Impacts of COVID-19 on Sustainable Development Goals and Effective Approaches to Maneuver them in the Post-Pandemic Environment

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Impacts of COVID-19 on Sustainable Development Goals and effective approaches to maneuver them in the post-pandemic environment

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Abstract

To resume the construction of a sustainable world, it is crucial to assess the damage imparted by the pandemic to the seventeen Sustainable Development Goals (SDGs). For this purpose, this study is formulated to assess the endurance of SDGs amidst the reverberating wave of impacts that unfolded from the pandemic, and further, to provide a direction in the post-pandemic environment to effectively progress towards the SDGs. A detailed investigation is carried out to examine the drag resulted due to the pandemic impacts in every goal and a quantified impact analysis is performed in terms of the targets of the SDGs. The results indicate that SDG 1 and SDG 8 are the most impacted goal. To dive deep down into the SDGs, the characterization of SDGs from their elemental point of view such as nature of goals, depending on factors, locus of the goal and SDGs interaction is accomplished. Further, a novel parameter, the degree of randomness is proposed whose application in environmental research is immense. The impact on each goal and impact interaction between all the SDGs are also mapped, through which the dynamics of SDG interaction is elaborated. In context with the post-pandemic scenario, the strategies to achieve the SDGs with environmental focus are presented with prioritization factor that helps in the quick revitalization. This prioritization factor is formulated by employing a multi-criteria analysis methodology. To add to it, the fundamental elements of SDGs are built upon one another to frame an optimized and effective approach to achieve the SDGs in the post-pandemic environment. Despite the strategies, a conceptual framework to align the business practices with the SDGs is propounded. This study deep down would provide a unique perspective to the research community and would impart deeper knowledge in connection with sustainability while the solutions framed would steer the policy and decision-makers.

Keywords: Sustainable Development Goals (SDGs); COVID-19 Pandemic; Environmental sustainability; SDGs interaction; Degree of randomness.

1. Introduction

The pandemic resulted from the novel coronavirus has caused a global crisis and affected people physically, mentally, and economically. This pandemic will prevail in the memories of generations of people and unfortunately, the impact caused by the pandemic cannot be erased by any sort of rapid remedies. The whole world realigned itself to fight the COVID-19 and the key elements of the society, especially the government, healthcare system, industries and the public are contributing their joint efforts in achieving the single goal of mitigating the spread and ultimately, to eliminate the coronavirus even if it leads to a consequential impact in terms of economic crisis. From another perspective, the cataclysm impact made by the pandemic crisis need to be assessed and proper measures should be implemented so that humanity can thrive with minimal impact in the post-pandemic scenarios.

The COVID-19 pandemic is distressing for the entire humanity and humans will control the outbreak and progress towards SDGs. The 17 SDGs supported by 169 targets were adopted in the historic UN summit in September 2015 for guiding the development that needs to take place in the next fifteen years (from 2015) and thus, giving rise to a sustainable world for all (UN SDGs, 2020; UNDP, 2020). Each SDGs is not an independent factor, that is, an advancement made in any goal may effectuate synergic effect or trade-
off effect with the progress of other goals. As every possibility for constructing a better world is being analyzed, engineered, and managed, the emerged unexpected enemy is influencing the multifold factors questioning the progress of SDGs. Further, a distinctive drag has resulted in these superior goals owing to the COVID-19 pandemic. This consequential drag might either accelerate the progress by overcoming specific challenges or slacken the pace of progression by creating much more challenges to resolve. Thus, understanding the interaction between the SDGs is crucial and knowing how the impact can reverberate across multiple goals would help us to resolve any similar problems in the near future. From another perspective, the pandemic can be considered as an opportunity for addressing SDGs key challenges by exploring the changes that happened in the stipulated time and such an approach can remap the pathway towards achieving SDGs. In context with this, analyzing the impacts on each goal is vital and, subsequent planning and effective execution of the best possible efforts as a revitalization strategy in the post-pandemic world is utmost which in the fullness of the time would sail us towards sustainability.

Wang and Huang (2021) performed meta-analysis and figures out that the COVID-19 pandemic has a negative influence on 17 SGDs while it has a positive influence on 14 SDGs. Another study by Tonne (2021) demonstrates that COVID-19 highlights the fragilities in society and human development, and envisions the situation to make better decisions towards sustainability. The impacts of COVID-19 on the socio-economic, energy-environment and transport sector globally and SDGs are presented by Nundy et al. (2021). Also, the study suggests that in the course of recovering from the pandemic influenced impacts, the progress in SDGs might even suffer and recommends collaborative efforts to progress towards sustainability.

The proposed study investigates the various impact on the individual goals caused by the pandemic and also, provides an insight into how the impact on one goal affects the other, altogether mapping an impact nexus between the 17 SDGs. The strategies that are required to tackle the impact is provided along with the prioritization factor which defines its significance to implement it. Besides, a direction is provided to effectively approach the SDGs in the post-pandemic world and a conceptual framework to define SDG-aligned business practices is presented. The section-wise framework of this study is graphically depicted in Fig. 1. The contributions of this work are as follows:

- Examined a detailed outlook on the impact resulted in each SDGs during COVID-19 along with the challenges in the post-pandemic world.
- Characterized the SDGs based on nature of goals, depending factors, sensitive dependency factor, locus of goal, and SDGs interaction. A novel parameter, “degree of randomness” is derived as a function of dependency factors to determine the effectiveness of the efforts implemented in a goal.
- SDGs impact interactions and a novel approach proposed to analyze the degree of influence between the goals
- Post-pandemic strategies with the prioritization factor are formulated through multi-criteria analysis.
- Mapping the SDGs for the effective implementation of strategies is accomplished and proposed a framework to align the business practices with the SDGs.
Fig. 1. Framework of this study.
2. Pandemic – A distinctive drag on UN Sustainable Development Goals

In this section, the discussion is presented concerning the various progress, impact and challenges encountered by the SDGs in line with the pandemic, accompanied by a clear depiction of positive or negative drag experienced by individual goals.

