem cash-based transfers.
2.	UNWomen is looking into using blockchain technology to promote gender equality by creating a civil registration system that allows people to deposit and receive digital assets directly.
3.	To improve children's access to social and welfare services, UNICEF is funding the creation of an open-source digital identification and personal information platform.
4.	UNOPS has begun a study to investigate how blockchain can improve the efficiency of aid transfers, particularly intra- agency transfers.
5.	In Serbia, UNDP, and AID: Tech are employing blockchain technology to provide beneficiaries with a Digital Identity that allows them to receive remittances directly.
6.	The World Bank has formed the Blockchain Lab, which is looking into land management, carbon trading, cross-border payments, and education payments.

Following is a paper by Kewell et al, (2017) titled Blockchain for Good? which has investigated the influence of distributed ledger technologies (DLTs) on the UN's Sustainable Development Goals (SDGs) and how blockchain solutions could be leveraged to create positive outcomes for the sustainable development agenda. It's dubbed "blockchain for good," and "good" can be defined in terms of the UN's Sustainable Development Goals. DLT projects designed for the public good, they claim, might theoretically aspire to achieve the United Nations' present sustainable development goals.

Blockchain technology is being used in ways that could turn this good intention into a practical reality, making it a viable catalyst for reaching global sustainable development goals. They discussed creative blockchain projects that might help provide socially and environmentally good outcomes by challenging established business models and giving new chances for revenue creation while simultaneously serving a charitable purpose, based on affordance theory. In 2017, Al-Saqafa and Seidlerb researched Blockchain technology for impact on society, claiming that blockchain technology and its operational and functional principles – such as decentralization, clarity, fairness, and accountability – could play a major role in restricting undue online surveillance, censorship, and human rights abuses that are assisted by the growing reliance on a few organizations that are controversies. They said that a few blockchain ideas are applicable in a variety of fields and might have a large-scale impact on society. Blockchain technology's transparency, equality, and autonomy are just a few of the features that could help advancement in areas including online identification, human trafficking, corruption, fraud, democratic participation, and freedom of expression.

2.9 Ethereum Blockchain

In late 2013, Vitalik Buterin, the creator of Ethereum, proposed that a new blockchain might be constructed that would have all the original blockchain's features plus a lot more. The Ethereum Blockchain would allow for reprogramming on its blockchain, allowing other blockchain-based applications to run directly on it. Ether, Ethereum's own digital money, was formed. Ether is comparable to Bitcoin in that it is mined and created by solving a difficult mathematical problem. The Ethereum Network is powered by the Ether itself. As previously stated, Ethereum's blockchain allows for the building of decentralized applications, or "dapps" for short. Self-executing "smart contracts" are used in a dapp. Nick Azabo, a computer scientist, created the term "smart contracts" in 1994. “A smart contract is a computerized transaction protocol that performs the provisions of a contract,” he explained. The overall goals are to meet common contractual constraints (such as payment terms, liens, secrecy, and even enforcement), limit malicious and unintentional exceptions, and reduce the need for trusted intermediaries. Lowering fraud loss, arbitration and enforcement expenses, and other transaction costs are all related economic goals.” Although it is true that bitcoin was the first dapp, dapps have come a long way since then. Since the creation of the Ethereum Blockchain, it has been the leading place for the establishment of these dapps because it was designed expressly for this purpose, not only to support cryptocurrency but also to allow a wide range of applications to run on its technology and network (Hu et al, 2021). Ethereum is generally known as the second most recognized cryptocurrency after Bitcoin. Because it was created specifically for this reason, not just to support bitcoin but also to allow a wide range of applications to run on its technology and network, the Ethereum Blockchain has been the primary site to produce these dapps from its inception (Hu et al, 2021). Ethereum, like all cryptocurrencies, is based on a blockchain network.

A blockchain is a decentralized, distributed public ledger that verifies and records all transactions. It's distributed in the sense that everyone on the Ethereum network has a duplicate of this ledger, allowing them to observe all previous transactions. It's decentralized in the sense that the network isn't run or maintained by a single entity, but rather by all of the distributed ledger owners. Cryptography is used in blockchain transactions to keep the network safe and verify transactions. Computers are used to "mine," or tackle complicated mathematical equations, that approve each transaction on the network and introduce additional blocks to the blockchain, that at its base. Tokens of bitcoin are offered to attendees as a reward. These tokens are known as Ether in the Ethereum system (ETH). Ether, like Bitcoin, may be used to buy and trade goods and services. Its price has also risen rapidly in recent years, making it a de facto speculative investment. However, Ethereum is unique in that users may create apps that "run" on the blockchain in the same way that software "runs" on a computer. These programs may store and transfer personal information as well as process sophisticated financial transactions (Chen et al, 2020).

Fig. 16- Ethereum Blockchain Network (Chen et al, 2020)

2.10 Ethereum Benefits

Existing network of considerable magnitude. “The virtues of Ethereum are an attempted-and-proper network that has been examined through years of operation and billions of dollars in value trading hands,” According to Fromm. “It boasts the greatest ecosystem in blockchain and cryptocurrency, as well as a vast and dedicated global community.” A wide range of functions are available. Ethereum can be used to perform different sorts of financial transactions, execute smart contracts, and store data for third-party applications in addition to being utilized as a digital currency. Constantly evolving. Ethereum's developer community is always seeking for new methods to improve the network and create new applications. “Ethereum tends to be the favored blockchain network for innovative and exciting (and sometimes hazardous) decentralized applications because of its popularity,” Avital notes.

Avoids the use of middlemen. The decentralized Ethereum network promises to free users from third-party intermediates like attorneys who draft and interpret contracts, banks who operate as financial intermediaries, and third-party site hosting providers (Kuma et al, 2021).

Chapter 3

Research Methodology

3.1. Introduction

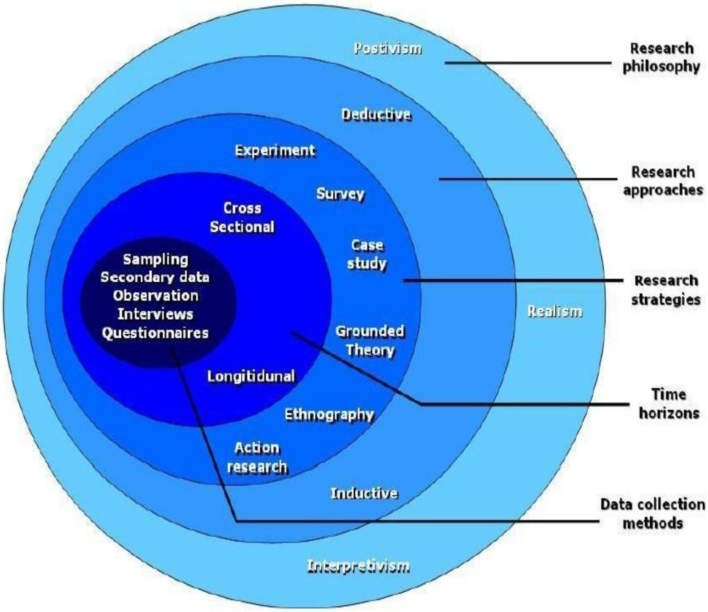
In this chapter, the researcher should select a research strategy in accordance with the research approach and collect and analyze data using appropriate methods. The present study also requires the use of these guidelines and follows them. The research method provides the framework for search operations or actions to achieve the purpose of the research, to test the hypothesis, or to answer the research questions. Therefore, the research method is appropriate to be selected based on research propositions. This section describes the research paradigm, research method, statistical population, sampling method, measurement tools, reliability, validity as well as the data analysis method.

3.2 Philosophical Foundations / Research Paradigm and Research Method

The research method is a strategy that includes the philosophical assumptions of the research design as well as how to collect the data. In this study, due to the adoption of a comprehensive approach to "Developing an innovative platform based on the Ethereum Blockchain to implement the 2030 agenda in Italy", it is necessary to try to understand how to explain the phenomenon in the real context. Therefore, a qualitative approach has been used.

The interpretive study does not predefine independent and dependent variables but focuses on the complete complexity of human meaning that occurs in a variety of situations (Myers, 1997). Based on the layers of the research onion (Saunders et al., 2009):

Figure. 17 - Research onion, Saunders et al. (2009) in research methodology



The first layer represents the researcher's worldview and view of the world. Based on this layer, the type of researcher's view in this research is the interpretive view of phenomena.

• In the second layer, since the results of this research are based on a developed model, located in the world, and used for the case study of the research, so this research is developmental research.

• In the third layer, the type of philosophical worldview adopted by the researcher is identified. In this study, due to the normative approach to the use of the Ethereum Blockchain to implement the 2030 agenda, a deductive approach has been used.

• In the fourth layer, the researcher can adopt any of the quantitative, qualitative, or combined methods in terms of resorting to quantifying the behavior of the phenomenon. In this research, a qualitative approach has been used.

• In the fifth layer, the researcher has used the field study and library method for each stage of

theoretical studies and text analysis.

• In the sixth layer, the researcher can apply different strategies based on the choice he has in each of the higher layers. The strategy adopted in this research has been a systematic review and theme analysis.

According to the seventh layer, the researcher has used exploration and understanding in this research.

• In the eighth layer, the researcher uses different methods to collect and analyze research data, depending on what approach, strategy, and method has been used in the higher layers. In this study, the semi-structured interview method has been used.

3.3 Statistical population and statistical sample

The statistical population of this research is in the stage of systematic literature review, studies from 2015 to 2020 in the field of blockchain and its applications according to the described protocol. In the field of content analysis, the statistical community consists of experts and university professors, and administrators who have a history of study or implementation in the field of understanding blockchain theories and models and their applications, especially in the field of sustainability. Attempts have been made to select an equal number of experts for interviews from both the academic and executive groups. The characteristics of these people are listed in Table. 8.

Table. 8- Profile of the experts interviewed

Respondent Code	Age	Education	Position	Background	level of familiarity with blockchain
P1	46	Ph.D.	Assistant Professor and Member of the advisory board of blockchain in the ministry of economic development of Italy	Information Engineering	High
P2	27	Ph.D.	Marie Curie s Researcher in Aalborg Business school	Business, Electrical engineering	Medium
P3	41	Ph.D.	Postdoc	Machine Learning	Medium
P4	45	Ph.D. + postd oc	Head of Department	Politics, economics, computer science	Advanced
P5	30	Ph.D.	Researcher	IoT and technology convergence , digital twin .	Good
P6	40	Ph.D.	Assistant Professor	Information Systems	High
P7	32	Ph.D.	Researcher	Blockchain technology in the field of security and privacy	Medium
P8	28	Ph.D.	Researcher	Big Data Management	High

3.4 Statistical Sampling and Sampling Method

In the thematic analysis stage, the purposive sampling method is used to select the sample, which is a non-probability method. The adequacy of sampling has been done by the theoretical sampling method of the researcher. In doing so, they use a method that requires synchronization and sequential selection of data and their analysis. In theoretical sampling, in-depth interviews go so far as to reach theoretical saturation. In other words, when the research has reached a point of decline in the field of data collection, we can be sure that the research has been sufficient. Therefore, first, a judgmental method has been used to select the sample in the sense that one of the leading academic experts in the field of blockchain and its applications especially in the field of sustainability has been contacted, and then the purposeful sampling method. It has been used as a snowball, i.e., with the introduction of other experts, managers, in this field by the first expert or manager. Relying on the purposeful snowball sampling method, finally, eight of the mentioned people have been selected and interviewed.

3.5 Implementation and Results of Systematic literature Review Method

According to Fink (2005), a literature review is a systematic, explicit, and reproducible plan for identifying, evaluating, and interpreting documented records. A review of the literature often pursues two main objectives (Seuring & Müller, 2008). First, it summarizes current studies by identifying patterns, themes, and issues.

Second, it assists to identify the conceptual content of a field and plays a role in the development of theory. To conduct a systematic review, the researcher should use rules or protocols for selecting previous articles and sources.

3.5.1 Systematic Literature Review Protocol

In this regard, the method of the current project in reviewing the literature is taken from the seven stages of a systematic review by Scaringella & Radziwon (2018), which are:

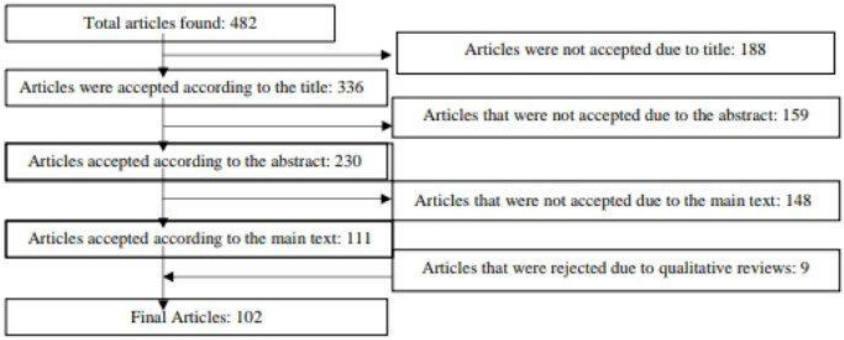
1) Initial search
2) Studies to determine the scope of research (Scoping studies)
3) Search for articles
4) Article selection
5) Reference articles backtracking
6) Content analysis of articles
7) Invariant Analysis

In the search for articles and sources, the following keywords were searched by referring to reputable scientific databases:

- Blockchain
- Applications of blockchain
- The benefits of blockchain
- Blockchain Use case
- Blockchain challenges and opportunities
- Blockchain technology
- Blockchain and sustainable development
- Blockchain Solutions
- Blockchain/Innovationione

In the next step, the title and the abstract of the articles were reviewed. At this stage, several articles that were not related in terms of compliance with the purpose of the research, i.e., the applications of blockchain in the development of sustainability, were removed. In the following, the main text of the articles that were accepted both in terms of title and abstract was reviewed and the proposed models, the dominant features discussed blockchain, and a detailed study of the discussion and conclusions of these articles were reviewed. Finally, in the seventh step, a complete review of the specifications, features, dimensions, and points of view provided for each of the blockchain applications described in the articles was performed to provide a comprehensive view of all blockchain applications, especially in accordance with the three modules. Data were obtained, governance and sustainability, and finally, the model of blockchain applications in these three modules and their 17 sub-modules were identified. Figure. 18 shows the selection steps from the beginning to the end of the articles:

Figure. 18- Steps for selecting articles (Researcher)



3.5.2 Conducting a systematic literature review steps based on the protocol

Based on the protocol and the steps mentioned for the final selection of articles, Table. 9 shows the analysis of the final articles (102) reviewed from the databases:

Table. 9- Final articles reviewed from databases (Researcher)

	Title of Article	Author(s)	Methodology	Date
1.	Blockchain Technology for the Advancement of the Future	Nguyen and Dang	Analytical-Review	2018
2.	Distributed Ledger Technology: beyond blockchain	UK Government Office for Science	Analytical-Review	2016
3.	Blockchain Disruption and Smart Contracts.	Cong, L. W., and He, Z.	Analytical - conceptual	2019
4.	Blockchain for Government Services – Use Cases, Security Benefits, and Challenges.	Alketbi et al	Analytical-Review	2018
5.	Blockchain and AI-based Solutions to Combat Coronavirus(COVID-19)-like Epidemics: A Survey.	Nguyen, D., Ding, M., and Pathirana, P.	Analytical-conceptual	2020
6.	Blockchain in healthcare applications: Research challengesand opportunities.	McGhin, T., Choo, K.R., and Liu, C.Z.	Analytical-Review	2019
7.	Blockchain-Based Applications in Higher Education: A Systematic Mapping Study 2020.	Awaji, B., Solaiman, E., and Albshri, A.	Analytical-Review	2020
8.	Benefits and Obstacles of BlockchainApplications in e-Government.	Alexopoulos et al	Analytical-Review	2019
9.	Reputation-based Distributed Knowledge Sharing System in Blockchain.	Hu,S.,Hou,L.,and Chen,G.	Analytical-conceptual	2018
10.	CitySense: blockchain-oriented smart cities.	Ibba, S., Pinna, A., and Seu, M.	Analytical-conceptual	2017
11.	Addressing Water Sustainability with Blockchain Technology and Green Finance.	Poberezhna, A.	Analytical-conceptual	2018
12.	Blockchain technology in the energy sector: A systematic review of challenges and opportunities.	Andoni, M., Robu, V., and Flynn, D.	Analytical-Review	2018
13.	Can CryptocurrencAssistting to Pave the Way to a More Sustainable Economy? Questioning the Economic Growth Paradigm.	Leonard D.,Treiblmaier H.	Analytical-Review	2019
14.	System architecture for blockchain-based transparency of supply chain social sustainability.	Venkatesh,V.G., Kang, K.,and Wang, B.	Analytical-conceptual	2020
15.	Blockchain-Based Settlement for Asset Trading.	Chiu, J., and Koeppl, T.V.	Quantitative-Experimental	2019
16.	Blockchain tokens and the potential democratization of entrepreneurship and innovation.	Chen, Y.	Analytical-Review	2018
17.	The blockchain as a sustainable business model innovation.	Tiscini, R., Testarmata, S., Ciaburri, M. and Ferrari, E.	Analytical-conceptual	2020
18.	Blockchain for 5G-enabled IoT for industrial automation: A systematic review, solutions, and challenges.	Mistry, I., Tanwar, S., Tyagi, S.	Analytical-Review	2020

19.	Blockchain technology: Is it hype or real in the construction industry?	Perera, S., Nanayakkara, S., and Rodrigoa, M.N.N.	Analytical-Review	2020
20.	Blockchain critical succesfactor for sustainable supply chain.	Yadav, S., Singh, S.P.	Analytical-conceptual	2020
21.	Triple entry ledgers with blockchain for auditing.	Simoyama, F.O., and Grigg, I.	Analytical-Review	2017
22.	Blockchain in Developing Countries.	Kshetri, N., Voas, J.	Analytical-Review	2018
23.	Blockchain governance and the role of trust service providers: The Trusted Chain network.	Atzori	Analytical-Review	2017
24.	The Application of Blockchain Technology in E-Government in China.	Hou	Analytical-conceptual	2017
25.	Blockchain: Opportunities for Health Care.	Krawiec et al	Analytical-Review	2016
26.	Blockchain and its Suitability for Government Applications.	Mark et al	Analytical-Review	2018
27.	Blockchain as a Next Generation Government Information Infrastructure: A Review of Initiatives in D5 Countries.	Ojo and Adebayo	Analytical-Review	2017
28.	Blockchain For Intelligent Transport System.	Balasubramaniam, A., Jami, M., Icon, G.	Analytical-conceptual	2020
29.	Blockchain for smart cities: A review of architectures, integration trends and future research directions.	Bhushan, B., Khamparia, A., Sagayam, K. M.	Analytical-Review	2020
30.	Tokenizing coopetition in a blockchain for a transition tocircular economy.	Narayan, R., and Tidström, A.	Analytical-conceptual	2020
31.	Blockchain and agricultural supply chains traceability: research trends and future challenges.	Mirabelli, G., Solina, V.	Analytical-Review	2020
32.	Utility of the Blockchain for Climate Mitigation..	Chen, D.B.	Analytical-Review	2018
33.	An effective blockchain-based, decentralized application for smart building system management.	Xu, Q., He, Z., and Li, Z.	Quantitative-Experimental	2020
34.	Design of a Smart Manufacturing System with the Application of Multi-Access Edge Computing and Blockchain Technology.	Lee, C. K. M.	Quantitative-Experimental	2020
35.	Blockchain for Internet of Energy management: Review, solutions, and challenges.	Miglani, A., Kumar, N., and Chamola, V.	Analytical-conceptual	2020
36.	Building trust and equity in marine conservation and fisheries supply chain management with blockchain.	Howson, P.	Analytical-Review	2020
37.	Blockchain and Internet of Things-Based Technologies for Intelligent Water Management System.	Dogo, E. M., Salami, A. F., and Nwulu, N. I.	Quantitative-Experimental	2019
38.	Blockchain with IoT, an Emergent Routing Scheme for Smart Agriculture.	Awan, S. H., Zaman, K., and Ahmed, S.	Quantitative-Experimental	2020
39.	Blockchain's roles in strengthening cybersecurity and protecting privacy.	Kshetri	Analytical-Review	2017
40.	Proposing the use of blockchain to improve the solid waste management in small municipalities.	França, A.S.L., Neto, J.A., Gonçalves, R.F.	Analytical-conceptual	2020
41.	Blockchain Primer: Enabling Blockchain Innovation in the U.S. Federal Government.	ACT-IAC	Analytical-Review	2017
42.	Blockchains Unchained: blockchain technology and its use in the public sector.	Berryhill, et al	Analytical-conceptual	2018
43.	Blockchain in the Government Technology Fabric.	DATTA	Analytical-Review	2019
44.	Algorithmic Government: Automating Public Services and Supporting Civil Servants in using	Engin, Z., and Treleaven, P.	Analytical-Review	2019