2.1. Poverty (SDG 1)

The primary target of this goal is to achieve a less than 3 percent extreme poverty rate at a global level by 2030 (SDGs Knowledge Platform, 2020a). Poverty is a multidimensional factor and numerous studies also represent the intense interdependence between poverty and other factors (Dhahri and Omri, 2020; Schleicher et al., 2018). According to a study by Robles Aguilar and Sumner, the young people residing in rural areas, although not working necessarily in agriculture are largely considered as the world’s multidimensionally poor (Aguilar and Sumner, 2020). Hence, specific attention is required in the case of multidimensional poverty control and poverty among children (Pinilla-Roncancio et al., 2020; Pac et al., 2020). Indirect ways of mitigating poverty are also being investigated such as co-benefits of the Paris Agreement that deals with the reduction of greenhouse gas emissions on climate change and poverty (Campagnolo and Davide, 2019).

In the period between 2015 and 2018, the rate of poverty reduction slowed down to less than 0.5 percent per year (The World Bank, 2020). However, due to the devastating impact of COVID-19, the poverty rate will shoot up for the first time since 1998. The people belonging to congested urban livings, involved in informal services and manufacturing, heavily affected by lockdowns as well as mobility restrictions are more prone to attain poverty than the chronic poor. The longevity of the pandemic occurrence and the economic recovery rate will influence the severity of these effects.

Fig. 2. Impact of pandemic on poverty and its projections up to 2050 under various scenarios. Source: (UNDP SDG Integration, 2020)
UN Development Programme (UNDP) conducted a new study to assess the recovery poverty trajectories in the post-COVID future (UNDP SDG Integration, 2020). The analysis is underpinned by three scenarios such as ‘COVID baseline’, ‘High Damage’, ‘SDG Push’ scenarios and is shown in Fig. 2. The COVID baseline scenario indicates the pandemic-influenced poverty increase and the subsequent nominal recovery. In this scenario, the impact of pandemic results in a raise of 44 million people in extreme poverty (UNDP SDG Integration, 2020). The High Damage scenario represents the future in which the economic recovery is slow and the world might witness an additional staggering 251 million people under the status of extreme poverty raising the total count above 1 billion (UNDP SDG Integration, 2020). The SDG Push scenario highlights the role of targeted policy interventions that focus on accelerating the efforts towards a resilient and green future and this scenario yields promising results to bring down the poverty even including the pandemic impact. On the other hand, the low- and middle-income countries suffer greater than high-income countries (Jahan and Rahman, 2020). It can be inferred that if we fail to follow the roadmap to achieve SDGs, then the pandemic influenced impact on poverty would prevail for a decade at the least.

2.2. Hunger (SDG 2)

The main moto of Goal 2 is to end hunger, and simultaneously, attain food security and promote sustainable agriculture. Regarding the recent progress, it is concerning that the undernourished rate is rising for three consecutive years after a prolonged decline (SDGs Knowledge Platform, 2020b). The impact of COVID-19 on Goal 2 occurs indirectly. Society is in demand for food, as usual, the production levels of staple foods are stable and only in meeting the demand, the pandemic plays a role directly through supply chain issues among different stages of markets. According to the report, the prices of world agricultural commodity are stable and is expected to continue in 2020 (World Bank Blogs, 2020). As people lose their jobs, it makes them vulnerable to poverty which hinders them to purchase their basic needs including food. So, it is clear that the main influence that drags down Goal 2 is poverty and thus, the goal is affected indirectly. In 2020, due to COVID-19, about additional 132 million people may suffer from undernourishment (UN statistics, 2020a). The prime impact on SDG 2 will be the lack of significant focus in the next few years as poverty will emerge as a potential and bigger problem which might amplify the malnutrition levels among children. On analyzing the key strategies to end hunger, a new approach in leadership, adaptive measures towards the agroecosystem diversification, investments in the agricultural sector are observed to be crucial to achieving the goal (Herrmann and Rundshagen, 2020; Blesh et al., 2019; Mason-D’Croz, 2019).

2.3. Health and well-being (SDG 3)

The emergence of COVID-19 affects and strains the healthcare system more straightforwardly than ever which drags SDG 3. The number of infections is rising rapidly and the healthcare unit all around the world is making a way to provide health support in all forms. Further, the government and the industries act as supporting bodies for the healthcare system during the pandemic (Elavarasan and Pugazhendhi, 2020). Currently, the main challenges associated with the COVID-19 and SDG 3 is to tackle the situation and to provide quality healthcare to every individual irrespective of the situation. Only when the pandemic is
controlled, the economy can be reshaped or the progress in SDGs can be resumed. A typical approach towards the pandemic is represented in Fig. 3.

Apart from these impacts, the progress that already taking place is affected in terms of other diseases. For instance, more than 70 countries have stalled the childhood vaccination programmes during this crisis (The Lancet Public Health, 2020). The health care sector’s normal functioning for providing service to cancer screening, non-COVID infectious diseases, family planning, and promoting health awareness are either interrupted or completely neglected. This may even have years of impact on the populations skipping these services and wiping out the years of progress achieved by consistent health and nutritional services (Khetrapal and Bhatia, 2020). For instance, according to a recent study, the deaths of children under the age of 5 per month would witness a rise of 9.8 to 44.8% and an increase of 8.3 to 38.6% in maternal deaths per month would result over six months if the routine health services and access to food are disrupted (UN statistics, 2020b).

In the post-pandemic period, the role of spending towards the progress of SDG 3 is significant and more funds are needed to be allocated for improving the health sector especially in low income and lower-middle-income countries. Meanwhile, a study claims that domestic resource mobilization is the key to generate sources for SDG 3 (Sundewall and Forsberg, 2020).

2.4. Quality Education (SDG 4)

Education is influenced by several social factors such as education policies, teacher’s ability, parents, civil society and politics. Feasible analysis of these factors can help us to reform the educational approaches towards SDG 4. Barbara et al. have performed one such analysis on the politics of quality reforms and presented the challenges associated with attaining quality education (Bruns et al., 2019) while another study maps the field of responsible management education in line with SDGs (Storey et al., 2017).
In this pandemic, the global wide closure of educational institutes impacted about 70% of the world’s student population (UNESCO, 2020a). The whole education system is backed up with the technology that allows the internet accessible to students to gain their knowledge. On the other hand, internet facilities are not accessible in every part of the world. Fig. 4 shows the internet penetration rate distributed throughout various geographical regions as of 2020 quarter 1 (Internet World Stats, 2020). From the figure, we can see that the world average is just 58.7% and the remaining population has to wait to continue their education until the pandemic disappears.

The exposure to distant learning methodology is enough to create an impact on the field of education and it might have a positive drag on SDG 4 in upcoming years. A study from UNESCO indicates that the cost of achieving SDG 4 has already increased before COVID-19 but with the impacts of the pandemic, the cost has further increased (UNESDOC Digital Library, 2020). The cumulative finance needed in the next decade (up to 2030), costs around US$ 335 billion owing to the need for additional capital for remediation, re-enrollment, second-chance programmes and infrastructure requirements which overall caused a net increase of US$ 205 billion as compared to the normal situation (UNESDOC Digital Library, 2020).

### 2.5. Social equalities (SDG 5 & 10)

Social equalities imply equalities within and among the societies which include gender equality, anti-racism, income equality and equal participation in societal activities and decision-making which covers both the SDGs 5 & 10. The relationship between SDG 5 and 10 is depicted in Fig. 5. The UN strategies do not focus on the inequalities in water access and social mobility but some studies have reported ways to reduce such inequalities too (Cetrulo et al., 2020; Hackl, 2018). It is seen that though the women employment is increasing day by day which is good progress as in the case of SDG 5, but their income isn’t justifying as compared to a man with a similar performance (not in all the cases) (UNESCO Inclusive Policy Lab, 2020a) which in turn contrasts the development in both SDG 10 & 5. Such complexities exist in strategically dealing with the progress of these goals and to encounter this problem, the awareness, the
governmental schemes and policies should appeal in such a way that it adores the perspective of social equalities.

Concerning the pandemic, the inequalities have played a role in directing the impact. For example, a report mentions that in the US, blacks are dying at a rate faster than whites (UNESCO Inclusive Policy Lab, 2020b). Also, resource-poor countries could not purchase the equipment and products that are desperately required when compared to resource-rich countries. In populous countries like India, urban inequalities exist and the massive population living in slums could not access water (World Resources Institute, 2020a). On the other hand, a report claims that the US experiences wealth inequality, meaning that when some experience a risk, the others (poor wealth) experience a double threat. To add to it, the report from the Federal Reserve indicates that about 40% of Americans couldn’t even cover the emergency expense of $400 (Scroll.In, 2020).

From the impacts, we can make a clear-cut argument that though inequality in general, have an impact on society, the distressing situation like pandemic will worsen the impact than ever. Thus, we can say that the pandemic amplifies the negative drag in the progress of attaining SDGs 5 and 10.

### 2.6. Clean water and sanitation (SDG 6)

Three in ten people lack access to clean drinking water and six in ten people lack access to sanitation facilities (Sustainable Development Goals, 2021). Wastewater treatment, local governance, policies and services in the water sector, and natural resources are some of the crucial factors that influence the progress of this goal (Herrera, 2019; Kookana et al., 2020).

On analyzing the impact of the pandemic on the water crisis, it is clear that the lack of water accessibility to the billions of populations is one of the boosting factors for the prevalence of pandemic. For controlling the pandemic, hand sanitizing measures and frequent hand washing have led to an increase in water consumption as well as the generation of waste water has increased multifold. A study shows that water utilities have a significant impact on revenues from industrial and commercials that utilizes the water (International Finance Corporation, 2020). It is estimated that on average, 27% of industrial water demand
will fall due to COVID-19 (International Finance Corporation, 2020). This is primarily ascribed to a
temporary halt in industrial operations. The major impact of SDG 6 in terms of the water and sanitation
sector is that the ability to make the critical capital investment was affected drastically. This would create
a significant delay in the implementation of projects to improve water security. To tackle this, investments
to protect water-related ecosystems is needed and effective management of the water usage pattern is
pivotal (World Resources Institute, 2020b).

2.7. Affordable and clean energy (SDG 7)

This goal emphasizes affordable, sustainable, reliable and modern energy for all. The global electrification
rate is accelerating and it reached 89% in 2017 but still, there are 800 million people without access to
electricity (SDGs Knowledge Platform, 2020c). The renewable energy usage from 2010 to 2019 has been
doubled according to the IRENA report (IRENA, 2020a).

The construction of new facilities and infrastructure related to the energy sector has been significantly
delayed or stopped due to supply chain disruption. In India alone, the project of extending a 3000 MW
power generation capacity through solar and wind energy-based projects have been delayed owing to the
pandemic (pv magazine, 2020). Also, regular maintenance activity has been limited to a minimum and
priorities are given to repair and restoration only. On the other hand, defaults in the payment of energy
utility bills have generated a financial debt among the energy communities.

The SDG 7 closely progresses with SDG 8 and SDG 9. For instance, energy-related commodities such as
oils, gases and petroleum products have drastically affected in terms of price during the pandemic. The
demand for crude oil and variation in the spot price of WTI (West Texas intermediate) in US dollars per
barrel from December 2019 to November 2020 is depicted in Fig. 6. In February, the WTI spot price had
dropped nearly by half with a constant decline and it attained the lowest price ever in mid-March ($
16.55/barrel WTI spot price) according to the data (Opendatasoft Data Network, 2020). Though the prices
are down, the corresponding effect on the cost of petroleum products at the consumer end was not
proportional due to future market uncertainties (Kevin et al., 2020). Besides, the countries that depend

![Fig. 6. Variation of Oil prices during pandemic.](image-url)
on the export of crude oil have a pronounced effect on their economy for the short term at least up to the end of 2020.