Data Science Technologies.			
45. Using blockchain to improve data management in the public sector.	Cheng, S., Daub,M., and Domeyer, A.	Analytical-Review	2019
46. Blockchain for Open Data – Explorin Conceptual Underpinnings and Practice.	Joseph, B.K.	Analytical-Review	2019
47. Blockchain with Internet of Things: benefits, challenges, and future directions.	Atlam,H.F.,and Alenezi,A	Analytical-conceptual	2018
48. Blockchain for government.	Palfreyman	Analytical-Review	2015
49. Proof of witness presence: Blockchain consensus for augmented democracy in smart cities.	Pournaras, E.	Analytical-conceptual	2020
50. Trust, but verify: Why the blockchain needs the law.	Werbach, K	Analytical-Review	2018
51. On legal contracts, imperative and declarative smart contracts, and blockchain systems.	Governatori, G., Idelberger, F., and Milosevic, Z.	Analytical-conceptual	2018
52. Blockchain Technology as a Support Infrastructure in e- Government.	Ølnes, S., Jansen, A	Analytical-Review	2017
53. The Interplay between Decentralisation and Privacy: the case of Blockchain technologies.	De Filippi	Analytical-Review	2017
54. Decentralizing Privacy: Using Blockchain to Protect Personal Data.	Zyskind and Nathan	Quantitative-Experimental	2015
55. Changing Governance Models by Applying BlockchainComputing.	Young, s	Analytical-Review	2018
56. Blockchain and OECD data repositories: opportunities and policymaking implications.	Sicilia, M and Visvizi, A	Analytical-conceptual	2019
57. An innovative IPFS-based storage model for blockchain.	Zheng et al	Quantitative - Experimental	2018
58. ArmChain-A Blockchain-Based Sensor Data Communication for the Vehicle as a Mobile Sensor Network.	Yusuf et al	Analytical-conceptual	2019
59. Blockchain for good?	Kewell, B., et al	Analytical-Review	2017
60. The Blockchain for IMPACT.	Ixo Protocol	Analytical-Review	2017
61. Statistical model of investment evolution in European Union in the context of a blockchain system.	Anghel, M.-G., et al	Quantitative - Experimental	2019
62. Privacy-Preserving Statistical Analysis of Health Data Using Paillier Homomorphic Encryption and Permissioned Blockchain.	Ghadamyari, M. et al	Quantitative - Experimental	2019
63. The Role of Collaborative Governance in Blockchain-Enabled Supply Chains: A Proposed Framework.	McCurdy	Analytical-conceptual	2020
64. A blockchain-based authorization system for trustworthy resource monitoring and trading in smart communities.	Alcarria, R., et al	Quantitative - Experimental	2018
65. MCS-Chain: Decentralize and trustworthy mobile crowdsourcing based on blockchain.	Feng, W	Analytical-conceptual	2019
66. Crypto-coin hierarchies: social contestation in blockchain networks.	Bousfield, D	Analytical-Review	2019
67. Collaborative and accountable hardware governance using blockchain.	Kundu, A., et al.	Analytical-conceptual	2018
68. Blockchains and the G20: Building an inclusive, transparent, and accountable digital economy.	Maupin, J.A., et al.	Analytical-Review	2017
69. Blockchain entrepreneurship opportunity in the practices of the Unbanked.	Larios-Hernández	Analytical-Review	2017
70. Privacy-preserving and Efficient Aggregation based on Blockchain for Power Grid Communications in Smart Communities.	Guan et al	Analytical-conceptual	2019

71. Blockchain for 5G-enabled IoT for industrial automation.	Mistrya et al	Analytical-Review	2020
72. Study on Ocean Intelligence Service Security Utilizin Blockchain Technology.	Kim et al	Analytical-Review	2019
73. Blockchain contributions for the climate finance: introducing a debate.	Neves and Prata	Analytical-Review	2018
74. Blockchain platform and future bank competition.	Harris	Analytical-conceptual	2018
75. Blockchain: The Ministry of economic development launches a call for experts.	The Ministry of Economic Development of Italy	Analytical-Review	2020
76. Research on the Development Trend of Traditional Financial Industry Based on Blockchain Technology.	Fu and Zhu	Analytical-Review	2020
77. Will Blockchain Revolutionize Mortgage Lending?	Patel	Analytical-Review	2019
78. Blockchain for humanitarian action and development aid.	Zwitter and Boisse- Despiaux	Analytical-Review	2018
79. Towards Blockchain Technology to Support Digital Government.	Zein and Twinomurinzi	Quantitative - Experimental	2019
80. Blockchain for Open Science and Sustainable Development Goals.	Rachovitsa	Analytical- Review	2108
81. Banking on Blockchain: Costs Savings Thanks to the Blockchain Technology.	Cocco et al	Quantitative - Experimental	2017
82. Blockchain and the United Nations Sustainable Development Goals: Towards an Agenda for IS Research.	Medaglia and Damsgaard	Analytical-Review	2020
83. Blockchain: A technological tool for sustainable development or a massive energy consumption network?	Palacio	Analytical-Review	2018
84. Blockchain and Internet of Things-Based Technologies for Intelligent Water Management System.	M. Dogo et al	Analytical-Review	2019
85. Digital Certificate System for Verification of Educational Certificates using Blockchain.	Badhe	Analytical-conceptual	2020
86. A Systematic Review of the Use of Blockchain in Healthcare.	Hölbl et al	Analytical-Review	2018
87. Assessing the Merits of Blockchain Technology for Global Sustainabl Development Initiatives.	Chamberlain	Analytical-Review	2019
88. Blockchain Enhancing Political Accountability?	Chohan	Analytical-Review	2018
89. Blockchain technology for social impact: opportunities and challenges ahead.	Al-Saqafa and Seidlerb	Analytical-Review	2017
90. Blockchain and its relevance to intellectual property law in the fashion industry.	Sacha	Analytical-Review	2019
91. Design of the blockchain smart contract: A use case for real estate.	Karamitsos et al	Analytical-conceptual	2018
92. 17 Blockchain Applications That Are Transforming Society.	Rosic	Analytical-Review	2017
93. Blockchain government - a next form of infrastructure for the twenty-first century.	Jun	Analytical-Review	2018
94. Governance and control in distributed ledgers: Understanding the challenges facing blockchain technology in financial services.	Zachariadis et al	Analytical-Review	2019
95. A governance framework with permissioned blockchain for the transparency in e-tendering process.	Mustafa and Waheed	Analytical-conceptual	2019
96. A blockchain-enabled participatory decision support framework.	Laskowski, M. A	Analytical-conceptual	2017
97. Blockchain Based Digital Health Care OBOR Polices Framework.	Batool	Analytical-Review	2019

98. Improving Data Security, Interoperability, and Veracity using Blockchain for One Data Governance, Case Study of Local Tax Big Data.	Wibowo and Sandikapura	Analytical-Review	2019
99. How Sentiment Impacts the Success of Blockchain Startups–An Analysis of Social Media Data and Initial Coin Offerings.	Albrecht, S., et al	Quantitative - Experimental	2019
100. Blockchain in internet of things: challenges and solutions.	Dorri et al	Analytical-conceptual	2016
101. Blockchain for the IoT: Privacy-Preserving Protection of Sensor Data.	Chanson et al	Analytical-conceptual	2019
102. Integrating blockchain technology for data collection and analysis in wireless sensor networks with an innovative implementation.	Wang, S., et al	Analytical-conceptual	2018

3. 5.3 Descriptive reviews of the selected articles

Figure. 19- Descriptive diagram of the articles reviewed (Researcher)

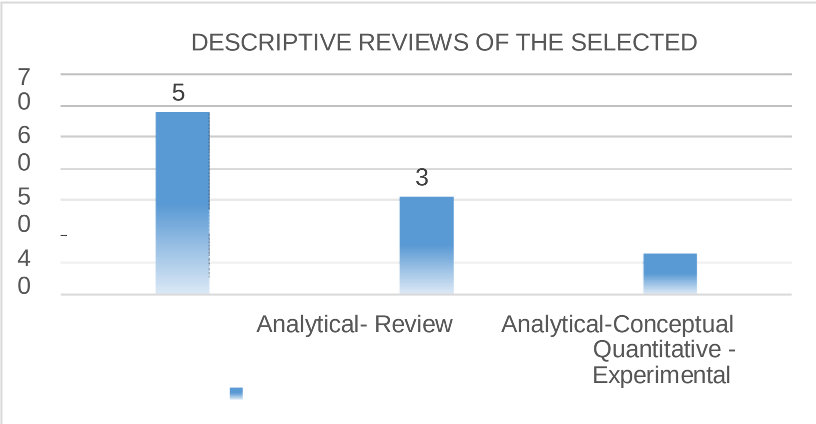
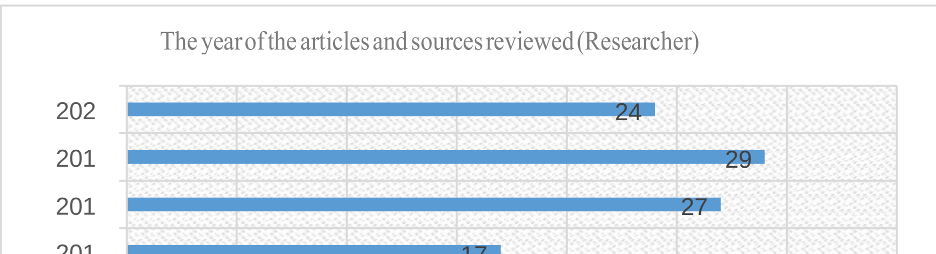


Figure. 20- Descriptive chart of the year of publication of the articles and sources reviewed (Researcher)



3. 5.4 Content review of selected articles

After studying the reviewed articles, first, all the applications of blockchain obtained in a variety of fields from the articles have been extracted, and then the blockchain use cases selected which have appropriate to improve the implementation of the three modules of data, governance, and sustainability according to by textual content analysis method and relying on the researcher's knowledge. and are organized as extracted codes from the articles reviewed. An example of this raw (open) coding is given in Table. 10

Table. 10-The Raw (open) extracted codes in the field of blockchain applications in three modules: data, governance, and sustainability from the reviewed articles (Researcher)

Author (year)	Application provided for blockchain	Relevant sub-Module	Relevant Module	Repetition in sources
(Sicilia and Visvizi, 2019),(Chen et al, 2020) (Alexopoulos et al, 2019) (De Filippi, 2017)	Ethereum and Smart Contracts	Statistical Data	Data module	4
(Anghel, M.-G., et al, 2019),(Ghadamyari, M. et al, 2019)	Investment evolution data Health Data	Statistical Data	Data module	2
(Zheng et al. 2018), (Chen et al, 2020), (Alexopoulos et al, 2019) (De Filippi, 2017)	Ethereum and (IPFS)	Statistical Data	Data module	4
(Yusuf et al. 2019), (Patel, 2019), (Chanson, M., et al, 2019), (Wang, S., et al, 2018)	Blockchain-based IoT	Sensor Data	Data module	4
(Alexopoulos et al, 2019 (Cheng et al, 2017) (Chanson et al, 2019) (Dorri et al, 2016) (Albrecht, S., et al, 2019) (Xu, R., et al, 2018)	Privacy	Social Data	Data module	6
(Hou, 2017), (Badhe, 2020) ,(ACT-IAC, 2017), (Alketbi et al, 2018), (Wibowo and Sandikapura, 2019), (Batool, 2019)	Records Management	Social Data	Data module	6
(Engin and Treleaven, 2018)	Public Engagement	Collaborative Governance	Governance module	1
(McCurdy, 2020)	Collaborative Governance in Blockchain-Enabled Supply Chains	Collaborative Governance	Governance module	1
(Werbach, 2018)	Legal Enforcements	Adaptive Governance	Governance module	1
(Governatori et al, 2018)	Legal Contracts	Adaptive Governance	Governance module	1
(Pournaras, 2020), (Atzori, 2017), (Young, 2018), Laskowski, M. A	Decision-Making	Adaptive Governance	Governance module	4
(Alexopoulos et al, 2019), (Simoyama, 2017), (Engin and Treleaven, 2018),(Palacio 2018),(Alketbi et al, 2018), (Hou, 2017), (Krawiec et al, 2016), (De Filippi, 2017), (Hu et al, 2018), (Atzori, 2017), (Ibba et al, 2017), (Mustafa and Waheed, 2019)	Transparency and Transparent Budgeting	Trustworthy Governance	Governance module	12

(Young, 2018) (Chamberlain, 2019)	Prevent from Abusing Power	Fair Governance	Governance module	2
(Qlnes et al, 2017), (Alexopoulos et al, 2019) (Chamberlain, 2019), (Alcarria, 2018), (Feng and Yan, 2019), (Zyskind and Nathan, 2015), (Zachariadis et al, 2019), (ACT-IAC, 2017),(Fu and Zhu, 2020) (Krawiec et al, 2016), (Hou, 2017), (Jun, 2018)	Increased Trust	Trustworthy Governance	Governance module	12
(Nguyen and Dang, 2018) (Engin and Treleaven, 2018), (Tapscott and Tapscott, 2016)	E-Democracy and Voting	Fair Governance	Governance module	3
(ACT-IAC, 2017) ,(Rosic, 2017), (Karamitsos et al, 2018), (Sacha, 2019, Cheng, 2019), (Chamberlain, 2019) (UK Government Office for Science, 2016), (Cong and He, 2019), (DATTA, 2019)	Smart Contracts	Trustworthy Governance	Governance module	8
Alcarria, R., et al., (2018) Feng, W., (2019)	Trustworthy resource monitoring Trustworthy mobile crowdsourcing	Trustworthy Governance	Governance module	2
(Hou, 2017)	Promoting the Integration of Resources	Network Governance	Governance module	1
(Hou, 2017)	Management System	Network Governance	Governance module	1
Bousfield, D.(2019) Atzori, M. (2017)	Global Networks Trusted Chain network	Network Governance	Governance module	2
(Joseph, 2019), (Al-Saqafa and Seidlerb, 2017), (Hu et al, 2018), (B.Chen, 2018) (Chohan, 2018, Funk, 2018)	Accountability	Accountable Governance	Governance module	5
(Zyskind and Nathan (2015)	Increased Control	Accountable Governance	Governance module	1
(Kundu, A., et al., 2018) (Maupin, J.A., et al., 2017)	Accountable hardware Governance using blockchain Building an accountable digital economy	Accountable Governance	Governance module	2
(Berryhill, et al, 2018), (Tapscott and Tapscott, 2016) ,(Alexopoulos et al, 2019)	Data Integrity and Higher Data Quality	Inclusion of Stakeholders	Sustainability module	3

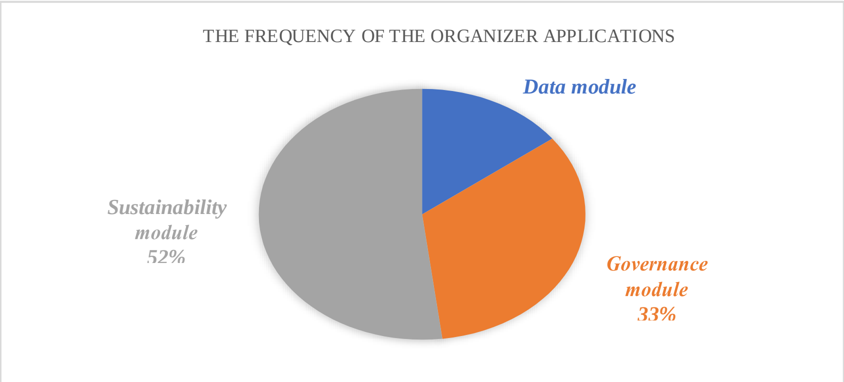
(Alexopoulos et al, 2019) (Pournaras, 2020)	Consensus Mechanisms	Priority Ranking of the SDGs	Sustainability module	2
(Krawiec et al, 2016) (M. Dogo et al, 2019)	Operations Cost Reduction	Integrated Assessment Models	Sustainability module	2
(Alexopoulos et al, 2019) (Rachovitsa, 2108)	Openness	Integrated Assessment Models	Sustainability module	2
(DATTA, 2019)	Smart Contracts (Quality of Service)	Integrated Assessment Models	Sustainability module	1
(Hu et al, 2018)	Better Share Knowledge	Sharing and Management of Knowledge	Sustainability module	1
Implementation of the SDGs			**Sustainability module**	
(Kshetri and Voas, 2018)	Property Rights	SDG. 1 (No Poverty)	Sustainability module	1
(Ixo Protocol, 2017)	Decentralized Digital Finance	SDG. 1 (No Poverty)	Sustainability module	1
(Larios-Hernández, 2017) (Chen, 2018)	A new entrepreneurial landscape	SDG. 1 (No Poverty)	Sustainability module	2
(Cong and He, 2019), (Nguyen and Dang, 2018), (Chamberlain, 2019)	Improved Welfare	SDG. 1 (No Poverty)	Sustainability module	3
(Nguyen and Dang, 2018), (Chamberlain, 2019), (Cong and He, 2019)	Public Welfare	SDG. 1 (No Poverty)	Sustainability module	3
(Kewell et al, 2017)	Financial Inclusion	SDG. 1 (No Poverty)	Sustainability module	1
(Nguyen and Dang, 2018)	Charity Activities	SDG. 2 (Zero Hunger)	Sustainability module	1
(UK Government Office for Science, 2016)	Benefits, Entitlements, and Aid	SDG. 2 (Zero Hunger)	Sustainability module	1
(Alketbi et al, 2018), (McGhin et al, 2019), (Hölbl et al, 2018), Mistrya et al, (2020), Bhushan et al, (2020) (Patel, 2019), (Fu and Zhu, 2020)	Healthcare	SDG. 3 (Good Health)	Sustainability module	8
(Awaji et al, 2020) (Badhe, 2020)	Education	SDG.4 (Quality Education)	Sustainability module	2

(Pinna and Ibba, 2018), (Medaglia and Damsgaard, 2020), (Zwitter and Boisse- Despiaux, 2018)	Temporary Employment	SDG. 5 (Gender Equality)	Sustainability module	3
(M. Dogo et al, 2019), (Poberezhna, 2018)	Efficient Water Management	SDG. 6 (Clean Water)	Sustainability module	2
(Miglani et al, 2020), (Guana et al, 2019)	Smart Energy	SDG. 7 (Affordable and Clean Energy)	Sustainability module	2
(Krawiec et al, 2016)	Boosting Operational and Financial Capacities	SDG. 8 (Economic Growth)	Sustainability module	1

(Kshetri, 2017) (Leonard an Treiblmaier, 2019), (Palacio 2018), (Medaglia and Damsgaard, 2020),(Cocco et al. 2017)	Economic Growth	SDG. 8 (Decent Work and Economic Growth)	Sustainability module	5
(Yadav and Singh 2020) ,(Mistrya et al, 2020)	Sustainable Supply Chain	SDG.9 (Industry Innovation)	Sustainability module	2
(Tiscini et al, 2020), (Narayan and Tidström, 2020), (Kewell et al, 2017), (Larios Hernández, 2017), (Rachovitsa, 2108), (Chen, 2018)	Sustainable business model innovation	SDG.9 (Industry Innovation)	Sustainability module	6
(Mistrya et al, 2020), (Zein and Twinomurinzi, 2019)	Industrial Sectors	SDG.9 (Industry Innovation)	Sustainability module	2
(Mark G.,2018), (Nguyen and Dang, 2018), (UK Government Office for Science, 2016), (Zwitter and Boisse- Despiaux, 2018)	The Conveyance of Funds	SDG.10 (Reduce Inequality)	Sustainability module	4
(Xu et al, 2020)	Smart Building	SDG.11 (Sustainable Cities and Communities)	Sustainability module	1
(Bhushan et al, 2020), (Mistrya et al, 2020), (Patel, 2019),(Fu and Zhu, 2020)	Smart Cities	SDG.11 (Sustainable Cities and Communities)	Sustainability module	4
(Ibba et al, 2017), (Pournaras, 2020)	Citizen Participation	SDG.11 (Sustainable Cities and Communities)	Sustainability module	2
(Lee et al, 2020)	Smart Manufacturing	SDG.12 (Responsible Consumption and Production)	Sustainability module	1
(Narayan and Tidström, 2020), (Ministry of Economic Development, 2020)	Circular Economy	SDG. 12 (Responsible Consumption and Production)	Sustainability module	2
(Mirabelli and Solinaa, 2020)	Agricultural Supply Chain	SDG.12 (Responsible Consumption and Production)	Sustainability module	1
(Balasubramaniam et al, 2020), (Nguyen and Dang, 2018)	Intelligent Transport System	SDG. 13 (Climate Action)	Sustainability module	2
(B. Chen,2018), (Neves and Prata, 2018), (Harris, 2018)	Climate Action	SDG. 13 (Climate Action)	Sustainability module	3
(Howson, 2020),(Kim et al, 2019)	Oceans Protection	SDG. 14 (Life Below Water)	Sustainability module	2
(Awan et al, 2020) (Mistrya et al, 2020)	Smart Agriculture	SDG.15 (Life on Land)	Sustainability module	2
(França et al, 2019)	Solid Waste Management	SDG.15 (Life on Land)	Sustainability module	1

(ACT-IAC, 2017)	Land Title Registry	SDG.15 (Life on Land)	Sustainability module	1
(Kshetri,2017),(Simoyama, 2017),(Atzori,2017), (Palfreyman,2015)	Reducing Corruption	SDG. 16 (Peace, Justice, and Strong Institutions)	Sustainability module	4
(Alexopoulos et al, 2019), (Guana et al, 2019)	Strengthening the Government Credibility	SDG. 16 (Peace, Justice, and Strong Institutions)	Sustainability module	2
(ACT-IAC, 2017)	Streamlining Interagency and Cross-sector Processes	SDG. 17 (Partnership for the Goals)	Sustainability module	1
(Cheng et al, 2017) (Hou, 2017)	Building Networked Public Services	SDG. 17 (Partnership for the Goals)	Sustainability module	2

Figure. 21- Descriptive diagram of the frequency of the organizer applications, extracted from resources (Researcher)

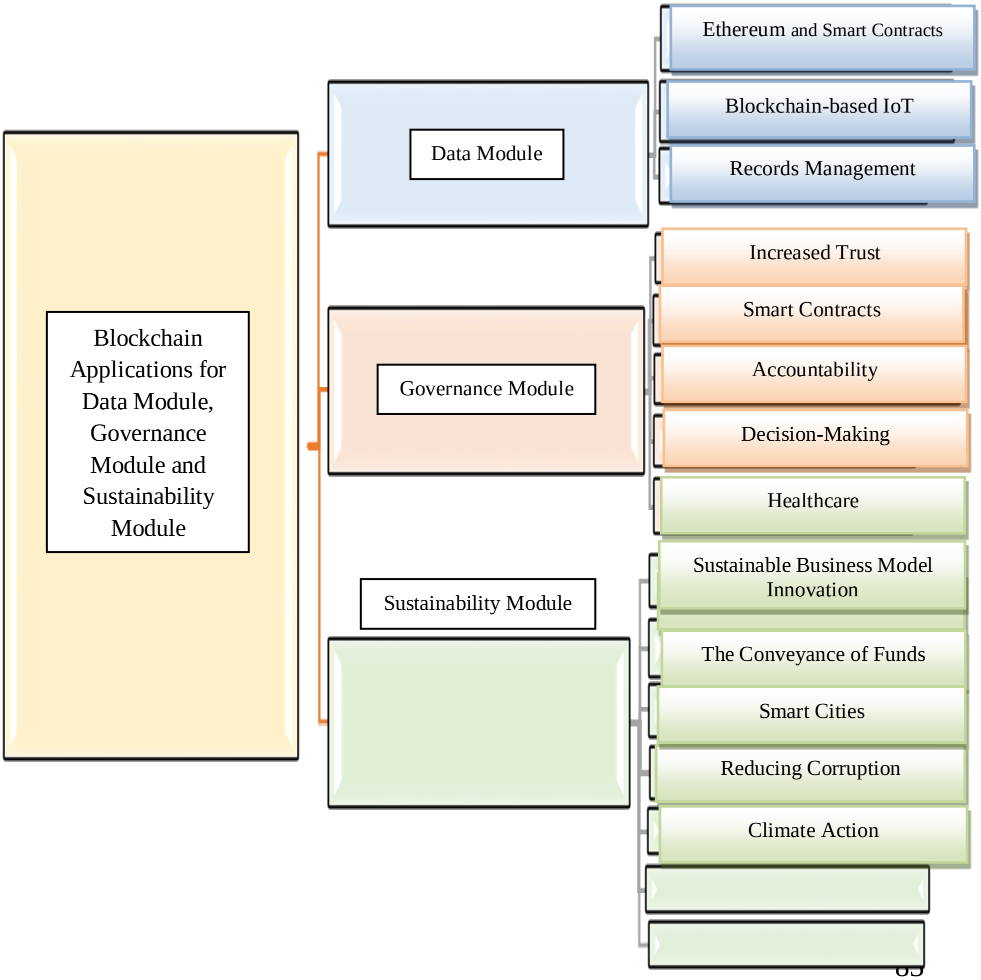


3.5.5 Extracting the proposed framework of "Blockchain

Applications in three modules of data, governance, and sustainability"from a systematic literature review

Based on the final codes extracted from the systematic literature review reviewed in Table .10, 15 extracted applications can be organized into three modules: data, governance, and sustainability, in form of the framework reflected in Figure. 22.

Figure. 22- Framework of blockchain applications in three modules of data, governance, and sustainability based on the results of systematic literature review (Researcher)



6. Thematic Analysis Method

One of the simple and efficient methods of qualitative analysis is thematic analysis. Thematic analysis is the first method of qualitative analysis that researchers must learn. This approach addresses the basic skills needed for many qualitative analyzes (Holloway & Todres, 2003). Thematic analysis is one of the common skills in qualitative analysis; For this reason, Boyatzis (1998) introduces it not as a specific method but as a suitable tool for different methods. thematic analysis should be considered as a special method, the most important advantage of which is flexibility. Thematic analysis is a method for identifying, analyzing, and reporting patterns in qualitative data. This method is a process for analyzing textual data and converting scattered and diverse data into rich and detailed data (Braun & Clarke, 2006). Thematic analysis is not just a specific qualitative method, but a process that can be used in most qualitative methods. In general, content analysis is a method for:

A- Seeing the text.

B- Appropriate perception of seemingly irrelevant information.

C- Qualitative information analysis.

D- Systematic observation of person, interaction, group, situation, organization, or culture.

E- Conversion of qualitative data in to quantitative data

(Boyatzis, 1998).

In thematic analysis, the unit of analysis is more than one word or term, and more attention is paid to the context of the data and their subtleties. Also, thematic analysis goes beyond the counting of obvious words and phrases and focuses on recognizing and explaining explicit and implicit ideas.

Then, the main content codes are used for deeper data analysis. In thematic analysis, the relative abundance of themes can be used to compare them, prepare a thematic matrix, and plot a thematic network (Namey et al., 2007). Thematic analysis, unlike other qualitative methods, does not depend on a pre-existing theoretical framework, and can be used in different theoretical frameworks for different purposes. Thematic analysis is also a method used to both express and explain reality (Braun & Clarke, 2006). In general, the theme is a repetitive and distinctive feature in the text that, according to the researcher, indicates a special understanding and experience in relation to research questions (King & Horrocks, 2010). In terms of content typology, due to the variety of methods used in content analysis and the diversity of viewpoints, there are different titles and classifications for themes. Some researchers have categorized themes in terms of nature and others in terms of their position and hierarchy in content analysis. A summary of the types of themes according to their classification basis is presented in Table.11. These titles may overlap or be used interchangeably. But what is important is to use appropriate titles for the topics, according to the techniques and methods used in the research.

Table. 11- Types of themes from the perspective of experts (Researcher)

Classification basis	Types of themes	Theme description	Researcher
Time to identify the theme	• Priori • Final	• It is known in the early stages of research. • It is presented in the final research report.	Ryan and Bernard, 2003
The nature of the theme in the text	• Descriptive • Interpretive • Relational	• It describes what is in the text as it is. • Interprets what is in the text. • Indicates the type of relationship in the text.	King and Horrocks, 2010
Thematic hierarchy in the form of themes	• Main • Sub	• At higher levels the hierarchy of themes is placed. • At lower levels the hierarchy of themes is placed.	King, 2004 and Ryan and Bernard, 2003
The position of the theme in the theme network	• Global • Organizer • Basic	• It is at the center of the network of themes. • It is the intermediary between the global • themes and the basic themes • It indicates an important point in the text, and by combining them, the organizer theme is created.	Attride-Stirling, 2001
Ability to view the theme in the text	• Semantic • Latent	• Be visible directly in the text. • Not be directly visible in the text.	Braun and Clarke, 2006
Origin of theme identification	• Data driven • Theory-oriented	• It is known based on research data. • It is known based on theories and research.	Braun and Clarke, 2006
The role of theme in analysis	• Overarching • Integrative • key	• It contains a large part of known themes and codes. • Brings together key themes around a common axis. • It shows an important and prominent point in the text.	King and Horrocks, 2010
Theme position stabilization	• Free • Tree	• Its position and relationship with other themes are not clear. • Its position and relationship with other themes are clear.	Richards, 2008

Theme cognition is one of the most important and sensitive tasks in qualitative research and in other words, it is the heart of the thematic analysis. Conventional consciousness, researcher values, orientations and research questions, and the researcher's experience on the subject affect how the themes are identified. Because thematic analysis is a qualitative analysis, there is no clear and quick answer to what the amount of appropriate and required data is, which indicates the existence or application of a content. The theme, therefore, does not necessarily depend on quantitative criteria; Rather, it depends on how important a point it is about research questions (Fereday & Cochrane, 2006). According to Braun & Clarke, (2006) and King & Horrocks, (2010), although there is no well-defined rule of theme recognition, appropriate guiding principles can be used to define and recognize it, some of which are:

- First, knowing the theme never means simply finding something interesting in the data, but requires the researcher to determine what to look for in the data. What should be ignored and how should the data be analyzed and interpreted?
- Second, the word "theme" implicitly and to some extent indicates "repetition"; Therefore, an issue that appears only once in the text of the data cannot be considered "content" (unless it has a prominent and important role in the final analysis of the data). Typically, repetition means seeing and appearing in two or more cases in the text.
- Third, the themes must be distinct from each other. Although overlap between themes is somewhat inevitable, a proper understanding of analysis and interpretation cannot be provided without a well- defined boundary between different themes.

What is a thematic network? The thematic network is a convenient method of the thematic analysis developed by Attride-Stirling (2001). What the thematic network offers are web-like roles as the organizing principle and presentation method. The thematic network, systematizes basic themes (codes and key points of the text), organizing themes (themes derived from the combination and summarization of basic themes), and global themes (excellent themes containing the principles governing the text as a whole) based on a specific process. Then these themes are shown in the form of web maps, drawings, and prominent themes of each of these three levels along with the relationships between them. Contrary to the theme formatting method, a thematic network is represented graphically and similarly to a website to eliminate the idea of any hierarchy between them, to float the themes, and to emphasize the interdependence and interrelationship between the networks. However, it should be noted that these networks are merely analytical tools and not self-analysis.

Once a thematic network has been developed, it can be used as a visual tool for text interpretation to make the results of the text and the text itself clear and understandable to the researcher and readers of the study (Attride-Stirling, 2001).

3.6.1 Interview design and validation

Applying the interview method in research requires certain steps. Wall (1996) outlines seven steps in the interview process:

Defining the topic: Determining the goals and describing the concepts related to the topic (theme) is the first step in the interview process.

In the present study, first the purpose of the subject, namely, "the use of the Atrium China block to implement the 2030 agenda", has been identified and then the related concepts have been discussed in detail in the systematic review section. The interviews conducted in the present study were conducted with an exploratory approach. Their purpose was not to test hypotheses, but the main purpose was to answer the main research question. According to the exploratory approach of the present study, the interviews conducted were semi-structured. In semi-structured interviews, the game questions are pre-arranged, but only the general atmosphere of the interview is clear, and the interviewer and the interviewee follow the topic of discussion in conversation and interaction. Of course, this does not mean the dispersion of data and the possibility of deviating from the process and results of the research, because the researcher in all stages of conducting interviews and data collection, has set a certain range for the subject and ongoing interviews. In qualitative research, the main goal is to produce interpretation and discover meaning. For this reason, it requires questions that have the necessary flexibility and freedom to study the phenomenon. Therefore, questions must be open and wide, but not so open as to encompass everything, nor so limited as to preclude the possibility of new discoveries. In research based on thematic analysis, interview questions should be arranged in a special way. In this research, by taking the opinions of professors and the researcher based on a complete study of literature and relying on three data modules, governance, and stability in the field. The subject area has been research, a design of interview questions has been done.

Design: Following the determination of the purpose and content of the interview using the "topic determination" stage, the planning of the study plan begins. In the present study, after determining the subject and choosing the interview method, the general planning of the interviews has been designed. At the beginning of this stage, the focus of the research is defined in detail and the words, phrases, concepts, questions, and topics related to the research are identified.

***Interview situation*:** The interview is conducted according to the set guidelines. In the short and limited time of the interview, the researcher is obliged to provide a safe and friendly environment to exchange ideas effectively. In the current research, to enter the interviews, the process followed by the researcher includes personal introduction, stating the purpose of the research, expressing confidentiality about the information, and explaining why the interviewee was selected for this interview. In the present study, the same cases have been emphasized by the researcher.

***Duplication*:** Preparing the information obtained in the interview for analysis. In this process, an oral interview becomes a coherent text. In the present study, the information received from the interviewees in the interview session was recorded by the interviewer and at the same time notes were taken. The interviews were then transcribed electronically using Word software.

Analysis: Interview analysis can be part of theorizing, theory testing, or application of findings. The purpose, title, and nature of the materials and information contained in the interview determine which method is most appropriate for analyzing the interview. In this study, to analyze the data obtained from the interviews, the method of coding and determining the main and secondary topics in qualitative analysis has been used.

Validation: In a qualitative study, validity refers to the extent to which the researcher's observation has been able to reflect the phenomenon under study or related concepts. In the present study, the acceptance criterion is used to confirm the findings, which is described in the evaluation section of the research.

Reporting: Reporting is the process of communicating the findings of an interview using the methods used based on scientific criteria, considering ethical considerations, and finally presenting the results as a written product. The purpose of reporting is to provide important and reliable findings to other researchers or the community. The present research report is presented in the data analysis section under the narration of the thematic analysis.

Research Project Interview
Dear Expert, Given the subject of the present study, "Developing an Innovative Platform based on the Ethereum Blockchain to Implement the 2030 Agenda in Italy". This research aims to explore the contribution of blockchain technology to

the improved implementation of the 2030 Agenda in Italy. You are in an ideal position to give us valuable information from your own perspective. Therefore, I would like to kindly ask you to participate in this interview and answer the following questions. In this interview, it is ensured that the utmost fidelity and privacy of the interviewees are taken into consideration.

First, the concepts of "Blockchain Technology and its applications", "Sustainable Development Goals" and "The Novel ICT Framework" are introduced to further clarify the subject.

- Blockchain Technology is a decentralized, transactional database technology that facilitates validated, tamper-resistant transactions consistent across many heterogeneous network participants, and comes with promises of tackling issues of trust, decentralization, and transparency among a wide variety of individuals, organizations. for example, has the potential to enhance supply chain transparency, support circular economies, and reduce information asymmetry in resource management.

- The 2030 Agenda represent the global action plan of the United Nations to eradicate poverty, protect the planet, and ensure prosperity for all, which is included seventeen Sustainable Development Goals (SDG)s.
- Goal 1. End poverty
- Goal 2. End hunger
- Goal 3. Healthy lives
- Goal 4. Inclusive education
- Goal 5. Gender equality
- Goal 6. Sustainable management of water
- Goal 7. Sustainable energy
- Goal 8. Sustained economic growth
- Goal 9. Sustainable industrialization
- Goal 10. Reduce inequality
- Goal 11. Sustainable cities
- Goal 12. Sustainable consumption and production patterns
- Goal 13. To combat climate change
- Goal 14. Sustainable use of the oceans
- Goal 15. Sustainable use of terrestrial ecosystems
- Goal 16. Promote peaceful and inclusive societies
- Goal 17. Strengthen the means of implementation for Sustainable Development

- A Novel ICT Framework to offer an extraordinary platform to address the complexity of sustainable development goals (SDGs) have been provided by Kostoska and Kocarev in 2019. The framework includes three basic modules (Data Module, Sustainability Module, and Governance Module). The Data Module included three sub-modules: *Statistical Data, Sensor Data, and Social Data*. and provides input data for the sustainability module and governance module. The Governance Module includes six submodules, *adaptive governance, trustworthy governance, network governance, collaborative governance, accountable governance, and fair Governance*. The Sustainability Module includes six submodules, *mapping the SDGs at the local level, ensuring the inclusion of the stakeholders, providing priority ranking of the SDGs, sharing and managing the knowledge, delivering integrated assessment models, and implementing the SDGs* at the local level and also for improved implementation of the seventeen SDGs.

- This research aims to explore the contribution of blockchain technology for the improved implementation each of the three modules of the Novel ICT Framework to address the 2030 Agenda.

Q1. Please introduce yourself fully. (Age, background (especially in the field of digital information technology, education, level of familiarity with blockchain technology).

	Age	Education	Position	Background	level of familiarity with blockchain

➢ Expert Answer:					

Q2. In general, what is your perception of blockchain technology and its applications, especially in the areas of sustainable development goals (economic, social and environmental)?

➢ Expert Answer:

Q3. In your field of professional or academic activity, have you had any executive experience in carrying out projects in the blockchain filed based on practical experience? If yes, please explain and list its applications in your professional field.

➢ Expert Answer:

Q4. In general, do you think blockchain can Assisting to better execute Three Modules of Data, Governance, and Sustainability of the Novel ICT Framework of Kostoska and Kocarev, (2019)?

➢ Expert Answer:

Q5. How much do you agree with the following options regarding the use of blockchain to improve the implementation of the "Data Module"? is there a use case that you do not approve of? Why? Do you think there is another option in the better implementation of the "Data module" that is not on this list?