On analyzing the energy usage pattern during the pandemic, a reduction in power consumption has resulted. The peak power demand dropped 3-4% in Italy. The energy demand in the USA, India, Singapore, Australia and China were reduced by 5.7%, 26%, 8%, 6.7% and 7.8% respectively (Madurai Elavarasan et al., 2020). Off-grid and mini-grid companies are facing a financial-issues and may even risk insolvency.

Concerning clean cooking, a survey of over 100 enterprises reported that two-thirds possess high concerns for the reduced paying ability of the customers (United Nations, 2020). To turn the table for clean cooking, strong political prioritization and subsequent investments are required.

2.8. Socio-economic impact (SDG 8 & 9)

SDG 8 & 9 deal with decent work, economic growth, industry, innovation and infrastructure. Amidst the pandemic, the economy and industrial activity have been affected to a much higher extent such that it resulted in the worst global economic fallout since the Great Depression in the 1930s. The World Trade Organization (WTO) predicts that world trade would fall by between 13% and 32% owing to the effects of the pandemic (World Trade Organization, 2020). In 2020, the GDP per capita is expected to decline by 4.2% before it starts to increase in 2021 at the pace of 3.1%. In the least developed countries, the development rate is projected to weaken to 0.8% while it is expected to increase at a rate of 4.6% in 2021 (UN statistics, 2020c). Regarding employment, the highest risk of disruption is subjected to daily wage earners, self-employed and other service-based firms affected by lockdown measures. According to International Labor Organization (ILO), due to the COVID-19 crisis, the forecasted impact shows a 14% drop in working time, meaning a loss of 400 million jobs in comparison to the fourth quarter of 2019 (International Labor Organization, 2020). Lower and middle-income countries are affected the most, with an estimated average drop in working hours up to 23.3% - equivalent to 240 million jobs in the second quarter of 2020. Moreover, the income in developing nations cuts by 15% (International Labor Organization, 2020). Hence, it is clear that the COVID-19 pandemic has catastrophic effects on the progress of SDG 8 in multiple aspects.

Significant impact is seen in service sectors such as travel and tourism, which needs more time to recover. The pandemic scenario affected the small-scale industries to a larger extent in terms of their recovery period. Since manufacturing industries drive the overall economic growth, a serious impact on the economy is resulted especially, in the least developed countries. The aviation industry which boosts economic development had undergone the deepest fall. According to the International Civil Aviation Organization, the estimates as of June 2020 indicates an overall drop in passengers ranging from 2.29 billion to 3.06 billion which results in gross revenue losses between $302 billion and $400 billion when compared to the normal situation (UN statistics, 2020d). In terms of innovations, the pandemic accelerated the R&D funding in the pharmaceutical industry and emerging technologies such as digital infrastructure, artificial intelligence, and service-based innovations (UN statistics, 2020d).

On the other hand, the work from home scenario amidst the pandemic is gaining attention, and it might change the post COVID world to adopt work from home methodology as a new type of employment
branch in line with the conventional working scenario. It will have a different positive drag on the employment with more sophisticated approaches which ultimately enhances the progress of SDG 8. Digital business is gaining attention among the public and this pandemic is been an opportunity for the customers to use it. Therefore, hastened digitalization might create more employment opportunities in near future.

2.9. Sustainable cities, communities and society (SDG 11 & 16)

SDG 11 & 16 aims at better living conditions for all the people in a sustainable society with a peaceful environment and justice. And, substantial progress has been made in improving the living standards of the people but yet numerous cities suffer from issues such as increased slums, poor quality of air, limited access for transportation and fewer public spaces. A study by Billie Giles-Corti et al. presented a more comprehensive approach in terms of monitoring, benchmarking and evaluating policies that are directed towards the development of healthy and sustainable cities (Giles-Corti et al., 2019).

Due to the prevalence of pandemic, the cities and society’s day-to-day activities are hindered and the whole society is fighting the pandemic crisis. Despite the lockdown, the power of societal culture and creativity of the people are leveraging the cooperation among the cities and binds different communities to express unity (UNESCO, 2020b). In terms of SDG 11, the major impact is seen on the lifestyle of the people. Around 90% of the COVID-19 cases are reported in urban areas and this hits the vulnerable the hardest (UN Statistics, 2020e).

Concerning SDG 16, the pandemic threatens to exacerbate the fragilities in society. This indirectly affects the peace of the society by amplifying the social insecurities, sufferings, and inequalities. Protest and blames on the various social bodies in different geographical regions amidst the pandemic are the clear depiction of the rupture of justice and peace within society. Besides, trends suggest that lockdown measures induced high homicide rates in Latin American countries while it is quite opposite in European countries with a reduced rate of violence (UN statistics, 2020f).

2.10. Sustainable consumption and conservation of resources (SDG 12, 14 & 15)

Table 1 gives a rough idea of how material consumption per capita is increasing at an alarming rate. Hence, well-designed national policy frameworks and cooperation are much needed to impart sustainability in consumption and production patterns (SDGs Knowledge Platform, 2020d). Apart from it, we can see a rise in ocean-acidification by 26% from past 30 years which if continues, will result in a devastating impact on marine life and even land degradation is happening at a worrying scale even though the recent year progress has shown a reduction (SDGs Knowledge Platform, 2020e; SDGs Knowledge Platform, 2020f).