Blockchain Use Cases	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
Ethereum and Smart Contracts (Sicilia et al, 2019)					
Ethereum and (IPFS) (Zheng et al. 2018)					
Blockchain-based IoT (Yusuf et al. 2019)					
Increased Trust (Qlnes et al, 2017)					
Records Management (Hou, 2017)					
Privacy (Alexopoulos et al, 2019)					

Expert Answer:

Q6. How much do you agree with the following options regarding the use of blockchain to improve the implementation of the "Governance Module"? (Please highlight them.). Is there a use case that you do not approve of? Why? Do you think there is another option for the better implementation of the " governance module" that is not on this list?

Blockchain Use Cases	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
Decision-Making (Pournaras, 2020)					
Transparency (Alexopoulos et al, 2019)					
LegalEnforcements (Werbach, 2018)					
SmartContracts (ACT-IAC, 2017)					
Promoting the Integration of Resources (Hou, 2017)					
Increased Control (Zyskind and Nathan (2015)					
E-Democracy and Voting (Nguyen and Dang, 2018)					
Legal Contracts (Governatori et al, 2018)					
Prevent from Abusing Power (Young, 2018)					
Increased Trust (Qlnes et al, 2017)					
Consensus Mechanisms (Alexopoulos et al, 2019)					
Management System (Hou, 2017)					

Public Engagement (Engin and Treleaven, 2018)					
Accountability (Joseph, 2019)					
Expert Answer:					

Q7. How much do you agree with the following options regarding the use of blockchain to improve the implementation of the " Sustainability Module"? Is there a use case that you do not approve of? Why? Do you think there is another option in the better implementation of the " sustainability module" that is not on this list?

Blockchain Use Cases	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
Smart Contracts (Quality of Service) (DATTA, 2019)					
Consensus Mechanisms (Alexopoulos et al, 2019)					
Smart Energy(Miglani et al, 2020)					
Smart Agriculture (Awan et al, 2020)					
Smart Building(Xu et al, 2020)					
Smart Manufacturing (Lee et al, 2020)					
Smart Cities (Bhushan et al, 2020)					
Agricultural Supply Chain (Mirabelli and Solinaa, 2020)					
Sustainable Supply Chain (Yadav and Singh 2020)					
Decision-Making (Pournaras, 2020)					
Citizen Participation (Ibba et al, 2017)					
Public Engagement (Engin and Treleaven, 2018)					
E-Democracy and Voting (Nguyen and Dang, 2018)					
Openness (Alexopoulos et al, 2019)					
Reducing Corruption (Kshetri, 2017)					
Decentralized Digital Finance (ixo Protocol, 2017)					
Boosting Operational and Financial Capacities(Krawiec et al, 2016)					
Financial Inclusion (Kewell et al, 2017)					
Sustainable business model innovation (Tiscini et al, 2020)					
Economic Growth (Leonard and Treiblmaier, 2019)					
Circular Economy (Narayan and Tidström, 2020)					
Transparent Budgeting (Simoyama, 2017)					
The Conveyance of Funds (Mark G.,2018)					
Charity Activities (Nguyen and Dang, 2018)					
Benefits and Aid (UK Government Office for Science, 2016)					
Improved Welfare (Cong and He, 2019)					

Public Welfare (Nguyen and Dang, 2018)					
OperationsCostReduction (Krawiec et al, 2016)					
Land Title Registry (ACT-IAC, 2017)					
Property Rights (Kshetri and Voas, 2018)					
Promoting the Integration of Resources (Hou, 2017)					
A new entrepreneurial landscape (Chen, 2018)					
Industrial Sectors (Mistrya et al, 2020)					
Education (Awaji et al, 2020)					
Efficient Water Management (M. Dogo et al, 2019)					
Healthcare (Alketbi et al, 2018)					
Intelligent Transport System (Balasubramaniam et al, 2020)					
Solid Waste Management (França et al, 2019)					
Climate Action (B. Chen, 2018)					
Oceans Protection (Howson, 2020)					
Expert Answer:					
Q8. In general, from your point of view, what strategies are effective for improving the applications of blockchain technology in various dimensions of sustainable development at the levels of science and technology policy? Do you have an example or experience of applying these strategies in the planning of government and business organizations?					
Expert Answer:					
Thank you so much for your valuable time for this interview					

6.3 Validity and Reliability of the Instrument

Qualitative research does not have specific tests to reliabilities it, and the nature of the research is often determined and modified by the researcher himself, and there may not even be any initial hypothesis. Therefore, the nature of the concept of validity in qualitative research is related to the representation of participants, research objectives and appropriateness of processes.

In qualitative research, reliability or validity does not have the same implicit meaning of validity in quantitative research and validity comparison is not significant. Internal validity is defined as: " internal validity deals with the question of how research findings match facts?" The question is whether what has been studied and found is what really exists and what researchers observe is what they think has been measured. To strengthen the internal reliability of qualitative research, the following has been suggestedeven steps in the interview process:

Pluralism: Several researchers, multiple data sources, or multiple methods are used to validate emerging data in the present study, interviews with elites (from different groups were performed as described in the statistical population of the study.

Theory pluralism: Using several theories and attitudes to interpret andexplaindata.Inthisstudy, based on the systematic literature review, an in-depth study of the blockchain applications in the field of sustainability has been done and the models in them have been studied.

Participating feedback: Presenting interpretations and results to participants by the researcher and identifying and correcting misunderstood cases: In this research, the results of interpretations are presented to professors and academic experts and their opinions are received.

Long-term observations of site visits or repetitive observations of similar phenomena: Data were collected over periods of time, with the aim of increasing the validity of the findings.

Receiving the opinions of colleagues: In this study, the explanations and results of the researcher have been reviewed by other researchers and colleagues by reviewing the results by respected professors and advisors.

Leaving aside prejudices: In this research, the researcher at the beginning of the research has identified his assumptions, theoretical tendencies, and prejudices and has prevented them from interfering in the research process.

Minimal intervention in description: In this research, descriptive expressions such as "quotation" have been used for this purpose.

Contradictions of expectation: In this research, the search and investigation of cases inconsistent with the explanations of the researcher have been considered. Therefore, to increase the internal validity, the methods of pluralism, pluralism theory, participatory feedback, long-term observation in visiting the research site, and minimal intervention in describing and receiving the opinions of colleagues have been used . In this research, the 6-step method of Braun & Clarke (2006) has been used for thematic analysis in the form of a Table. 12:

Table. 12-Step-by-step process of thematic analysis
and thematic network (Braun&Clarke,2006)

Phase	Step	Action
1.Analyze text	1.Familiarity with the text	• Write the data (if necessary) • Preliminary study and re-reading of data • write initial ideas
	2. Generate source code and coding	• Propose a coding framework and prepare a theme template • Split the text into smaller sections • Coding interesting data features
	3.Search and identify topics	• Match the codes with the theme template • Extract themes from coded sections of text • Refine and review themes
2. Explanation and interpretation of the text	4. Drawing themes networks	• Check and control the consistency of the themes with the extracted codes • Sort themes • Selection of the basic, organizer and global themes • Mapping themes • Modify and approve the theme network
	5.Theme Nework Analysis	• Defining and naming themes • Describe and explain themes network
3.Text composition and integration	6.Compilatio nofreports	• Summarize the network of topics and its concise and explicit expression • Extract interesting data samples • Writing scientific and specialized reports of analyzes

3. 6. 4. Steps to implement thematic analysis

Step 1: Familiarize yourself with the data when starting content analysis**.** In this study, first, the researcher has studied the complete and in-depth text of the data extracted through the interviews, to first get an overview of the concepts and themes of the interviewees.

Step 2: Creating the initial codes and coding. In this study, the researcher, after the initial study of the text of the interviews, has encoded the textual data obtained from the key sentences extracted from the interviews and has organized and extracted them in the form of words and phrases. In the first step, all duplicate and non-duplicate codes are extracted, and in the second step, duplicate codes are removed, and the codes are integrated. The results of both the first and second steps are given in Table.13.

Table. 13- Results of stages 1 and 2 of thematic analysis

(extraction of key text sentences and basic themes) (Researcher)

N	**Respondent Code**	**Keywords Interview Text**	**Basic Theme**
1	P1	I think that blockchain technology could provide a tool/platform to enable/facilitate the implementation of a variety of social coordination mechanisms.	A platform to enable/facilitate the implementation of a variety of social coordination mechanisms
2	P1	Thesemechanismscouldaimattacklingrelevant economic, social, and environmental problems.	Tackling economic, social, and environmental problems
3	P1	Through virtuous behavior (such as use of renewable energy sources) tokenization, it could be possible to design better and more far-reaching incentives towards sustainable behaviors.	Virtuous behavior tokenization

4	P1	Using tokens, it could be possible to design more focused and ad hoc public support policies, such as UBI.	Using tokens
5	P1	New forms of funding are enabled by blockchain.	New forms of funding
6	P1	Identity representation and management (SSI) blockchain- based project has been implemented.	Identity representation and management (SSI)
7	P1	Energy markets blockchain-based project has been implemented.	Energy markets
8	P1	Energy communities credit rewarding blockchain-based project has been implemented.	Energy communities credit rewarding
9	P1	Ethereum and Smart Contracts	Ethereum and Smart Contracts
10	P1	Ethereum and (IPFS)	Ethereum and (IPFS)
11	P1	Records Management	Records Management
12	P1	Privacy	Privacy
13	P1	Decision-Making	Decision-Making
14	P1	Transparency	Transparency
15	P1	Legal Enforcements	Legal Enforcements
16	P1	Accountability	Accountability
17	P1	Agricultural Supply Chain	Agricultural Supply Chain
18	P1	Citizen Participation	Citizen Participation
19	P1	Decentralized Digital Finance	Decentralized Digital Finance
20	P1	Financial Inclusion	Financial Inclusion
21	P1	Sustainable business model innovation	Sustainable business model innovation
22	P1	Economic Growth	Economic Growth
23	P1	Economic Growth	Economic Growth
24	P1	Transparent Budgeting	Transparent Budgeting
25	P1	Charity Activities	Charity Activities
26	P1	Benefits and Aid	Benefits and Aid
27	P1	Improved Welfare	Improved Welfare
28	P1	Blockchain-based IoT	Blockchain-based IoT
29	P1	Smart Contracts	Smart Contracts
30	P1	Promoting the Integration of Resources	Promoting the Integration of Resources
31	P1	E-Democracy and Voting	E-Democracy and Voting
32	P1	Legal Contracts	Legal Contracts
33	P1	Prevent from Abusing Power	Prevent from Abusing Power
34	P1	Increased Trust	Increased Trust

35	P1	Consensus Mechanisms	Consensus Mechanisms
36	P1	Management System	Management System
37	P1	Public Engagement	Public Engagement
38	P1	Smart Contracts (Quality of Service)	Smart Contracts (Quality of Service)
39	P1	Smart Energy	Smart Energy
40	P1	Smart Agriculture	Smart Agriculture
41	P1	Smart Building	Smart Building
42	P1	Smart Manufacturing	Smart Manufacturing
43	P1	Smart Cities	Smart Cities
44	P1	Sustainable Supply Chain	Sustainable Supply Chain
45	P1	Public Engagement	Public Engagement
46	P1	Openness	Openness
47	P1	Reducing Corruption	Reducing Corruption
48	P1	Boosting Operational and Financial Capacities	Boosting Operational and Financial Capacities
49	P1	Public Welfare	Public Welfare
50	P1	Operations Cost Reduction	Operations Cost Reduction
51	P1	Land Title Registry	Land Title Registry
52	P1	Property Rights	Property Rights
53	P1	Promoting the Integration of Resources	Promoting the Integration of Resources
54	P1	A new entrepreneurial landscape	A new entrepreneurial landscape
55	P1	Industrial Sectors	Industrial Sectors
56	P1	Education	Education
57	P1	Efficient Water Management	Efficient Water Management
58	P1	Healthcare	Healthcare
59	P1	Intelligent Transport System	Intelligent Transport System
60	P1	Solid Waste Management	Solid Waste Management
61	P1	Climate Action	Climate Action
62	P1	Oceans Protection	Oceans Protection
63	P2	Blockchaintechnologyisoneofthenewest technologiesand no one can underestimate its role in SDGs.	From the latest technologies
64	P2	In terms of economic sustainability, it can Assisting us through new supply chains and targeting new customers through new channels.	New supply chains and targeting new customers with new channels
65	P2	In terms of social sustainability, it increases trust and transparency between B2C and even B2B levels.	Increase trust and transparency between B2C and even B2B levels

66	P2	Increases peer-to-peer (P2P) trade in the energy sector.	Peer-to-peer (P2P) trading in the energy sector
67	P2	Improves charging of electric vehicles in the energy sector.	Charging electric vehicles in the energy sector
68	P2	The Internet of Things has been expanded by it.	IoT Expansion
69	P2	Has expanded smart networks.	Extent of smart networks
70	P2	Has developed cryptocurrencies in the energy sector.	Increasing cryptocurrency in the energy sector
71	P2	It enhances data security, data quality, data traceability, data sharing and real-time data analysis.	Security, quality, traceability, data sharing and analysis
72	P2	blockchain technology has the potential to make government operations more efficient.	Making government operations efficient
73	P2	It can improve public services and build more trust.	Improving the provision of public services
74	P2	Lack of interconnection between departments raises more concerns about data integrity and compatibility.	Solve the problem of lack of interrelationship between departments with data integration and compatibility
75	P2	Increases sustainability by Assisting to strengthen collaboration between consumers and producers.	Assisting strengthen cooperation between consumers and producers
76	P2	Assisting people to adopt more sustainable ways of life has an emerging role in sustainability.	Helpingn people adop t more sustainable lifestyles
77	P2	Assisting companies improve supply and recycling resources has an emerging role in sustainability.	Assisting companies improve supply and recycling resources has an emerging role in sustainability.
78	P2	It can guarantee transparency.	Transparency
79	P2	Blockchain provides a verifiable record of who buys from whom.	Traceability of seller and buyer
80	P2	Companies' claims that resources are positive, and their environmental impacts are reduced can be checked and confirmed by blockchain.	Reducing environmental impacts
81	P2	Ethereum and smart contracts	Ethereum and smart contracts
82	P2	Blockchain-based IoT	Blockchain-based IoT
83	P2	Increased Trust	Increased Trust
84	P2	Records Management	Records Management
85	P2	Privacy	Privacy

86	P2	Transparency	Transparency
87	P2	Legal Enforcements	Legal Enforcements
88	P2	Promoting the Integration of Resources	Promoting the Integration of Resources
89	P2	Increased Control	Increased Control
90	P2	E-Democracy and Voting	E-Democracy and Voting
91	P2	Legal Contracts	Legal Contracts
92	P2	Prevent from Abusing Power	Prevent from Abusing Power
93	P2	Smart Contracts	Smart Contracts
94	P2	Improving service quality	Improving service quality
95	P2	Smart Energy	Smart Energy
96	P2	Smart Agriculture	Smart Agriculture
97	P2	Smart Building	Smart Building
98	P2	Smart Manufacturing	Smart Manufacturing
99	P2	Smart Cities	Smart Cities
100	P2	Smart Cities	Smart Cities
101	P2	Agricultural Supply Chain	Agricultural Supply Chain
102	P2	Sustainable Supply Chain	Sustainable Supply Chain
103	P2	E-Democracy and Voting	E-Democracy and Voting
104	P2	Openness	Openness
105	P2	Sustainable business model innovation	Sustainable business model innovation
106	P2	Economic Growth	Economic Growth
107	P2	Circular Economy	Circular Economy
108	P2	Transparent Budgeting	Transparent Budgeting
109	P2	Benefits and Aid	Benefits and Aid
110	P2	Public Welfare	Public Welfare
111	P2	Operations Cost Reduction	Operations Cost Reduction
112	P2	Land Title Registry	Land Title Registry
113	P2	Property Rights	Property Rights
114	P2	Promoting the Integration of Resources	Promoting the Integration of Resources
115	P2	A new entrepreneurial landscape	A new entrepreneurial landscape
116	P2	The first step is to understand what the blockchain is.	Understanding the applications and benefits of blockchain
117	P2	Managers and CEOs need to be educated about the opportunities and risks of using this technology, at the same time.	Educating managers about the opportunities and risks of using this technology.

118	P2	The second step is to develop a business case and choosing the blockchain according to their needs.	Developing a business case and selecting the blockchain according to the needs.

119	P2	The last and most important is to create an ecosystem of partners. Because blockchain works best when more stakeholders are involved.	Creating an ecosystem of partners and stakeholders.
120	P3	I think Blockchain is a new paradigm shift in economics that has a significant impact on social and environmental dimensions.	A new paradigm shift in economics.
121	P3	We are going to use machine learning and in-depth learning to make a proposal for fraud detection in Bitcoin.	Detection of fraud in Bitcoin based on machine learning.
122	P3	I think based on the capacity for transparency and security in the Blockchain approach, we can expect practical ways to deal with data, governance, and sustainability in the future.	Increase the capacity for transparency and security.
123	P3	Ethereum and Smart Contracts	Ethereum and Smart Contracts
124	P3	Blockchain-based IoT	Blockchain-based IoT
125	P3	Increased Trust	Increased Trust
126	P3	Records Management	Records Management
127	P3	Privacy	Privacy
128	P3	Smart Contracts	Smart Contracts
129	P3	Consensus Mechanisms	Consensus Mechanisms
130	P3	Smart Energy	Smart Energy
131	P3	Smart Agriculture	Smart Agriculture
132	P3	Smart Building	Smart Building
133	P3	Smart Manufacturing	Smart Manufacturing
134	P3	Smart Cities	Smart Cities
135	P3	Agricultural Supply Chain	Agricultural Supply Chain
136	P3	Decision-Making	Decision-Making
137	P3	Citizen Participation	Citizen Participation
138	P3	Improvement Public Engagement	Improvement Public Engagement
139	P3	E-Democracy and Voting	E-Democracy and Voting
140	P3	Openness	Openness

141	P3	Reducing financial Corruption	Reducing financial Corruption
142	P3	Decentralized Digital Finance	Decentralized Digital Finance
143	P3	Boosting Operational and Financial Capacities	Boosting Operational and Financial Capacities
144	P3	Financial Inclusion	Financial Inclusion
145	P3	Sustainable business model innovation	Sustainable business model innovation
146	P3	Economic Growth	Economic Growth
147	P3	Circular Economy	Circular Economy
148	P3	Transparent Budgeting	Transparent Budgeting
149	P3	Transfer of funds of charitable activities	Transferoffundsofcharitableactivities
150	P3	Benefits and Aid	Benefits and Aid
151	P3	Improved public Welfare	Improved public Welfare
152	P3	Operations Cost Reduction	Operations Cost Reduction
153	P3	Land Title Registry	Land Title Registry
154	P3	Property Rights	Property Rights
155	P3	Promoting the Integration of Resources	PromotingtheIntegrationofResources
156	P3	A new entrepreneurial landscape	A new entrepreneurial landscape
157	P3	Industrial Sectors	Industrial Sectors
158	P3	Education and Efficient Water Management	Education and Efficient Water Management
159	P3	Healthcare	Healthcare
160	P3	Intelligent Transport System	Intelligent Transport System
161	P3	Solid Waste Management	Solid Waste Management