Table 1. Worldwide material consumption (SDGs Knowledge Platform, 2020d).

| Year | Worldwide material consumption |
|------|-------------------------------|
| 1970 | 27 billion                     |
| 2015 | 87 billion                     |
| 2017 | 92.1 billion                   |

If the extraction remains uncontrolled without political action
Concerning SDG 12, a large amount of food is lost in the supply chain before reaching the end customer and upheaval of waste generation is witnessed including the medical waste during the pandemic. The resource consumed to control the pandemic is high in the medical sector and the prevailing problem of proper disposal of the mask remains a serious task. As human activities are the paramount cause for the impact in SDG 14 & 15, the pandemic does not have much effect on these goals. Instead, the pandemic muffled the human activities which had a positive impact on the progress of SDGs 14 & 15. It can be inferred that the pandemic had given some breathing time for both land and marine resources (Forbes, 2020). Hence, the pandemic provides a positive drag in an indirect way towards these goals.

2.11. Climate action (SDG 13)

This goal influences almost every other goal and the progress in SDG 9 without progress in SDG 12 & 15 will result in degrading effects which in turn powers the climate change, hindering the progress in SDG 13. Hence, balancing the contrasting effect between the goals is necessary by keeping SDG 12 (Sustainable
consumption) as the centre of balance (Campbell et al., 2018). Also, individuals should indulge the notion of climate action in their behavior, feelings and values for effective action (Bouman et al., 2020).

The pandemic has no direct effect on climate action but it helped in suppressing human activities in terms of lockdown and quarantine, during which nature’s replenishment activities occurred with negligible human interventions. This resulted in a significant reduction in the concentrations of CO₂ and particulate matter (PM 2.5) levels. For instance, a 30% drop in air pollution is observed over the Northeast US (NASA Aura Atmospheric chemistry, 2020). Also, countries like China and India have experienced ever achieved carbon and NO₂ reduction. Fig. 7 shows the level of NO₂ reduction in India from March 25 to April 25, 2020 (NASA Aura Atmospheric chemistry, 2020). Apart from air pollution, the pandemic resulted in a cleaner beach than ever, reduced marine pollution and environmental noise (Zambrano-Monserrate et al., 2020). Hence, the pandemic boosted the progress towards achieving green Earth and indeed it is a positive drag concerning this goal, yet, the effect is ephemeral.

2.12. Partnerships for the goal (SDG 17)

The moto behind this goal is to promote the means of implementation through strong global partnerships for overall sustainable development or in other words, it is a goal meant to expedite the progress of other goals through joint efforts in terms of global partnerships.

The pandemic has caused several impacts but in regards to SDG 17, the impact can be assessed in two approaches. One aspect can be approached as to how multiple organizations, governments and industries have put their joint efforts in mitigating the spread within and among societies. The other aspect deals with how the pandemic impacted the existing partnerships among various countries, and organizations. For instance, India has agreed to partially ease the export of hydroxychloroquine and paracetamol to the US and other countries as India is one of the major global producers of hydroxychloroquine (The Print, 2020). This was indeed a good gesture among the countries and it would strengthen their global relationship for near-future needs. Hence, we can claim that the new partnerships might have been created and existing partnerships have strengthened. Also, there might be a deterioration among existing partnerships, trade, and foreign direct investments due to the pandemic. Besides the global partnerships, the UN says that trade tensions exist, significant digital divides are experienced, more importantly, the private investment flows aren’t in line with sustainable development (GreenBiz, 2020). If these challenges aren’t encountered properly, SDG 17 won’t make any sense towards sustainability even though several partnerships exist.

2.13. Overall COVID-19 pandemic impact analysis on SDGs

The above sub-sections elaborated the various impacts that dragged the progress in SDGs but a quantified approach would be much effective in understanding the intensity of impact experienced by each goal. This section frames and discusses the impact analysis on SDGs based on the previous section discussion linking with each of 169 targets. A simple ranking method based on weightage is allocated to each target by analyzing the possible influence caused by the pandemic impact on the progress of the considered target and the impact score weightage allocation is based on Table 2.
Table 2. Impact score for the various intensity of impacts corresponding to each goal.

| Impact categories                      | Impact score | Description                                                                 |
|----------------------------------------|--------------|-----------------------------------------------------------------------------|
| Catastrophic irreversible impact       | 5            | The extreme impact that wiped the progress made in the target and its effect is pronounced for long-term even up to a decade |
| Massive temporary impact               | 4            | Destructive impact for a short-term period that degraded the target’s progress that would last for a few years |
| Indirect amplified impact              | 3            | Impact occurred indirectly through a cycle of effects that hinders the progress in the target for a short-span |
| Stalled progress impact                | 2            | Impact completely stalled the progress without affecting the already achieved progress |
| Endurable impact                      | 1            | Manageable impact by finding alternative ways to make a progress to achieve the target |
| Insignificant impact                  | 0            | Impact’s effect becomes insignificant to the progress in the target |
| Temporary positive drag                | -1           | The impact resulted in a small boost in progress towards the target for a temporary period |
| Revolutionary compliment               | -2           | A foundational positive change has been incurred that yields a promising way to progress in the target |
| Long-term positive reverberation       | -3           | Highly amplified progress is made in the target aided by the impact |

For a given goal, after quantifying the impact for each target with the help of Table 3, the overall impact score of the goal is calculated by using Eq. (1).

\[
\text{Overall impact score (OIS) of the goal} = \frac{\sum_{i=1}^{n} \text{Impact score of target } i}{\sum_{n \times 5}}
\]  

where \( n \) represents the number of targets in the considered goal. The denominator captures the maximum impact situation for the goal. As a result, the OIS will help us to analyze the intensity of impact and the OIS of each goal is presented in Table 3.

Table 3. Impact analysis for 17 SDGs.
As a whole, the pandemic ultimately impacted the progress of most of the SDGs. And it is clear that SDGs 1 and 8 are the most affected goal as the OIS of these goals are 0.69 and 0.55 meaning more than half of the targets in these goals have been highly impacted due to the pandemic. Besides, SDGs 15,13,16 are the least impacted goals and SDG 14 has a net positive impact due to the pandemic. Hence, significant efforts are needed in addressing the challenges to minimize the impacts on these goals.