162	P3	Climate Action and Oceans Protection	Climate Action and Oceans Protection
163	P3	Smart Contracts	Smart Contracts
164	P3	Decision-Making	Decision-Making
165	P3	Transparency	Transparency
166	P3	Legal Enforcements	Legal Enforcements
167	P3	Promoting the Integration of Resources	PromotingtheIntegrationofResources
168	P3	E-Democracy and Voting	E-Democracy and Voting
169	P3	Legal Contracts	Legal Contracts
170	P3	Prevent from Abusing Power	Prevent from Abusing Power
171	P3	Increased Trust	Increased Trust
172	P3	Consensus Mechanisms	Consensus Mechanisms
173	P3	Improvement Public Engagement	Improvement Public Engagement
174	P3	Accountability	Accountability
175	P3	We can classify the effective factors into two different groups including change resistance and deployment infrastructure.	Manage and reduce resistance to changethroughblockchaintechnology. Preparation and upgrading of blockchain deployment infrastructure.
176	P3	I think, like other paradigm shifts, this new model could force industry and other sections of society to use it.	I think, like other paradigm shifts, this new model could force industry and other sections of society to use it.
177	P3	The requirements for using this technology to suggest sustainable and better ways to solve the real problem increase.	Providing requirements for the use of this technology.
178	P4	The inherent potential of this technology is enormous, especially in the case of SDGs. The challenge, however, is how to put technological insights into action.	Combininghighinherentpotentialwith providing solutions to turn technological insights into action.
179	P4	We created a prototype where blockchain and smart contracts can be used in reception centers, where illegal immigrants apply for legal protection and asylum status.	Tracking and authenticating illegal immigrants for legal protection and asylum status.
180	P4	Ethereum and Smart Contracts	Ethereum and Smart Contracts
181	P4	Increased Trust	Increased Trust
182	P4	Records Management	Records Management
183	P4	Privacy	Privacy
184	P4	Decision-Making	Decision-Making
185	P4	Transparency	Transparency

186	P4	Legal Enforcements	Legal Enforcements
187	P4	Promoting the Integration of Resources	Promoting the Integration of Resources
188	P4	Increased Control	Increased Control
189	P4	E-Democracy and Voting	E-Democracy and Voting
190	P4	Legal Contracts	Legal Contracts
191	P4	Increased Trust	Increased Trust
192	P4	Management System	Management System
193	P4	Public Engagement	Public Engagement
194	P4	Smart Energy	Smart Energy
195	P4	Smart Agriculture	Smart Agriculture
196	P4	Smart Building	Smart Building
197	P4	Smart Manufacturing	Smart Manufacturing
198	P4	Smart Cities	Smart Cities
199	P4	Agricultural Supply Chain	Agricultural Supply Chain
200	P4	E-Democracy and Voting	E-Democracy and Voting
201	P4	Reducing Corruption	Reducing Corruption
202	P4	Decentralized Digital Finance	Decentralized Digital Finance
203	P4	Transparent Budgeting	Transparent Budgeting
204	P4	Operations Cost Reduction	Operations Cost Reduction
205	P4	Land Title Registry	Land Title Registry
206	P4	Property Rights	Property Rights
207	P4	Education	Education
208	P4	Efficient Water Management	Efficient Water Management
209	P4	Healthcare	Healthcare
210	P4	Intelligent Transport System	Intelligent Transport System
211	P4	Solid Waste Management	Solid Waste Management
212	P4	Members of government, managers, or decision-makersare not able to know what blockchain and smart contracts are, andthereforecannotimagine whatkindofbenefitstheycan reap from them.	Educate and inform government officials and decision makers on what blockchain and smart contracts are and their applications.
213	P5	In my opinion, the most important advantage of the blockchain is that it creates transparency.	Creating transparency
214	P5	This leads to increased trust between institutions.	Increasing trust between institutions
215	P5	In the economic sector, contracts can be pursued, and this prevents systemic economic corruption.	Prevent systemic economic corruption

216	P5	Blockchain can be used to make elections transparent and increase voter security.	Transparency of elections and increase of voter security.
217	P5	Citizens can also use blockchain-based applications or platforms to worry less about privacy violations.	Increasing the privacy of individuals
218	P5	Convergence between the Internet of Things, Blockchain and ML is achieved with a technology convergence approach.	Convergence between IoT, Blockchain and ML with technology convergence approach

219	P5	Blockchain-based security solutions for H-IoT systems.	Blockchain-based security solutions for H-IoT systems.
220	P5	Blockchain offers Smart city, healthcare, industry 4.0, agriculture and transportation, and supply chain.	Smart city
			healthcare
			Approaching the fourth generation of industrial economics.
			Sustainability in transportation and supply chain.
221	P5	Scalability and inhomogeneity are the main features of blockchain.	Scalability and heterogeneity
222	P5	Eliminates the need for third parties.	Eliminate third party need.
223	P5	It can be a good solution for secure data sharing across multiple domains.	Provide security for secure data sharing across multiple domains.
224	P5	Blockchain can be a valuable tool in data management and management. Data security, inter-institutional trust, transparency, and privacy are the four areas in which Blockchain can be most focused.	A valuable tool in data management and privacy management
225	P5	Ethereum and Smart Contracts	Ethereum and Smart Contracts
226	P5	Blockchain-based IoT	Blockchain-based IoT
227	P5	Increased Trust	Increased Trust
228	P5	Records Management	Records Management
229	P5	Decision-Making	Decision-Making
230	P5	Transparency	Transparency
231	P5	Legal Enforcements	Legal Enforcements
232	P5	Public Engagement	Public Engagement
233	P5	E-Democracy and Voting	E-Democracy and Voting
234	P5	Increased Trust	Increased Trust
235	P5	Consensus Mechanisms	Consensus Mechanisms
236	P5	Smart Energy	Smart Energy
237	P5	Smart Agriculture	Smart Agriculture
238	P5	Smart Building	Smart Building
239	P5	Smart Manufacturing	Smart Manufacturing

240	P5	Smart Cities	Smart Cities
241	P5	Sustainable Supply Chain	Sustainable Supply Chain
242	P5	Citizen Participation	Citizen Participation
243	P5	E-Democracy and Voting	E-Democracy and Voting
244	P5	Decentralized Digital Finance	Decentralized Digital Finance
245	P5	Boosting Operational and Financial Capacities	Boosting Operational and Financial Capacities
246	P5	Sustainable business model innovation	Sustainable business model innovation
247	P5	The Conveyance of Funds	The Conveyance of Funds
248	P5	Charity Activities	Charity Activities
249	P5	Improved Welfare	Improved Welfare
250	P5	Operations Cost Reduction	Operations Cost Reduction
251	P5	Property Rights	Property Rights
252	P5	A new entrepreneurial landscape	A new entrepreneurial landscape
253	P5	Healthcare	Healthcare
254	P5	Intelligent Transport System	Intelligent Transport System
255	P5	Setting reference standards (due to heterogeneity among blockchain technologies.	Setting reference standards (due to Heterogeneity among blockchain technologies.
256	P5	Set reference standards among different digital technologies	Set reference standards among different digital technologies

257	P5	Determining the role of each stakeholder (determining the level of accountability and responsibility of each of the manufacturers, developers, and service providers).	Determining the role of each stakeholder (determining the level of accountability and responsibility of each of the manufacturers, developers, and service providers).
258	P5	The implemented frameworks must comply with international standards and regulations such as ISO 27000, ISMS, GDPR.	Compliance of implemented frameworks with international standards and regulations such as ISO 27000, ISMS, GDPR
259	P5	The technical infrastructure (hardware and software) should support Blockchain applications well.	Technical infrastructure support (hardware and software equipment)
260	P5	The use of blockchain should be alongside other digital technologies because blockchain has its own challenges.	Using blockchain along with other digital technologies.
261	P6	Blockchain is an important part of the Sustainable Development Goals, especially on economic issues.	An important component of sustainable development especially in economic issues.
262	P6	In the context of smart cities, using blockchain technology, the application of information technology is generally the main driver in "smartening" cities.	Smartening "Cities
263	P6	A new driver of technological change that incorporates many of the core technologies and protocols and its potential impact on intelligent societies.	A new driver of technological change includes many technologies and basic protocols
264	P6	Ethereum and Smart Contracts	Ethereum and Smart Contracts
265	P6	Blockchain-based IoT	Blockchain-based IoT
266	P6	Increased Trust	Increased Trust
267	P6	Decision-Making	Decision-Making
268	P6	Transparency	Transparency
269	P6	Legal Enforcements	Legal Enforcements
270	P6	Promoting the Integration of Resources	Promoting the Integration of Resources
271	P6	Increased Control	Increased Control
272	P6	E-Democracy and Voting	E-Democracy and Voting
273	P6	Legal Contracts	Legal Contracts
274	P6	Prevent from Abusing Power	Prevent from Abusing Power

275	P6	Consensus Mechanisms	Consensus Mechanisms
276	P6	Management System	Management System
277	P6	Accountability	Accountability
278	P6	Smart Energy	Smart Energy
279	P6	Smart Agriculture	Smart Agriculture
280	P6	Smart Building	Smart Building
281	P6	Smart Manufacturing	Smart Manufacturing
282	P6	Smart Cities	Smart Cities
283	P6	Agricultural Supply Chain	Agricultural Supply Chain
284	P6	Citizen Participation	Citizen Participation
285	P6	E-Democracy and Voting	E-Democracy and Voting
286	P6	Reducing Corruption	Reducing Corruption
287	P6	Decentralized Digital Finance	Decentralized Digital Finance
288	P6	Boosting Operational and Financial Capacities	Boosting Operational and Financial Capacities
289	P6	Sustainable business model innovation	Sustainable business model innovation
290	P6	Economic Growth	Economic Growth
291	P6	Circular Economy	Circular Economy
292	P6	Public Welfare	Public Welfare
293	P6	Operations Cost Reduction	Operations Cost Reduction
294	P6	Land Title Registry	Land Title Registry
295	P6	Property Rights	Property Rights
296	P6	Promoting the Integration of Resources	Promoting the Integration of Resources
297	P6	Efficient Water Management	Efficient Water Management
298	P6	Healthcare	Healthcare
299	P6	Intelligent Transport System	Intelligent Transport System
300	P6	Solid Waste Management	Solid Waste Management
301	P6	Climate Action	Climate Action
302	P6	Oceans Protection	Oceans Protection
303	P6	Businesses must be able to implement blockchain without stopping their projects.	Accelerate the implementation of blockchain in various Businesses.
304	P6	Blockchain technology allows individuals and organizations who may not know or trust each other to collectively agree and record information without third party registration.	Increasing the agreement coefficient on information by different groups.

305	P7	The information stored in this type of system is shared among all members of a network.	Increasetherateofsharinginformation stored on a network
306	P7	Eliminate the possibility of hacking, deleting, and manipulating recorded information by encrypting and distributing personal data.	Reduce and eliminate the possibility of hacking, deleting, and manipulating personally registered information
307	P7	It is a set of processes of intelligence, cryptography, mass distribution, etc. that gave rise to this idea.	A set of intelligence, encryption and information distribution processes.
308	P7	Used wherever storage space is needed and eliminates th need for trust.	Increasing the storage space of trusted information.

309	P7	By using this innovation, the risk of election fraud and the need for human resource can be greatly reduced.	Reduce and manage the risk of election fraud Reducing the need for human resource in elections
310	P7	Another example is the use of the Chinese block in supply and transportation.	Sustainable transportation
311	P7	Factories can register their goods and shipping information from the beginning to reach the customer in the database, which ensures the authenticity of the goods and the quality of raw materials for the customer.	Increasing the originality of goods and quality of raw materials for the customer in the supply chain of factories
312	P7	Ethereum and Smart Contracts	Ethereum and Smart Contracts
313	P7	Blockchain-based IoT	Blockchain-based IoT
314	P7	Increased Trust	Increased Trust
315	P7	Records Management	Records Management
316	P7	Privacy	Privacy
317	P7	Decision-Making	Decision-Making
318	P7	Transparency	Transparency
319	P7	Legal Enforcements	Legal Enforcements
320	P7	Promoting the Integration of Resources	Promoting the Integration of Resources
321	P7	E-Democracy and Voting	E-Democracy and Voting
322	P7	Legal Contracts	Legal Contracts
323	P7	Prevent from Abusing Power	Prevent from Abusing Power
324	P7	Increased Trust	Increased Trust
325	P7	Consensus Mechanisms	Consensus Mechanisms

326	P7	Climate management system	Climate management system
327	P7	Accountability	Accountability
328	P7	Smart Energy	Smart Energy
329	P7	Smart Agriculture	Smart Agriculture
330	P7	Smart Building	Smart Building
331	P7	Smart Manufacturing	Smart Manufacturing
332	P7	Agricultural Supply Chain	Agricultural Supply Chain
333	P7	Public Engagement	Public Engagement
334	P7	E-Democracy and Voting	E-Democracy and Voting
335	P7	Decentralized Digital Finance	Decentralized Digital Finance
336	P7	Boosting Operational and Financial Capacities.	Boosting Operational and Financial Capacities
337	P7	Sustainable business model innovation	Sustainable business model innovation
338	P7	Circular Economy	Circular Economy
339	P7	Transparent Budgeting	Transparent Budgeting
340	P7	Transparency	Transparency
341	P7	The Conveyance of Funds	The Conveyance of Funds
342	P7	Charity Activities	Charity Activities
343	P7	Benefits and Aid	Benefits and Aid
344	P7	Public Welfare	Public Welfare
345	P7	Promoting the Integration of Resources	Promoting the Integration of Resources
346	P7	A new entrepreneurial landscape	A new entrepreneurial landscape
347	P7	Industrial Sectors	Industrial Sectors
348	P7	Education	Education
349	P7	Healthcare	Healthcare
350	P7	Intelligent Transport System	Intelligent Transport System
351	P7	Solid Waste Management	Solid Waste Management
352	P7	Banks as service-oriented institutions have an important role in the process of sustainable development of a country. The introduction of blockchain technologies, changing customer preferences, the world of open banking and the pressure of financial markets have created a new situation.	Smart banks with sustainable and integrated services.
353	P7		Increase bank customers' preferences for integrated and transparent banking services.

354	P7	Insurance companies, like banks, are intermediaries,andat first glance, there is great potential for insurers to use Blockchain technology to simplify premiums and receivables.	High potential for insurers to simplify premiums and claims.
355	P7	blockchain technologies can contribute to the digital transformation of the industry, because it relies heavily on this transformation.	Contribute to digital transformation in the industry.
356	P7	Long-term austerity has dire consequences for the government, with administrative budget cuts making it difficult for central and local governments to choose. One option is total savings, reducing the number of employees and reducing services, and the other option is a comprehensive change in service delivery.	Help increase government efficiency and downsize, especially during times of recession.
357	P7	blockchain can be used to address the inefficiencies of existing systems and increase the efficiency of public service delivery.	Assistinging eliminate inefficiencies in public service delivery systems.
358	P7	Significant challenges remain, especially on how digital content can be freely copied and distributed on the Internet, and how revenue should be distributed when using works by artists or purchasing through legal channels.	Take measures to prevent the distribution of digital content by increasing the rate of adherence to intellectual property law.
359	P7	Blockchain technology can Assisting address some of these challenges by connecting directly with writers, musicians, filmmakers, and consumers, as well as increasing the productivity of industry-leading organizations Inefficient management processes will be prone to errors and costly backup management such as transaction verification and checking for various forms.	Establish direc communication between writers,musicians, filmmakers, and consumers, as well as greater productivity of industry-leading organizations.
360	P8	My idea is of a revolutionary technology that is modeling a good way of socio-economic development.	Revolutionary technology for modeling socio-economic development.

361	P8	Blockchain technologies can increase the possibility of achieving sustainable development goals as it is based, increase automation, and integrate physical and virtual environments.	Possibility of achieving sustainable development goals by increasing automation and integration of physical and virtual environments.
362	P8	Ethereum and Smart Contracts	Ethereum and Smart Contracts
363	P8	Blockchain-based IoT	Blockchain-based IoT
364	P8	Records Management	Records Management
365	P8	Privacy	Privacy
366	P8	Decision-Making	Decision-Making
367	P8	Transparency	Transparency
368	P8	Legal Enforcements	Legal Enforcements
369	P8	Promoting the Integration of Resources	Promoting the Integration of Resources
370	P8	Increased Control	Increased Control
371	P8	Prevent from Abusing Power	Prevent from Abusing Power
372	P8	Consensus Mechanisms	Consensus Mechanisms
373	P8	Public Engagement	Public Engagement
374	P8	Accountability	Accountability
375	P8	(Quality of Service)	(Quality of Service)
376	P8	Consensus Mechanisms	Consensus Mechanisms

377	P8	Smart Agriculture	Smart Agriculture
378	P8	Smart Building	Smart Building
379	P8	Smart Manufacturing	Smart Manufacturing
380	P8	Smart Cities	Smart Cities
381	P8	Agricultural Supply Chain	Agricultural Supply Chain
382	P8	Sustainable Supply Chain	Sustainable Supply Chain
383	P8	Citizen Participation	Citizen Participation
384	P8	Reducing Corruption	Reducing Corruption
385	P8	Decentralized Digital Finance	Decentralized Digital Finance
386	P8	Boosting Operational and Financial Capacities	Boosting Operational and Financial Capacities
387	P8	Financial Inclusion	Financial Inclusion
388	P8	Sustainable business model innovation	Sustainable business model innovation
389	P8	Economic Growth	Economic Growth
390	P8	The Conveyance of Funds	The Conveyance of Funds
391	P8	Public Welfare	Public Welfare
392	P8	Land Title Registry	Land Title Registry
393	P8	Property Rights	Property Rights

394	P8	A new entrepreneurial landscape	A new entrepreneurial landscape
395	P8	Education	Education
396	P8	Efficient Water Management	Efficient Water Management
397	P8	Healthcare	Healthcare
398	P8	Intelligent Transport System	Intelligent Transport System
399	P8	Solid Waste Management	Solid Waste Management

Step 3: Search and identify themes

At this stage, based on the basic themes that were extracted from the key sentences extracted from the text in the previous steps, the organizing themes were created. Since the main interview questions in the field of data module, governance module, and sustainability module are related to the applications of blockchain in sustainable development, as a result, creating organizing themes, from these dimensions as well as some dimensions that the interviewees mentioned in other aspects of sustainability, has been exploited.

Table. 14- Extraction of the organizer and global themes from basic themes (Researcher)

N	Basic Themes	Organizer Themes	Global Theme
1	One of the latest technologies for technological transformation in industry and economy.	1. Basic features of blockchain technology	Development, deployment, and application of blockchain in sustainable development
2	Aplatformtoenable/facilitatetheimplementation of a variety of social coordination mechanisms.		
3	A platform to tackling economic, social, and environmental problems.		
4	A platform to enable new forms of funding.		
5	A new paradigm shift in the economy.		
6	Increase the capacity for transparency and security.		
7	Combining high inherent potential with providing solutions to turn technological insights into action.		
8	Scalability and heterogeneity.		
9	Eliminating the need for third-party.		
10	A valuable tool in data management and privacy.		
11	An important component of sustainable development especially in economic issues.		
12	Increasing the agreement coefficient on information by different groups.		
13	A set of intelligence, encryption, and information distribution processes.		
14	Increasing the storage space of trusted information.		
15	Possibility of achieving sustainable development goals by increasing automation and integration of physical and virtual environments.		
16	Convergence between IoT, Blockchain and ML with technology convergence approach.		
17	Ethereum and Smart Contracts		
18	Blockchain-based IoT		
19	Increased Trust		
20	Records Management		

21	Privacy	2. Data module	
22	Increasing cryptocurrency in the energy sector.		
23	Security, quality, traceability, sharing and analysis of data.		
24	Detection of fraud in Bitcoin based on machine learning.		
25	Reduce and eliminate the possibility of hacking, deleting, and manipulating personally registered information.		
26	Provide security for secure data sharing across multiple domains.		
27	Decision-Making	3. Governance module	
28	Transparency		
29	Legal Enforcements		
30	Promoting the Integration of Resources and control.		
31	E-Democracy and Voting		
32	Legal Contracts		
33	Prevent from Abusing Power		
34	Increase trust between institutions and customers in various industries.		
35	Mechanisms of consensus and agreement		
36	Increasing Public Engagement		
37	Accountability		
38	Peer-to-peer (P2P) trading in the energy sector		
39	Making government operations more efficient		
40	Improving the provision of public services.		
41	Solve the problem of lack of interrelationship between departments with data integration and compatibility.		
42	Assisting strengthen cooperation between consumers and producers.		
43	Providing people more sustainable lifestyles to people.		
44	Traceability of seller and buyer.		

45	Tracking and authenticating illegal immigrants for legal protection and asylum status.		
46	E-Democracy and Voting		
47	Transparency of elections and increase of voter security.		
48	Increasing the privacy of individuals.		
49	Blockchain-based security solutions in H-IoT systems.		
50	Making increasegovernmen efficiency and downsizing, especially during times of recession.		
51	Reducing the need for human resource in elections.		

52	Assisting address, the inefficiency of public service systems.		
53	Smart Contracts	4.Sustainability module	
54	Consensus Mechanisms		
55	Smart Energy		
56	Smart Agriculture		
57	Smart Building		
58	Smart Manufacturing		
59	Smart Cities		
60	Agricultural Supply Chain		
61	Decision-Making		
62	Citizen Participation		
63	Improving Public Engagement		
64	Openness		
65	Reducing Financial Corruption		
66	Decentralized Digital Finance		
67	Boosting Operational and Financial Capacities.		
68	Financial Inclusion		
69	Sustainable business model innovation		
70	Economic Growth		
71	Circular Economy		
72	Transparent Budgeting		
73	The Conveyance of Charity Activities Funds.		
74	Benefits and Aid		
75	Improved Public Welfare		
76	Operations Cost Reduction		
77	Property registration operation		
78	Property Rights		
79	Promoting the Integration of Resources		
80	A new entrepreneurial landscape		
81	Industrial Sectors		
82	Efficient water management training		
83	Healthcare		
84	Intelligent Transport System		
85	Solid Waste Management		
86	Climate Action for the Protection of the Oceans.		

87	New supply chains and targeting new customers with new channels.		
88	Increase trust and transparency between B2C and even B2B levels.		
89	Charging electric vehicles in the energy sector.		
90	IoT Expansion		
91	The extent of smart networks		

92	Assisting companies in improving supply and recycling resources.		
93	Prevent systemic economic corruption		
94	Approaching the fourth generation of industrial economics.		
95	Increasing the originality of goods and quality of raw materials for the customer in the supply chain of factories.		
96	Smart banks with sustainable and integrated services		
97	Increase bank customers' preferences for integrated and transparent banking services		
98	High potential for insurers to simplify insurance premiums and claims.		
99	Establish direct communication between writers, musicians, filmmakers, and consumers, as well as increase the productivity of the industry's core Organizations.		
100	Understanding the applications and benefits of blockchain.	Strategies for the development and	
101	Educate managers about the opportunities and risks of using this technology at the same time.		

102	Developing a business case and selecting a blockchain according to need.	deployment of blockchain technology	
103	Creating an ecosystem of partners and stakeholders.		
104	Manage and reduce resistance to change through blockchain technology.		
105	Preparation and upgrading of blockchain deployment infrastructure.		
106	Providing the requirements for the use of this technology.		
107	Educate and inform government officials and decision-makers on what the blockchain is and its smart contracts and applications.		
108	Setting reference standards (due to heterogeneity among Blockchain technologies.		
109	Set reference standards (among different digital technologies).		
110	Determining the role of each stakeholder (determining the level of accountability and responsibility of each of the manufacturers, developers, and service providers.		
111	Compliance of implemented frameworks with international standards and regulations such as ISO 27000, ISMS, GDPR.		
112	Technical infrastructure support (hardware and software equipment).		
113	Using blockchain along with other digital technologies.		
114	Accelerate the implementation of blockchain in various business.		
115	Take measures to prevent the distribution of digital content by helping to increase the rate of adherence to the Intellectual Property Law.		
116	Using tokens, it could be possible to design more focused and ad hoc public support policies, such as UBI.		

117	Through virtuous behavior (such as use of renewable energy sources) tokenization, it could be possible to design better and more far-reaching incentives toward sustainable behaviors.		

Step 4 and 5: Draw and analyze the thematic network

In this study, the topics obtained from the text of the interviews are classified into similar and coherent groups. Decisions about how to group themes are based on content and, if necessary, on theoretical foundations, and it has been noted that the themes under each network are appropriate in number and on similar topics. If the themes are very diverse and numerous or have completely different and distinct themes, several groups have been formed. Each group of themes leads to a distinct, pervasive theme that is supported by separate basic themes and organizers. Also in this research, according to the themes extracted in the previous stage, the thematic network has been designed. In the following figures, the networks of sub-main and main themes are presented:

Table. 15- Types of themes and their number in this research

Theme type	Number
Basic them (descriptive)	117
Organizer theme (communicator)	5
Global theme (interpretive)	1

3.7. Integrate systematic literature review results and thematic analysis

As seen in the thematic analysis phase, the views of experts on the contexts and dimensions modules of application of blockchain technology in sustainable development and strategies for the development and deployment of this technology in various industries were identified and themed. Among these, 117 basic themes, 5 organizer themes and 1 key theme were extracted. Combining the results of the systematic literature review and thematic analysis sections, an integrated framework emerges that defines the data module with 5 blockchain- based dimensions, the governance module with 7 blockchain-based dimensions, and the sustainability module with 10 blockchain-based dimensions to support the 2030 Agenda .Also, 15 features of blockchain technology are the underlying factors of the proposed framework around the model, and finally 18 strategies for the development, implementation, and better application of this technology from the perspective of experts. This integrated framework is shown in Figure. 26 and is the result of two stages of qualitative research.

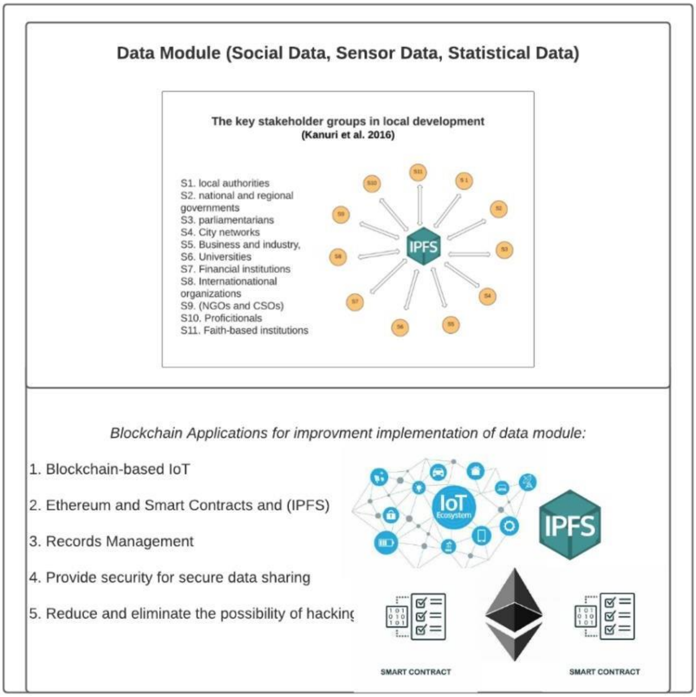
Chapter. 4
Research Findings

As explained in the research methodology chapter, with combining the results of the systematic literature review and thematic analysis sections, an integrated framework emerged that defines the data module with 5 blockchain-based dimensions, the governance module with 7 blockchain-based dimensions, and the sustainability module with 10 blockchain-based dimensions to support the 2030 Agenda. Also, 15 features of blockchain technology are the underlying factors of the proposed framework around the model, and finally, 18 strategies for the development, implementation, and better application of this technology from the perspective of experts. In this chapter, we discuss this integrated framework that is the result of two stages of qualitative research.

4.1. Data module with 5 blockchain- based dimensions

1. Provide security for secure data sharing across multiple domains
2. Reduce and eliminate the possibility of hacking, deleting, and manipulating registered personal information
3. Ethereum and Smart Contracts and (IPFS)
4. Blockchain-based IoT
5. Records Management

Figure. 23- Data module with 5 blockchain- based dimensions



4.2. Governance module with 7 blockchain- based dimensions

1. Making increase government efficiency and downsizing, especially during times of recession.
2. Providing people more sustainable lifestyles to people
3. Increased Trust
4. Transparency and Transparent Budgeting
5. Smart Contracts
6. Accountability
7. Decision-Making

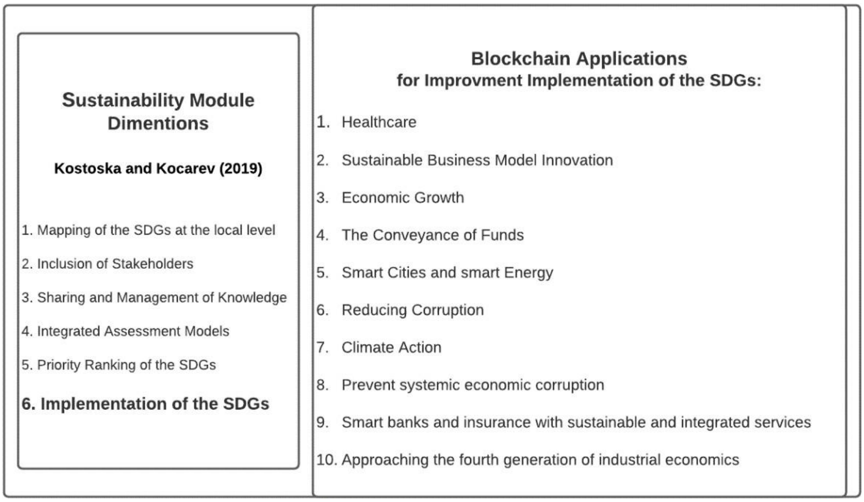
Figure. 24- Governance module with 7 blockchain- based dimensions

Governance Module Dimentions Kostoska and Kocarev (2019)	*Blockchain Applications for improvment implementation of Governance module :*
1. Network governance	*1. Providing people more sustainable lifestyles*
2.Trustworthy governance	*2. Transparency and Transparent Budgeting*
3. Collaborative governance	*3. Increased Trust*
4. Accountable governance	*4. Accountability*
5. Adaptive governance	*5. Making increase government efficiency*
6 Fair governance	*6. Smart Contracts*
	7. Decision-Making

4.3 Sustainability module with 10 blockchain- based dimensions

1. Healthcare
2. Sustainable Business Model Innovation
3. Economic Growth
4. The Conveyance of Funds
5. Smart Cities and smart Energy
6. Reducing Corruption
7. Climate Action
8. Prevent systemic economic corruption
9. Smart banks and insurance with stable and integrated services
10. Approaching the fourth generation of industrial economics

Figure. 25- Sustainability module with 10 blockchain-based dimensions



4.5. 15 features of blockchain technology

1. One of the latest technologies for technological transformation in industry and economy.
2. A platform to enable/facilitate the implementation of a variety of social coordination mechanisms.
3. A platform to tackling economic, social, and environmental problems.
4. A platform to enable new forms of funding.
5. A new paradigm shift in the economy.
6. Increase the capacity for transparency and security.
7. Combining high inherent potential with providing solutions to turn technological insights into action.
8. Scalability and heterogeneity.
9. Eliminating the need for third-party.
10. A valuable tool in data management and privacy.

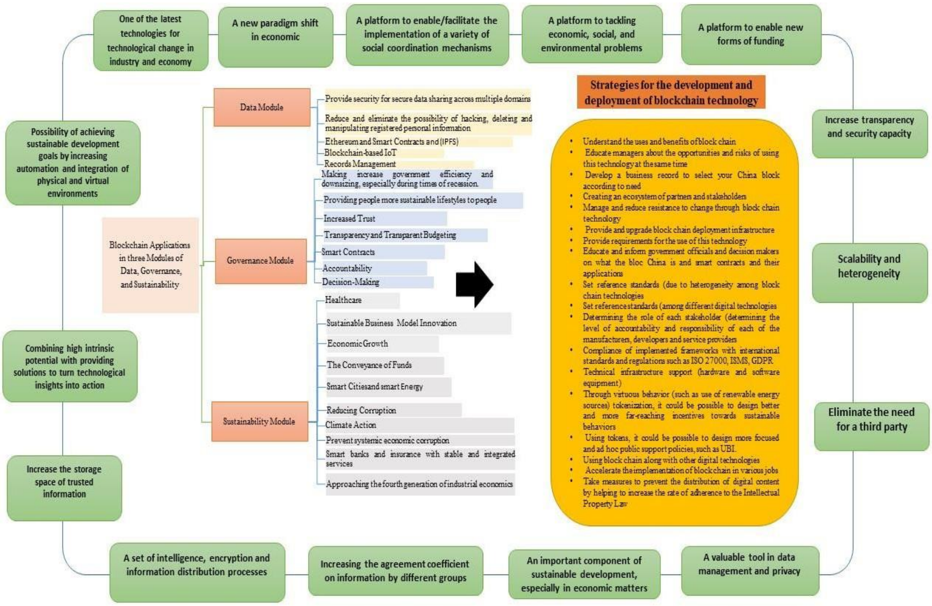
11. An important component of sustainable development especially in economic issues.
12. Increasing the agreement coefficient on information by different groups.
13. A set of intelligence, encryption, and information distribution processes.
14. Increasing the storage space of trusted information.
15. Possibility of achieving sustainable development goals by increasing automation and integration of physical and virtual environments.

4.5. 18 Strategies for the development, implementation, and better application of blockchain technology

1. Understanding the applications and benefits of blockchain.
2. Educate managers about the opportunities and risks of using this technology at the same time.
3. Developing a business case and selecting a blockchain according to need.
4. Creating an ecosystem of partners and stakeholders.
5. Manage and reduce resistance to change through blockchain technology.
6. Provide and upgrading of blockchain deployment infrastructure.
7. Providing the requirements for the use of this technology.
8. Educate and inform government officials and decision-makers on what the blockchain is and its smart contracts and applications.
9. Set reference standards (due to heterogeneity among blockchain technologies).
10. Set reference standards (among different digital technologies).
11. Determining the role of each stakeholder (determining the level of accountability and responsibility of each of the manufacturers, developers, and service providers.

12. Compliance with implemented frameworks with international standards and regulations such as ISO 27000, ISMS, GDPR.
13. Technical infrastructure support (hardware and software equipment).
14. Through virtuous behavior (such as use of renewable energy sources) tokenization, it could be possible to design better and more far-reaching incentives towards sustainable behaviors.
15. Using tokens, it could be possible to design more focused and ad hoc public support policies, such as UBI.
16. Using blockchain along with other digital technologies.
17. Accelerate the implementation of blockchain in various business.
18. Take measures to prevent the distribution of digital content by helping to increase the rate of adherence to the Intellectual Property Law

Figure. 26- The Integrated network resulting from the thematic analysis and Systematic Review in this research (Researcher)



4.6. Discussion of the research Findings

4.6.1. Data module with 5 dimensions

4.6.1.1 Provide security for secure data sharing across multiple domains

The blockchain technology provides a high level of accountability, and hence has the capacity to boost knowledge sharing transparency and security (Hu et al, 2018). In the short and medium term, blockchain technology can be utilized to address concerns related to data integrity, providing suitable security architecture and infrastructure management controls (Berryhill, et al, 2018).

One of the most important features of blockchain technology is that it may boost a network's overall capacity. Thousands of computers working together can be more powerful than a few centralized servers (F. Atlam et al, 2018). The use of private keys can ensure the anonymity of users or information. By giving encryption keys, users can remain anonymous, or access can be restricted to prevent others from reading their data (Alexopoulos et al, 2019). Data is kept in a variety of locations. Consensus procedures ensure that information is only altered when all parties involved agree. BCT makes advantage of the consensus method to ensure the chain's integrity (data) (Alexopoulos et al, 2019).

4.6.1.2 *Reduce and eliminate the possibility of hacking, deleting, and manipulating registered personal information*

In blockchain Information is kept in several locations, which improves accessibility and speed (Palfreyman, 2015). With using blockchain, without the possibility of manipulating records authentication and ownership which include passports, medical records, birth certificates, marriage certificates, ownership documents, and IDs, this information recorded (Sacha, 2019, Cheng, 2019). Information stored in a system corresponds to what is being represented due to the need for consensus voting when transacting and distributed nature. This results in higher data quality (Tapscott and Tapscott, 2016). Blockchain technology can be used to address issues associated with information integrity in the present and near term, assuming proper security architecture and infrastructure management controls (Berryhill, et al, 2018). Land titles and other ownership records, as well as other information pertinent to a property transaction, might be kept chronologically on a Blockchain ledger. This could reduce the need for transactional third-party involvement, which is both expensive and time-consuming (ACT-IAC, 2017).

4.6.1.3 Ethereum and Smart Contracts and (IPFS)

A combination of decentralized file systems with an open blockchain, such as Ethereum, that supports smart contracts, can broaden the range of statistical data and findings that can be reused (Sicilia et al 2019). Blockchain data is considerably decreased using IPFS network characteristics and IPFS hash features in an IPFS-based data storage strategy Zheng et al. (2018).

4.6.1.4 Blockchain-based IoT

The Internet of Things and wireless networks are commonly used to communicate amongst the components of a microgrid (Kyriakarakos and Papadakis, 2018). The Internet of Things (IoT) has become increasingly prevalent in many aspects of daily life. One of the IoT's uses is as a mechanism for monitoring the environment. IoT-based environmental monitoring systems are made up of one or more sensors that are placed in different places and linked via unique protocols. When a network has thousands of IoT devices and one of the network's functions is to serve as a server and control center, storing and disseminating data from the sensor necessitates control and management. The use of blockchain in this system requires reviewing and calculating the number of blocks involved. In a review article, university researchers in Spain conducted a comprehensive study of how the blockchain adapts to the specific needs of the IoT to develop blockchain-based IoT (BIoT) applications. After describing the basics of the blockchain, (BIoT) applications were investigated to emphasize how the blockchain could affect traditional cloud based IoT applications. Yusuf and his colleagues examined the potential of using this technology on the Internet of Things by presenting a mathematical model with an approach based on the modeling of random behavior from the blockchain (Yusuf et al, 2019).

The use of IoT technology in conjunction with blockchain technology has the potential to improve the efficiency of BSIOT chains. The combination of IoT technology and blockchain has the potential to increase the efficiency of BSIOT chains. Researchers have demonstrated how combining blockchain technology with IoT infrastructure can support both modern structure and simplification at the same time, as well as boost the value of chain networks, and how blockchain technology can focus on the most important characteristics of IoT, such as scalability, safety, non- changeability, flow of information, traceability, and collaboration (Rejeb et al, 2019). The continual production of data by sensors on the Internet of Things, but from the other side, pushes researchers to integrated service solutions. In this way, artificial intelligence (AI) and machine learning (ML) solutions are offered in a variety of integrated services that make products significantly "smarter."

The focus of these technologies is "data". IoT vendors should be able to increase their efficiency with AI/ML methods. Researchers investigated data efficiency in an AI/ML solution. In this way, IoT vendors and AI /ML solution providers interact closely and provide access to agreed data by facilitating a transparent data exchange platform. Finally, the data is used in a smart contract (Özyilmaz et al, 2018). Although blockchain technology can have significant benefits for the Internet of Things, it has challenges. It suffers from security vulnerabilities. Due to decentralized topology and limited resources, most of its devices use the blockchain to provide security and privacy in peer networks. It's worth noting that the blockchain is expensive in terms of computing and includes bandwidth and delays that aren't suitable for IoT devices. Therefore, a new safe, private, and lightweight architecture is required for IoT, based on BC technology. In addition, maintaining the greatest security and privacy benefits should be considered in this architecture.