### 3. A Deeper interpretation of Sustainable Development Goals

SDGs are the key to attain a sustainable world and thus, understanding the characteristics of the goal is significant for directing our efforts. This section elucidates in-depth concepts of SDGs which is a prerequisite to understanding the upcoming sections.

**Nature of goals:** On analyzing the 17 goals and their targets, it can be observed that a complex relationship exists between each other. Generally, when deducing how each goal can be attained, the nature of the goals can be segregated as implementation based and consequence-based. Implementation based goal means that the advancement related to the goal is possible only by implementing certain measures while consequence-based goals cannot be attained by direct implementation of any strategies but can be only achieved as a function of reaction to a few or many activities.

**Depending factor:** The depending factor is another fundamental parameter that depicts the factor that a goal depends on and it is derived by analyzing the goal and its corresponding targets. The depending factor for implementation-based goals should be viewed as what developments has to be made to achieve the goals, while for the consequence-based goals, it should be imagined as what factors are responsible for hindering the progress in the goal. The various categories of dependency factors are provided below

- Environmental factors: climate, weather, pollution, natural resource availability.
- Societal factors: Inequalities, culture, societal behaviour, acceptance, exposure.
- Human development factors: Human activities, health, income, employment, agriculture, innovation, education, partnerships.
- Political factors: Governance, national and international cooperation, policies, bribery, political vision.
- Economic factors: Economy and GDP, investment capacity, exports and imports, economic efficiency.
- Technological factors: Clean energy, industries, research, technological development.
**Sensitive dependency factor:** The sensitive dependency factor refers to a certain depending factor that can highly influence the progress in the goal than the rest of the dependency factor for a given goal. In other words, it simply marks the degree of influence of each depending factor whether high or low corresponding to a goal.

**Locus of the goal:** Based on the sensitive depending factor, the goals can be grouped as economy, technology, society, environment-centred and also, multi-locus centred goals. This grouping is done to know the locus of the goal where the measures should be focused on when dealing with a particular goal.

**SDG interaction:** As mentioned earlier, the SDGs have a complex relationship with each other but these can be broken down into simple relations with the depending factor. If any two goals, share a similar depending factor, then the possibility of one goal influencing the other is high and even interdependency might exist. With such analysis using the dependency factor and logical interpretation of targets within the goals, the interaction between the goals can be figured out. The resulted SDGs interactions can be of three types (i) a goal’s progress influence other goal’s progress by hastening (synergic effect) or degrading them (trade-off effect), (ii) a goal’s progress depends on another goal’s progress, (iii) considered two goals progress are mutually interdependent. Key SDG interaction just involves the most significant interaction between the goals from the existing interaction.

**Degree of randomness:** The authors define a unique characteristic of the SDGs namely, “Degree of randomness” in the pathway of the goal. The degree of randomness simply explains the predictable nature of multiple factors on which the goal depends. This can be figured out by the general assessment of the depending factor in each goal. By assessing the randomness, one can easily know which goal can be progressed as planned provided that the execution is in line with the planning. With this parameter and SDGs interaction, an effective measure that integrates more SDGs progress can be developed which can hasten the progress in many goals. The quantification method for evaluating the degree of randomness is based on a simple modified ranking method (designed by authors). Here, each depending factor is analyzed for uncertainties in the progress or the possible effectiveness for an implemented measure to provide prominent progress. For instance, to achieve a target that depends on environmental factors, measures are needed from multi-dimensional aspects such that all people are involved in the whole process. This indicates a high level of uncertainty or randomness in the process. While implementing technological-based solutions, it is easier to process as relatively fewer contributors is required to substantiate effectiveness. This marks a low level of uncertainty or randomness. Similarly, the uncertainty involved in other factors can be reasoned. Table 4 shows the randomness score for each dependency factor. It can be observed that among the dependency factors of the SDGs, the environmental factors are the most uncertain or random factor as they cannot be controlled which is followed by societal factors and human development factors. Thus, these factors have the highest random factors and technology being more focused, less randomness prevails and accordingly the randomness score is the least for this factor.

**Table 4.** Randomness score corresponding to the depending factors.

| Depending factors | Randomness score |
|-------------------|-----------------|
Environmental factors 6
Societal factors 5
Human development factors 4
Political factors 3
Economic factors 2
Technological factors 1

From the sensitive dependency factor, it is seen that all the SDGs are not equally dependent on every factor and thus, a weighted score needs to be considered for sensitive factors. The proposed modified weighted ranking method gives more weightage to sensitive dependency factors than the rest of the factors. This is designed with two assumptions: (i) The sum of weightage assigned corresponding to each depending factor is equal to one, (ii) The weightage assigned to sensitive dependency factor is twice that of the rest of the dependency factors. These assumptions can be formulated as shown in Eq. (2) and (3).

\[ ax + b(n - x) = 1 \]  \hspace{1cm} (2)
\[ a = 2b \]  \hspace{1cm} (3)

Where \( x \) is the number of sensitive dependency factor that a goal possess, \( n \) is the number of depending factor a goal depends on, \( a \) and \( b \) are the weightage corresponding to sensitive dependency factors and the rest of the factors. Since \( x \) and \( n \) vary for each goal, the weightage ‘a’ and ‘b’ will vary. The values of \( a \) and \( b \) for all SDGs is presented in Appendix Table A1. After determining the values of \( a \) and \( b \), the degree of randomness can be calculated using Eq. (4).

\[
\text{Degree of randomness (DOR)} = \frac{nx[a \sum_{i=1}^{x} (S_i) + b \sum_{i=1}^{n-x} (D_i)]}{\sum \text{Randomness score of all depending factors}}
\]  \hspace{1cm} (4)

Where \( S_i \) and \( D_i \) are the randomness score for \( i^{th} \) sensitive depending factor and \( i^{th} \) non-sensitive depending factor, respectively. A sample calculation is presented in Appendix A1. Table 5 characterizes all SDGs in terms of the nature of goals, depending factors, sensitive dependency factor, locus of goal, SDG interaction, and degree of randomness for all goals. The results show that SDG 1, SDG 11 and SDG 2 are the goals that possess the top-three highest degree of randomness and SDG 7 and SDG 9 possesses the least degree of randomness among the seventeen SDGs.
Fig. 8. Progress in SDGs (world average) since 2015 in percentage points. Source: Sustainable Development Report, (2021).