Dorri et al. presented a hierarchical design that includes smart homes, a covered network, and cloud storage that trades data with BC for privacy and security, with various forms of BC being utilized based on where the transaction network hierarchy is done. This proposal considers the use of distributed trust mechanisms to guarantee a decentralized topology, qualitative assessment of architecture under typical threat models, and the influence on security and privacy (Dorri et al, 2016). Another important point to consider when using IoT is the legal part of the issue. Blockchain can help solve this problem, but legal issues related to data protection law must be considered and supported by the government,

legal issues related to data protection law and privacy must be considered. In fact, it is necessary to consider legal issues before preparing applications. Assessing legal issues and preventing them from being published and privacy using network design is very fundamental. The IoT system allows us to transfer data by the Internet, including personal data. In this regard, attention to the new European General Data Protection Regulation (GDPR), which can be implemented in, 2018, the main legal issues related to privacy and data protection, focusing on the Privacy by Design approach has been considered. Fabiano believes that this issue should be considered on a global scale. In fact, a global standards framework for privacy that organizations can use to protect their data should be created and require governments to follow it (Fabiano, 2017).

Cyber-attacks and other damage to the Internet of Things are a thought-provoking position that should be limited by blockchain technology. Although the blockchain is one of the promising technologies to cope with cyber-attacks, it still faces serious challenges for the security of the IoT program. Several cyber-attacks and threats that may occur on the Internet of Things blockchain systems include DoS attacks, attacks on private keys, attacks caused by incorrect data, hidden blocks, and so on. By the advent of each of these attacks, Nir's defense protocols are provided to counter it, which could help increase network security (Ferrag et al, 2018).

4.6.1.5 Records Management

The primary purpose of records management is to ensure that records are reliable. Physical security, data security, application system security, secret key security, and risk management should all be part of a blockchain platform's security system. Building a secure system can help to protect routine activities while also ensuring the integrity of records stored on the platform (Hou, 2017).

4.6.2 Governance module with 7 dimensions

4.6.2.1 Making increase government efficiency and downsizing, especially during times of recession

Blockchains have the capability to impact a huge range of subjects and "create real opportunities for the government and different neighborhood and nearby government" in phrases of lowering operational prices, growing transparency and believe between governments and citizens, facilitating monetary inclusion, and boosting the operational and financial competencies of small and medium-sized corporations (Krawiec et al, 2016).

Local governments have a critical role in formulating policies, directing actions, and inspiring research to help accomplish the anticipated sustainable development goals (Nagy et al, 2018). To address societal and environmental issues, new techniques must be developed that combine top- down global oversight with bottom-up subnational expertise (Capitani et al. 2016).

Allowing credit blockchain as a service platform to be accessed via the digital marketplace to lower the barrier to entry for government agencies. Because data saved in Blockchain is immutable, customers can access data such as traffic accidents, congestion, delays, and so on to present it in court. Furthermore, the insurance firm can use Blockchain data to gain insight into any bad events that occur on the road (Ojo and Adebayo, 2017).

With the aid of disposing of the want for third parties and automating transaction managing, blockchains and clever contracts can automate some transactions and make interagency procedures greener and more effective (uk residence of Lords, 2017). The groups that are a part of a Blockchain community may additionally securely and effects proportion records kept on a shared ledger, decreasing the probabilities of inconsistencies, and ensuring agencies work with the identical straightforward records (ACT-IAC, 2017). Because information can be accessed easily and quickly, blockchain improves government operations by speeding up necessary subprocesses (Alexopoulos et al, 2019). Blockchains have the capacity to affect an extensive variety of subjects and "create proper possibilities for the authorities and other nearby and regional government" in terms of reducing operational fees, growing transparency and consider between governments and residents, facilitating financial inclusion, and boosting the operational and economic capabilities of small and medium-sized agencies (Krawiec et al, 2016).

4.6.2.2 *Providing people more sustainable lifestyles to people*

Human rights assurance is a basic requirement for certifying a company's social sustainability. Retailers, governments, and non-governmental organizations (NGOs) can, for example, use a blockchain network to determine whether corporations are breaching overtime rules and whether workers are receiving living wages on time. These actions and efforts will be documented in a blockchain network, which may be used to support social sustainability certificates (Venkatesh et al, 2020).

Blockchain and smart contracts can reduce information asymmetry and promote welfare and consumer surplus by allowing more people to participate in the market but disclosing information during consensus building may encourage more collusion. Blockchains, in general, maintain market equilibria with a broader range of economic outcomes which lead to Improved Welfare for citizens (Cong and He, 2019). Pinna and Ibba (2017) characterized a distributed blockchain-based framework capable of developing smart contracts for proper management of transitory employment agreements, with the goal of ensuring respect for human laws of all individuals involved in momentary contractual arrangements, to provide employees with equal and legal remuneration (such as taxes) for career performance, as well as safeguards in the workplace (Pinna and Ibba, 2018). Property rights enforcement encourages investment and gives resources to help people avoid poverty. The use of blockchain technology can reduce friction and disagreement, as well as the expenses of property registration (Kshetri and Voas, 2018).

Small-scale economic opportunities can be provided by decentralized digital banking and market access, which promotes resilience and prosperity. Blockchain could be used to help people break free from poverty and improve their economic engagement, such as microfinance (ixo Protocol, 2017). Financial Inclusion: One of the big promises of DLTs for SDGs is the chance for greater financial inclusion. Automation, disintermediation, low cost, and secure transmission provide opportunities for low-value transactions and enabling isolated, disenfranchised, peripheral, and marginal populations to connect in new ways—either among themselves or with activities in the larger world (Kewell et al, 2017).

4.6.2.3 *Increased Trust*

Blockchain provides openness and trust because transactions are recorded indefinitely and openly and cannot be changed (Eikmanns, 2018). By requiring consensus to add transactions, the level of control has been increased. Increased control owing to immutable recordkeeping and data verification by numerous nodes increases trust in the process (Zyskind and Nathan (2015). Increased control owing to immutable recordkeeping and data verification by numerous nodes increases trust in the process. Blockchain serves as both a data processing and a trust-building system for society (Jun 2018), (Qlnes et al, 2017). The use of the blockchain guarantees that the blockchain belongs to a governing institution (for example, the Electoral Commission), and no unauthorized access from outside is possible. Security and data management challenges are considered in the blockchain, which makes the electronic voting process trustworthy (Shahzad and Crowcroft, 2019).

4.6.2.4 Transparency and Transparent Budgeting

Anyone can see and use the information stored in blockchain (Alexopoulos et al, 2019). The blockchain technology offers a high level of accountability and hence can strengthen knowledge sharing transparency and security (Hu et al, 2018). On a chain, transactions and their history data are visible to the public and cannot be changed. Whereas "decentralized systems often rely on the disclosure of everyone's interactions," permissionless Blockchains allow for complete transparency. The blockchain provides a platform for participating parties to communicate in a transparent and exact manner, such as through the development of coded contracts (Ethereum) (Alexopoulos et al, 2019), (De Filippi, 2017).

An open government based on immutable data in a blockchain system provides the public with more than just convenience. Transparency generates trust, and when people can identify the origins of any information that affects their lives, they feel more secure. As a result, by adopting blockchain technology, the government can increase its power and confidence with the public, allowing it to rule more effectively (Hou, 2017). Citizens can use BCT-based platforms to gain access to credible government information, improving their trust in governments. As a result, the government can gain more power and trust from the public by implementing blockchain technology, allowing it to rule more effectively (Hou, 2017) (Alexopoulos et al, 2019). Transparency in service procurement, budgeting, and account presentation are among the many obligations enforced by governments around the world.

However, agencies in countries with high levels of corruption, particularly smaller agencies, have difficulty complying with the law. Furthermore, national auditors are usually unable to audit all the accounts rendered, so they select a small sample for auditing based on their level of risk. Blockchain, a new technology that is gaining traction, could provide a solution to all these issues (Simoyama, 2017).

4.6.2.5 Smart Contracts

By eliminating the use of third parties and automating transaction processing, blockchains and smart contracts can automate some transactions and make interagency procedures more efficient and effective (ACT-IAC, 2017). Without compromising excessively on privacy rights, public services could become fully networked. Individuals and businesses would no longer have to waste time filling out forms with data they had already given to the government. In some cases, smart contracts could expose some information to specified agencies if predetermined circumstances are met, allowing agencies to modify their services to match the needs of individuals (Cheng et al, 2017). Smart contracts can be used in conjunction with a ‘Blockchain platform as a service' to automate a variety of functions, including near real-time monitoring and actuation of action plans, as well as, in the long run, to improve workflows and decision processes driven by analytics (artificial intelligence). The cost-effectiveness and quality of service that can be offered can both benefit from such automation (DATTA, 2019).

4.6.2.6 Accountability

In various contemporary information and knowledge management systems, blockchain has been employed as a tool for imposing accountability and responsiveness (Joseph, 2019).

4.6.2.7 *Decision-Making*

In policy development, community involvement refers to the engagement of the public through online voting, referendums, petitions, blogs, and forums. Open data platforms, such as blockchain, can help boost citizen engagement and transparency while also facilitating public-sector collaboration with private and non-profit parties (Engin and Treleaven, 2018). Distributed ledgers, consensus procedures, and crypto-economic models are examples of decentralized information systems that can be used to produce more informed and participatory collective decision-making. To build a more informed and participatory collective decision-making, decentralized information systems, particularly distributed ledgers, consensus processes, and crypto-economic models might be used. Additionally, expanding involvement in existing democratic procedures and providing new forms of representation for other social groups (Pournaras, 2020).

4.6.3 Sustainability module with 10 dimensions

4.6.3.1 Healthcare

4.6.3.1 Healthcare

Government policies such as social welfare and pension payments, basic healthcare payments, and nationally and internationally aid might all benefit from blockchain technology. The benefits of blockchain can be applied to the healthcare business to tackle a variety of issues such as record sharing, security, and access control (McGhin et al, 2019) (Hölbl et al, 2018). Government institutions will be able to better deliver medical services by keeping patient health information that can then be accessible with other service suppliers due to the use of Blockchain. Another advantage of this application example is the cost and clarity of health-care services (Alketbi et al, 2018).

4.6.3.2 Sustainable Business Model Innovation

Blockchain technology can aid in the unification of the basic development platform and application programming interface, as well as the promotion of interoperability between numerous blockchain systems and the optimization of business operations. This will lower costs while also increasing consumer pleasure (Hou, 2017). Due to its ability to ensure all the attributes consumers demand, such as greater integrity, security, and transparency of the products they buy, blockchain could be a source of sustainable business model (SBM) innovation in the agri-food industry. As a result, the use of BC in the BM of a company in the agri-food industry verifies the technology's status as an SBM breakthrough (Tiscini et al, 2020). Yadav and Singh (2020) presented an integrated strategy of blockchain and supply chain to produce efficient sustainable supply chain management (SSCM).
They discovered the causes of the SSC using the Fuzzy-DEMATEL tool after integrating new technology "BC" with the SC, which included six primary causes: data security and decentralization, accessibility, laws and policy, documentation, data management, and quality.

4.6.3.3 Economic Growth

Given present production and consumption systems, putting the circular economy concept into practice is a difficult task that demands tactics that enable competition and cooperation among many actors to produce and scale up the best ideas. To promote a transition to circular forms of value generation and appropriation, coopetition might be operationalized and maximized utilizing tokens in a blockchain.

Blockchain tokens have the potential to bring previously disjointed product ecosystems together, unleashing the creativity and innovation needed for circular business models (Narayan and Tidström, 2020).

The use of blockchain technology can expand commercial opportunities. Cryptocurrencies may ease a basic institutional motor for economic expansion and support the preservation of a sustainable relatively stable economy by reducing demands for debt-based money as a medium of trade (Kshetri, 2017), (Leonard and Treiblmaier, 2019). In the blockchain industry, there is an exciting potential for research NGOs and social researchers; if more professional brains work together to create answers, the decentralizing impact of Blockchain will soon be seen in our society. Decentralization of business and organizations is the most essential social characteristic of Blockchain. Rather than maintaining the "winner takes it all" model, it might have a positive impact on income inequality and encourage fair economic growth for all human classes on Earth (Palacio 2018). The use of blockchain smart contracts in the workplace provides a once-in-a-lifetime opportunity to learn more about how technology is affecting the future of work (Medaglia and Damsgaard, 2020). Aside from enabling digital currencies, blockchain technology has enabled innovators to create digital tokens to represent scarce assets, possibly changing the entrepreneurship and innovation scene. Blockchain tokens can democratize (1) entrepreneurship by allowing entrepreneurs to raise funding and engage stakeholders in new ways, and (2) innovation by allowing innovators to design, deploy, and disseminate decentralized apps in new ways.

The use of blockchain technology and tokens has spurred a new wave of invention that has the potential to transform entrepreneurship and innovation. Digital finance innovations, such as blockchain, have aided a sort of crescent entrepreneurship that seeks out possibilities for financially disadvantaged people. Blockchain entrepreneurship has the potential to create semi-formal financial services that bring people's financial goals closer to them. The practices of the unbanked are presented by blockchain entrepreneurs as a source of information for the development of creative solutions (Larios- Hernández, 2017), (Chen, 2018).

4.6.3.4 The Conveyance of Funds

Bureaucracy also affects public welfare. Using blockchain to assist the general population in safely and directly reaching, validating, and managing the delivery of welfare or unemployment benefits. Govin, an English firm, is using blockchain technology to help the government distribute assistance (Nguyen and Dang, 2018). Each person will be awarded “personal credit” and a valid digital identity, both of which will be kept on the blockchain network in an immutable manner. In this situation, the government will provide public services based on individual credit records rather than other factors, simplifying bureaucratic processes and boosting government approval speed and authority (Hou, 2017). Organizations would be able to record all transfers of monies, whether intra-agency, inter-agency, or external, using a permissioned blockchain, allowing the budget to be assigned and tracked at every step of the process (Mark G.,2018). Government policies such as social welfare and pension payments, basic healthcare payments, and nationally and internationally aid might all benefit from blockchain technology. Smart contracts could be used to automate the confirmation of eligibility and the distribution of funds. Advantages could be sent to the right people and not misdirected via blockchain technology (UK Government Office for Science, 2016). Using blockchain technology to track charity transfers and guarantee that funds are transferred to the correct recipients, hence eliminating waste and fraud. BitGive Foundation, a Bitcoin charity, uses the Blockchain ledger to transfer payments securely and transparently, allowing contributors to see for themselves that their money is going to the correct individuals (Nguyen and Dang, 2018).

4.6.3.5 Smart Cities and Smart Energy

A smart city can develop new methods for individuals to participate in public life and encourages them to become active citizens to improve a two-way interaction with local government. To accomplish these objectives, blockchain technology might be used as a publicly accessible shared database and then as a tool for reliability, transparency, and security (Ibba et al, 2017). In smart cities, smart homes, healthcare 4.0, smart agriculture, autonomous automobiles, and supplier management, Mistrya et al. (2020) advocated adopting 5G-enabled IoT as a backbone for blockchain-based industrial automation. Many transactions in the industrial areas, they claim, can be easily traced utilizing blockchain for consistency and privacy protection (Mistrya et al, 2020). Also, in smart cities, blockchain can be adopted for Intelligent Transport System. In an intelligent transportation system, blockchain can be conceived of as digital proof (Balasubramaniam et al, 2020). Blockchain's decentralized architecture can support Internet of Things applications, smart business governance, and smart cities in ways we can't even imagine (Patel, 2019). Smart cities' trust infrastructure was built in the same way as other network systems, resulting in the same security and trust leaks as other systems. (Fu and Zhu, 2020) propose blockchain technology as a trust infrastructure for the smart city, (Fu and Zhu, 2020).

They merged the smart city's network and data architectures, built a blockchain architectural system for smart city applications, proposed a special implementation technique, and designed models and algorithms. Due to its beneficial qualities like as audibility, transparency, immutability, and decentralization, blockchain has the potential to assist the development of smart cities. Bhushan et al. (2020) presented state-of-the-art blockchain technology to address smart city security issues, as well as a survey of blockchain's utility in a variety of smart communities, including healthcare, transportation, smart grid, supply chain management, financial systems, and data center networks (Bhushan et al, 2020) (Patel, 2019) (Fu and Zhu, 2020).

Smart Agriculture: Agricultural IoT and blockchain opens new pathways, such as clustered farm environment monitoring and data exchange with farmers and other stakeholders for prompt decision making to boost agricultural production (Awan et al, 2020).

Smart Energy: As renewable energy supplies became more widely available; the current energy sector began to transition toward distributed and decentralized solutions. Blockchain technology provides automatic data interchange, complicated energy transactions, demand response management, and peer-to-peer (P2P) energy trading, among other things, by utilizing smart contracts. As distributed renewable resources, blockchain will play a critical role in the evolution of the IoE market (Miglani et al, 2020). The Energy Internet allows distributed energy sources and customers to connect, and it uses the Internet to collect energy data from various edge devices to create a distributed smart energy infrastructure.

Guana et al. (2019) suggested a blockchain-based secure and efficient energy trading scheme that is relevant to the distributed energy trading environment backed by IoT. They also devised a credibility-based equity proof mechanism to boost system availability (Guana et al, 2019) (Miglani et al, 2020). Blockchains provide innovative ways for consumers and small renewable providers to participate more actively in the energy market and monetize their assets (Andonia et al, 2018).

4.6.3.6 Reducing Corruption

Corruption can be avoided by storing data in distributed ledgers. For example, land ownership can be stored in blockchain with clear regulations for changing ownership that cannot be altered (Kshetri, 2017). The ability to track transaction history and build an audit trail on the blockchain. Having numerous ledgers that may be accessed for consistency is also beneficial (Palfreyman,2015).

“Code is law” in the blockchain architecture: the protocol is open-source, and anyone can review it. The neutrality of the code, distributed consensus, and transaction audibility can dramatically minimize or eliminate friction and failures in centralized enterprises' decision-making processes (e.g. lack of transparency, corruption, coercion, etc.) (Atzori, 2015). Legal contracts frequently incorporate temporal components like as deadlines, and the time from paced block validation does not always correspond to this legal time. Though declarative representations are probably more creative at capturing temporal legal information, they are vulnerable to the temporal granularity of blockchain systems because they are imperative representations (Governatori et al, 2018).

4.6.3.7 Climate Action

It is necessary to adopt technology for climate change action and to design a set of actions to mitigate the effects of climate change, such as global warming, rising sea levels, increased frequency of extreme weather events, shifting rainfall patterns, increased risks for wildlife, and economic instability (especially in the agricultural sector) (Neves and Prata, 2018). In addition, by managing the low-carbon transition, blockchain plays a significant role in strengthening the accountability and transparency of carbon markets and energy markets (B. Chen, 2018). Furthermore, blockchain could help scale up climate investment, as well as play a critical role in facilitating peer-to-peer energy transactions (B. Chen, 2018) (Neves and Prata, 2018) (Harris, 2018). The use of blockchain technology for ocean space information security treatment was investigated by Kim et al. (2019). GML data with a typical S-10X electric navigation chart structure was used for the experiment. The findings of the trial indicated that ocean space information was successfully protected using blockchain technology, and it is believed that it would be used for additional sorts of ocean space information in the future. Blockchain is being touted for a variety of services and industries, including transparent resourcing for marine conservation, reducing plastic pollution, ending slavery at sea, and managing sustainable fisheries (Kim et al, 2019) (Howson, 2020).