To validate this conceptualization, the degree of randomness of each goal can be contrasted with the progress in the world for each SDGs. The progress made in each SDGs is represented as change since 2015 in Fig 8. It can be observed that SDG 9 has the highest progress which is followed by SDGs 1, 3 and 11. When comparing the degree of randomness scores, SDG 7 and 9 have the lowest scores and it can be expected that the progress can be satisfied to quite a level. But the progress change in SDG 7 was relatively low. This is because renewable energy penetration and other initiatives towards clean energy, energy accessibility and energy intensity were predominant only in recent years. On contrary, SDG 1 has the highest degree of randomness score yet exhibits the second-highest progress. This can be ascribed to SDGs interaction as progress in SDG 9 indirectly supports the progress in SDG 1 through SDG 8. The lowest progress is observed to obtain in the goals that depend primarily on environmental factors, i.e, SDGs 12 to 15. Altogether, the progress in a goal can be rendered as a function of the degree of randomness as well as SDGs interaction.
| SDGs | The motto of the goal | Nature of goal | Depending factors | Sensitive dependency factor | Locus of goal | SDG Interaction | Key Interaction | Degree of randomness |
|------|----------------------|----------------|-------------------|----------------------------|--------------|-----------------|-----------------|---------------------|
| SDG 1 | End poverty in all its forms everywhere | Consequence based goal | Environmental factors, human development factors, societal factors, economic factors, political factors | All | Multi-locus goal | SDG 2,3,5,10,11 | SDG 2,3,11 | 0.952 |
| SDG 2 | End hunger, achieve food security and improved nutrition and promote sustainable agriculture | Consequence based goal | Environmental factors, human development factors, economic factors, political factors, technological factors | Human development factors, environmental factors, economic factors | Multi-locus goal | SDG 3,11 | SDG 3,11 | 0.833 |
| SDG 3 | Ensure healthy lives and promote well-being for all at all ages | Implementation based goal | Technological factors, human development factors, economic factors, societal factors | Technological factors, economic factors, human development factors | Multi-locus goal | SDG 5,10,11 | SDG 11 | 0.477 |
| SDG 4 | Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all | Implementation based goal | Societal factors, technological factors, human development factors | All | Multi-locus goal | SDG 1,8,9,16 | SDG 1,8 | 0.476 |
| SDG 5 | Achieve gender equality and empower all women and girls | Consequence based goal | Societal factors, political factors, human development factors | All | Social centered goal | SDG 1,3,4,10,16 | SDG 1,10 | 0.486 |
| SDG 6 | Ensure availability and sustainable management of water and sanitation for all | Combined characteristics | Environmental factors, technological factors, political factors | All | Multi-locus goal | SDG 3,11 | SDG 3,11 | 0.476 |
| SDG 7 | Ensure access to affordable, reliable, sustainable and modern energy for all | Implementation based goal | Technological factors, human development factors | Technological factors, political factors | Technology centered goal | SDG 1,8,9,11,13,15,17 | SDG 8,9,11,13,17 | 0.343 |
| SDGs   | The motto of the goal                                                                 | Nature of goal                      | Depending factors                                                                 | Sensitive dependency factor | Locus of goal                      | SDG Interaction | Key Interaction | Degree of randomness |
|-------|---------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|----------------------------------------------------------------------------------|-----------------------------|------------------------------------|-----------------|------------------|-------------------|
| SDG 8 | Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all                         | Implementation based goal           | Technological factors, societal factors, economic factors, human development factors | Technological factors, economic factors, human development factors | Economy centered goal | SDG 1,3,7,9,11,17 | SDG 1,7,9,11       | 0.518             |
| SDG 9 | Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation                                    | Implementation based goal           | Technological factors, political factors, human development factors               | Technological factors, political factors, human development factors | Technology centered goal | SDG 7,8,11,12,13,15,17 | SDG 7,8,11,12,13,17 | 0.343             |
| SDG 10| Reduce inequality within and among countries                                                                                               | Consequence based goal              | Societal factors, political factors, human development factors                    | All                         | Social centred goal               | SDG 1,3,4,5,16   | SDG 1,5           | 0.486             |
| SDG 11| Make cities and human settlements inclusive, safe, resilient and sustainable                                                              | Combined characteristics            | Societal factors, technological factors, political factors, environmental factors, human development factors | Technological factors, economic factors, environmental factors | Multi-locus goal               | SDG 1,3,6,7,8,9,12,13,16,17 | SDG 7,8,9,12,13,16 | 0.951             |
| SDG 12| Ensure sustainable consumption and production patterns                                                                                  | Consequence based goal              | Technological factors, societal factors, political factors, environmental factors | All                         | Environment centered goal         | SDG 2,6,7,9,11,14,15 | SDG 7,9,15        | 0.714             |
| SDG 13| Take urgent action to combat climate change and its impacts                                                                                | Consequence based goal              | Technological factors, environmental factors, human development factors           | All                         | Environment centered goal         | SDG 1,3,7,9,11,14,15,17 | SDG 1,7,9,11,14,15 | 0.667             |
| SDG 14| Conserve and sustainably use the oceans, seas and marine resources for sustainable development                                               | Consequence based goal              | Technological factors, political factors, human development factors               | All                         | Environment centered goal         | SDG 9,12,13,17   | SDG 13,17         | 0.593             |
| SDG 15| Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss | Consequence based goal              | Societal factors, political factors, technological factors, human development factors, environmental factors | Human development factors, political factors | Environment centered goal         | SDG 3,7,9,12,13,17 | SDG 9,12           | 0.885             |
| SDGs  | The motto of the goal                                                                 | Nature of goal                  | Depending factors                                                      | Sensitive dependency factor | Locus of goal | SDG Interaction | Key Interaction | Degree of randomness |
|-------|-------------------------------------------------------------------------------------|---------------------------------|------------------------------------------------------------------------|-----------------------------|---------------|----------------|-----------------|----------------------|
| SDG 16 | Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels | Implementation based goal      | Societal factors, political factors, human development factors        | All                         | Social centered goal | SDG 4,5,10,11,13 | SDG 5,10,11       | 0.486                |
| SDG 17 | Strengthen the means of implementation and revitalize the global partnership for sustainable development | Combined characteristics      | Economic factors, human development factors, technological factors, political factors | All                         | Multi-locus goal  | SDG 7,8,9,11,13,14,15 | SDG 7,8,9         | 0.476                |
4. Impact Nexus between pandemic and SDGs – The dynamics of SDGs interaction