Water management can be made more effective by using advances in upcoming blockchain, Internet of Things (IoT), and sensor technologies. M. Dogo et al. (2019) looked at the advantages of combining blockchain and IoT, including increased security and transparency, lower operating costs, and overall efficiency. According to them, blockchain may be used to address sustainability concerns in a variety of scenarios, including stormwater management, water quality monitoring, and direct reporting to customers and other relevant stakeholders, as well as smart payments and contracts. Smart 4tech1's strategic blockchain incorporation, and the water trading new concept as innovative solutions and a partnership approach, could address water sustainability and the systemic failure of water shortages, leveraging advancements in emerging blockchain, the Internet of Things (IoT), and sensor technologies (Poberezhna, 2018). (França et al, 2020) have provided the utility of Ethereum's Blockchain virtual architecture for strong waste management, pointing out that this blockchain-based machine

presents monetary control for waste series in the municipality, with the goal of enhancing health and socio- environmental schooling as well as the financial scenario.

4.6.3.8 Prevent systemic economic corruption

By limiting get entry to government assets, the net-primarily based blockchain will constrain government choices. “By means of dispersing choice-making strength to diverse events using more than one signature (multi-sig) code, which prevents the execution of movement until more than one events conform to a transaction,” consistent with the blockchain. There are methods that a blockchain-coded governance version may prohibit authorities’ actors from misusing their powers, further, to increasing the velocity and potential of electorate to make and have an impact on choices (Young, 2018). Blockchain technology and its operational and functional principles – such as decentralization, clarity, fairness, and accountability – could play a major role in restricting undue online surveillance, censorship. Blockchain technology's transparency, equality, and autonomy are just a few of the features that could help advancement in areas including corruption, fraud, democratic participation, and freedom of expression (Al-Saqafa and Seidlerb, 2017). Blockchains, may be used to supplement, complement, or replace legal enforcement. Excessive or premature implementation of strict legal obligations will stifle innovation and lead to missed opportunities to use technology to achieve public policy goals.

Developers of blockchain technology and legal organizations can collaborate. Each system must be aware of the other's distinct advantages (Werbach, 2018).

4.6.3.9 Smart banks and insurance with sustainable and

integrated services

The decentralized Ethereum network promises to free users from third-party intermediates like as attorneys who draft and interpret contracts, banks who operate as financial intermediaries, and third-party site hosting providers (Kuma et al, 2021). Banks may be able to save money by implementing blockchain technology, and the advantages such as lowered costs through blockchain could subsequently be utilized to accelerate the development of renewable technology and stimulate economic growth (Cocco et al., 2017). The World Bank has formed the Blockchain Lab, which is looking into land management, carbon trading, cross-border payments, and education payments (Chamberlain, 2019).

Zachariadis and co-workers in 2019 performed a case observe of the primary blockchain network for ecu carrier providers, wherein designs are performed especially for sensitive sectors, with critical packages for public management, e-government, banking, e-health, and enterprise. Therefore, the emphasis on systematic accept as true with, regulation enforcement, adequate technical overall performance, the confidentiality of transactions, and long-term statistics retention as essential situations of blockchain networks are powerful and reliable to progress and carry out complex duties. The key benefit of blockchain technology is that it can speed up settlement by eliminating fragmented post-trade infrastructure and introducing a more flexible settlement cycle. Faster settlement times are frequently cited by financial market players as the primary concern in modern financial markets (Chiu and V. Koeppl, 2019).

4.6.3.10 Approaching the fourth generation of industrial *economics*

Examining the issue of industrial developments after the blockchain requires close government collaboration in the advancement of this technology. Due to the widespread adoption of information and communication technologies, the manufacturing industry is changing rapidly and is being described as the fourth industrial revolution. Under these conditions, there will be completely complex and interdependent systems. One of the aspects of this change is the horizontal integration or close connection of companies in a value chain. Production systems are completely interconnected and dependent. Especially, regarding trust, new challenges are emerging with coordination (Lumineau et al, 2020).

As part of the fourth industrial revolution, blockchain technology has been one of the technologies altering governments (Zein and Twinomurinzi, 2019). Blockchain technology appears to be the viable driver for achieving global sustainability objectives, and it is already being employed in ways that might make this noble ambition a reality (Kewell et al, 2017). For instance, Smart Building: A smart constructing system can be a useful resource in the optimization of all a constructing's device and structures. Xu et al. (2020) advised Uranus, a blockchain-based DApp for smart constructing device management with a personal Ethereum blockchain, wherein sensors accumulate actual-time constructing temperature and shop it in a smart settlement applied at the personal Ethereum blockchain. Crimson or green LEDs will illuminate as warnings if the real-time temperature or humidity cost exceeds the edge cost selected via the users, and an air conditioner or dehumidifier can be becoming on (Xu et al, 2020).

Also, Smart Manufacturing: Smart manufacturing is at the heart of modern production. The assist of records era, data era, and operational era is required for a success deployment of clever production. Lee et al. (2020) presented a smart manufacturing machine based on the mixing of edge computing and blockchain generation. Blockchain era can be used to facilitate each tool-level information transmission and production service transactions, in step with Lee et al. Numerical experiments show that incorporating area computing into smart manufacturing can dramatically lessen processing time, specially whilst managing a high quantity of sports (Lee et al, 2020). In the agricultural setting, blockchain technology appears to be very promising, but more work needs to be done before it reaches maturity. China and the United States are among the most active investors in this technology, while Italy is also heavily involved. The necessity for an efficient traceability system, according to Mirabelli and Solinaa (2020), is motivated by various poor habits and problems, such as the widespread use of pesticides and fertilizers in fruits and vegetables, which are particularly damaging to human health (Mirabelli and Solinaa, 2020). In addition, the analysis discovered that blockchain has a genuine potential in the construction projects due to the exponential usage of blockchain, the investments engaged, and the number of start-up firms participating in Industry 4.0 (Perera et al, 2020). Furthermore, blockchain can be used to E-Democracy and voting and register for elections and verify personal information.

Only genuine votes will be counted, and no vote will be modified or moved if votes are counted electronically. Elections will become more democratic and fairer as votes are recorded on a public ledger blockchain (Nguyen and Dang, 2018).

4.7 The proposed communications architecture to

support the implementation of the 2030 Agenda

The 2030 Agenda emphasizes the importance of the participation of the local stakeholders for the implementation of the SDGs, local authorities could improve relations between local politicians and administrations, to encourage the administration to adopt the novel strategies to fulfill the 2030 Agenda. On the other hand, local stakeholders, including small and medium-sized enterprises and CSOs, could develop strong implementation capacities to improve their engagements with the SDGs (Katramiz et al, 2020).

In the current research, we proposed a blockchain-based platform to create an ecosystem of stakeholders and based on the results obtained from the Integrated network resulting from the thematic analysis and systematic literature review in order to improve implementation of the 2030 Agenda in Italy, with considering the key stakeholder groups in local development (Kanuri et al. 2016) that including local authorities, national and regional governments, parliamentarians, City networks, Business and industry, Universities, Financial institutions, international organizations, non-governmental organizations, civil society organizations (NGOs and CSOs), Professionals, and Faith-based institutions.

In fact, we offer a blockchain-based system and framework to support multi-user collaboration to improve implementation of the 2030 Agenda and document sharing in a trusted, safe, and decentralized manner in this research. To regulate the functions among the stockholders, this approach relies on Ethereum smart contracts. Furthermore, our approach makes use of the IPFS (Interplanetary File

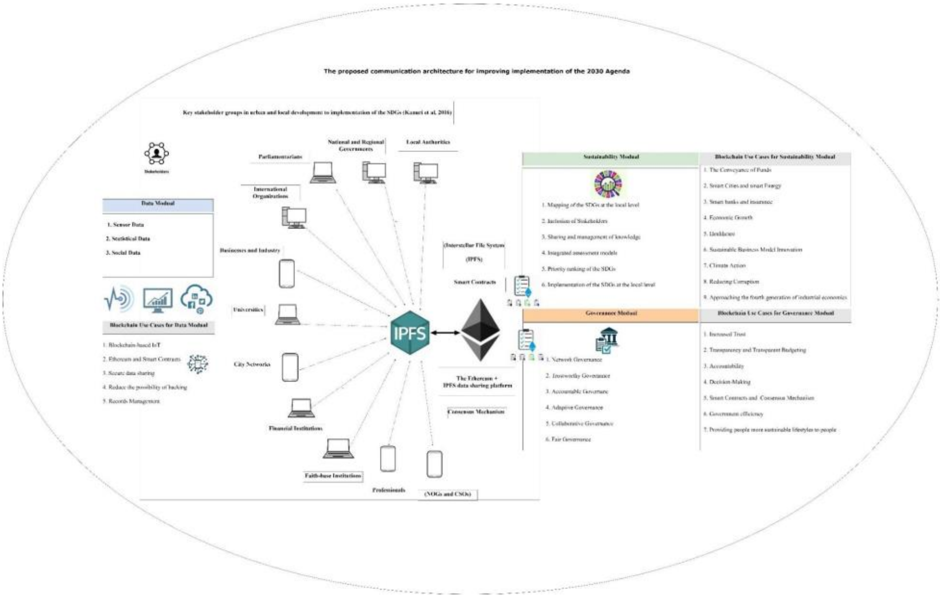
System) features to store documents on a decentralized file system. The suggested approach automates interactions between various actors. The platform's main components are made up of three basic modules (data, sustainability, and governance) derived from Kostoska and Kocarev's novel ICT framework for implementing the 2030 Agenda in 2019. Their proposed ICT architecture provides an exception framework dealing with the complexities of the 2030 Agenda. Their proposed scheme consists of a set of principles organized into three modules (database, sustainability, and governance) that could be used to improve SDG implementation. They believe that the three modules of the ICT framework should be linked in a network to improve and utilize this type of platform in practice. The Figure.27 depicts the proposed communications architecture. In such an architecture the solutions include blockchain-based IoT, Ethereum and smart contracts and (IPFS), and records management used for collecting a variety of data including sensor data, statistical data, and social data from stakeholders' groups. By their nature, distributed file systems distribute all the stored files and documents among their participating peers.

(IPFS) can store in a secure way the collected data into the blockchain, which also allows the proposed system to participate in smart contracts that enable the direct participation of stakeholders. It is important to note that very similar features may be provided by traditionally centralized solutions like databases, cloud-based services, or complex-event processing software, but blockchain technologies include the following features that make them attractive for sustainable developments scenarios. Transparency, application decentralization, data authenticity, data security, and operational efficiency. All operations existing in the platform include stakeholder register, recording the initial data, consensus protocols documents by using Ethereum smart contracts and distributed IPFS on the blockchain. The procedure of chain begins when stakeholders register in the system. The stakeholder groups can join the platform by providing initial information and after registry can enter their user account. They indeed have signed the membership in the smart contract through this registry.

The proposed platform could be implemented with smart contracts so that the full potential of the blockchain's different properties can be used. The final set of the blockchain use cases proposed in this research for the improved implementation of the three modules (data, sustainability, and governance) can be written in Solidity language and could be customized in accordance with the development challenges in the Italian cities. The research findings indicate that there is huge potential for blockchain technology to improve the implementation of the three Modules of our proposed platform to implement the 2030 Agenda which includes the data module, sustainability module, and the governance module.

The research also highlights future research in the areas of concern that required further investigations.

Figure. 27- The proposed communications architecture
to support the implementation of the 2030 Agenda



Chapter 5
Conclusion

This study suggests a new paradigm for improving the 2030 Agenda's implementation by integrating Ethereum and IPFs Technology (data-sharing platform) and, by utilizing Ethereum smart contracts. Our approach focuses on document sharing among key stakeholder groups, approval, and tracking of new versions of documents saved on the decentralized file system IPFS, and the use of smart contracts to allow involved actors to monitor, track, and trace each transaction in real-time towards implementation of the sustainable development goals. Smart contracts hosted on the Ethereum blockchain, disseminate events to all users on the network. If predetermined terms are broken, it assists in quickly rebounding and restoring the conditions to their original state.

Our proposed platform is in fact a decentralized application (DAPP) that could be implemented in the Ethereum blockchain ledger using several smart contracts and Ether cryptocurrency. Furthermore, the accurate use of the consensus feature of blockchain in the proposed system helps stakeholders to reach an agreement. In this case, the final comment will be more decisive and low-cost. and since executed automatically by using associated smart contracts, it avoids bureaucratic processes that are energy and time-consuming. All transactions are done by using the Ether cryptocurrency on the Ethereum blockchain ledger. The reason for using the Ether instead of a unique token is that the users are familiar with the digital cryptocurrency of Ether.

However, in future works, we introduce a unique cryptocurrency to tokenization the process of the platform instead of the Ether. The qualities of blockchain in dealing with trust in highly decentralized situations could make it a platform for new sharing economy applications. With the use of IoT devices multiple parties can securely share unprocessed IoT data, text, and multimedia in the context of location and point-of- interest sharing, conduct financial transactions while concealing the true identities of individuals involved in various online operations, and conduct user authentication. In addition, IoT devices use Ethereum coins to transmit value between actors (Rahman et al, 2019).

When Ethereum and IPFS are combined, we acquire the power to timestamp any data, regardless of its size. Considering that blockchains are limited in their ability to store massive volumes of data. For example, depending on the cost of Ether, there is a cost of hundreds to thousands of dollars per megabyte (MB) of data you put on Ethereum, combining Ethereum with the Interplanetary File System (IPFS) creates a simple yet powerful system of immutable content. For instance, in the real- world, the signed PDF of the agreements could store on IPFS, and the corresponding hash was printed onto the Ethereum blockchain. since the hash has been added to the Ethereum blockchain at the time of upload to the IPFS network, the signed document was timestamped in a tamper-proof way. therefore, IPFS provides tamper-proof content retrieval. To retrieve content that has been stored on IPFS, the requester of the content is cryptographically guaranteed to receive the same content that was initially uploaded to the IPFS network (Ober, 2018).

IPFS (Interstellar File System) which is often known as the interstellar file system, is one of the most well-known distributed file storage systems. Because IPFS is a file-based storage protocol, user nodes have easy access and secure availability. Any node in the IPFS network is self-contained and unradiant on other nodes. When the data is saved in the IPFS node, the IPFS node will identify the file's unique hash value based on the incoming file information, and the data will be stored in the network environment indefinitely. When extracting file information, you can identify the hash value based on the demands of the user and get the file from there. IPFS addresses data using hashes, ensuring data integrity and distributed durability. IPFS addressing allows users to share data with one another, reducing bandwidth requirements and speeding up data sharing. Moreover, IPFS distributed storage provides immutable and integrated data storage with offline capabilities.

The Ethereum + IPFS data-sharing platform could intelligently recognize the identity of the user. as well as filtering transaction data. IPFS provides an information identification system, and Ethereum could perform independent verification. information on the user, as well as identity and authorization without third-party certification. The smart contract set module allows you to create contracts (Jianjun et al, 2020). To create a user identification, signature technology is used user information in the form of agreements and validates user information in the form of logical operations and intelligent protocols. Ethereum is a technology that has drastically changed the way people conduct transactions.

Ethereum is becoming more mature in terms of use and development, with a bigger number of transactions than Bitcoin. The benefits of Smart Contracts that are hosted on Ethereum are endless; For instance, Decentralized finance: everything from a loan to a transfer may be done safely on the Ethereum blockchain. The blockchain-based voting system helps to prevent vote-rigging and gives reliable results. and Digital identity that the blockchain allows for the creation of a unique digital identity. Because Ethereum is used by more than half of the top 200 projects in terms of market capitalization, it will continue to expand and remain one of the most important participants on the market. The network's improvement will allow for the development of a long-lasting and scalable protocol for global use in the future (Muster, 2021).

5.1. Theoretical and practical contributions of the research

Three theoretical contributions are made in this thesis. First, the study findings have supplied useful information on how to use an emerging technology (blockchain) with respect to create innovation in the digital age. Second, by recommending a few theoretically functional blockchain utilize cases that could lead to the enhancement of the implementation of the SDGs, the existing body of knowledge in the fields of blockchain and sustainable development objectives and the 2030 Agenda research has been expanded. In fact, the identified blockchain solutions in this research, can contribute to addressing sustainable development goals challenges and highlight blockchain as an emerging technology that brings with it an array of possible solutions for the 2030 Agenda. Third, has developed an innovative Ethereum blockchain platform to adopt the potential of blockchain technology to implement the 2030 Agenda considering existing discussions in governance science, sustainability science, and data science. The research results have three key practical ramifications in addition to their theoretical contributions. First, it serves as a starting point for identifying and evaluating blockchain use cases for the 2030

Agenda. Second, the study provides insights for decision-makers and government administrations and helps practitioners to invest in promising blockchain-based projects. Third, governors and community officials in Italy who are devoted to pursuing sustainable urban development could use the findings of the thesis to help implement the SDGs at the regional level and minimize territorial inequalities in the country.

5.2 Research limitations

The research has two limitations. First, although most of the participants in this research work in international organizations, future studies should try to generalize the findings on an international level. This would help to confirm the aspects that have been discovered and to develop best practices for better generalizability. The second limitation is the statistical sample of the research in the field of thematic analysis. The statistical sample of this research is in the stage of systematic literature review included 102 articles.

In the field of content analysis, the statistical community consists of experts and administrators who have a history of study or implementation in the field of understanding blockchain theories and their applications, especially in the field of sustainability. Although attempts had been made to conduct a greater number of interviews with the experts in the field of this novel and emerging technology, but since we were collecting data during the Coronavirus Pandemic, there was some limitation such as hard access to experts in the pandemic period, which was not a suitable time for some respondents to participate in the interviews. However, specific features of the research sample in the field of research interview were conducting an interview with a member of the blockchain advisory board of the ministry of the economic development of Italy and a very well-known expert in the field of blockchain technology that in evaluating the extent to which results from the interviews conducted might generalize could be considered. Therefore, future studies would be to build a stronger overall evidence base.

5.3 Future Research

Future research could focus on how government agencies and municipalities deal with the research findings, such as how to take advantage of the opportunities that blockchain bring. Much work remains to be done, and we have a long road ahead of them to turn the technological insights that we understood from the dissertation results, into action. Considering the blockchain features emphasized by the interviewees such as; a platform to facilitate the implementation of the

2030 Agenda, a platform to tackle economic, social, and environmental problems, a platform to enable new forms of funding, a platform to increase the capacity for transparency and security, a platform to eliminate the need for third-party, a valuable tool in data management and privacy, a platform to Increase the agreement coefficient on information by different groups, a platform to increasing the storage space of trusted information, and eventually, a platform to the possibility of achieving sustainable development goals by increasing automation and integration of the three modules (data, governance, and sustainability), we intend to conduct a pilot implementation for research findings in the municipalities in the south of Italy. in this way, educating and informing the government officials and decision-makers on what the blockchain is and its smart contracts and how their applications can be utilized to produce newly sustainable solutions to support the 2030 Agenda will be the first step. Creating an ecosystem of partners and stakeholders, determining the role of each stakeholder, selecting, and setting the components of the governance module to govern the implementation of the sustainable developments goal by citizens and stakeholders according to the need and regional developments gaps, and blockchain deployment infrastructure will be the second step. In addition, Interviewee No. 1, who is a member of the advisory board of blockchain in the ministry of economic development of Italy, believes: " Through virtuous behavior (such as the use of renewable energy sources) tokenization, it could be possible to design better and more far-reaching incentives towards sustainable behaviors. and using tokens, it could be possible to design more focused and ad hoc public support ".

Accordingly, introducing and issuing a specific token for its own project on the Ethereum blockchain could be included in future projects. However, some academics advise that the advantages of blockchain adoption in publicly or privately services be carefully evaluated because the cost of developing, running, and maintaining the Blockchain Technology may be greater than the benefits of developing, running, and maintaining the Blockchain Technology (Marsal-Llacuna & Lusa 2017; Angraal et al., 2017). All existing technological hurdles in using Blockchain Technology are, however, due to the technology's immaturity. This might be seen as something that occurs frequently with the introduction of new technologies. Blockchain technology has a lot of promise for introducing new ideas. However, deploying Blockchain Technology could be highly costly. Organizations must invest a significant amount of time and money to migrate or move legacy systems.

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