In Section 2, the progress of SDGs, impact of pandemic, challenges and the corresponding drag in the goals due to a pandemic are discussed as well as impact analysis is performed. However, to have a big picture of these impacts and to know how the pandemic impacts influence SDGs, a cumulative effect of the pandemic is mapped through the pipelines of “key SDG interaction” which is defined in Table 5. This would help us to understand the gravity of the pandemic acting on the SDGs and also, a clear understanding of the dynamics of SDG’s interaction.

The various impact is grouped at the centre of the impact nexus image and is termed as impact box. The prime circle of SDGs is a conceptualized term that indicates that the goals involved in the prime circle of SDGs highly influence other goals and their advancement will go in hand with the development in the other goals within the prime circle. The impact due to the pandemic primarily strains the health sector (Goal 3) and the goals in the prime circle (SDGs 7, 8, 9, 11). Apart from these goals, direct impact prevails in SDGs 5, 10 and 4. These are the goals that are directly impacted by the pandemic (connected directly from the impact box) and the drag may be positive (red arrows) or negative (green arrows). All the remaining impacts are caused by indirect influence (connected from one goal to another) from the affected goals as mentioned above. For example, Goal 9 is directly impacted by the implementation of lockdown. Due to which the pollution level has significantly come down and thus, a green medium thickness line is marked towards goal 13 from goal 9 meaning an indirect positive drag on SDG 13. On the other hand, the stalling of industrial operation has caused a lag in the implementation of new projects and this is depicted as a negative drag towards SDG 7 and a double arrow head is used to explain that the progress towards affordable energy is put to a temporary halt which in turn also influences the progress in SDG 9. Due to the same reason, the economy is affected and thus, a red line is connected to SDG 8. Since the economy influences poverty to a greater extent, a strong red line is marked from SDG 8 to SDG 1. Numerous red lines point towards SDG 8 and SDG 1 which aligns with the result of pandemic impact analysis on SDGs in Section 2.13. Apart from these coloured lines, the black coloured lines indicate a general SDG interaction that exists between the goals. Through these interactions, minor impacts get influenced due to pandemic.

The types of SDG interaction that are defined in Section 3 can be interpreted through Fig. 9. For instance, let us consider the Goal 8, here the type 1, 2 and 3 of SDG interaction is observed with the SDGs 1, 17 and 7, respectively. Further, each type of SDG interaction can be of two different nature such as synergic and trade-off. A synergic nature of interaction means a fostering effect in the progress while a trade-off effect has a degrading effect in the progress of one goal when another goal involved in the SDG interaction progresses. For example, progressing in SDG 6 will have a synergic effect in SDG 3 and SDG 11 while progressing in SDG 12 might hinder the progress in SDG 9, 11.

When analyzing the interdependence between the goals, one goal may exert more influence on the other goal which cannot be interpreted from Fig. 9. However, the proposed new parameter, “degree of randomness” as defined in Section 3, would help in analyzing the degree of influence between two interdependent goals. This can be assessed by analyzing the degree of randomness score for the involved two interdependent goals and the low randomness goal prevails to have a higher influence on the high randomness goal. For example, consider the interdependence linkage between SDG 8 and 9. SDG 9 is a
Fig. 9. Impact nexus between pandemic and SDGs.
more focused goal and hence, the degree of randomness is lower (DOR = 0.343) whereas SDG 8 possess
a high degree of randomness (DOR = 0.518) since they depend on many uncertain factors. When analyzing
the extent of influence between these two goals, it is seen that influence of SDG 9 on SDG 8 is intense
than the influence of SDG 8 on SDG 9 according to the randomness parameter. In other words, the
development towards SDG 9 will drive the SDG 8 whereas the reverse effect is not always favorable. This
inference can be evidentially proved from the pandemic impacts. For instance, stalling the industrial
activities devastated the economic growth while the impacted economy influence on industrial
development is very less. As a whole, the complex SDG interaction can be interpreted using Fig. 9, but
with the proposed randomness factor, one can easily understand the dynamics of SDG interaction and the
easiest approach to achieve SDGs can be drafted with such analysis which is discussed in the upcoming
sections.

5. Maneuvering towards SDGs in the aftermath of the pandemic

With proper envision and effective implementation of the various means of strategies presented in this
section, the pathway towards sustainability can be laid in a short time.

5.1. Comprehensive strategies to accelerate the progress in the post-pandemic environment

The strategies that possibly speed up the progress corresponding to each goal in the post-pandemic period
is presented in Table 8 with a direction of implementation primacy defined by the prioritization factor.
The priority factor is obtained by considering the prior need to the society since from the end of the
pandemic and it varies from 0 to 1. In this study, it is obtained through a multi-criteria analysis, following
the steps provided in the analysis framework (Fig. 10). On investigating the impacts caused by the
pandemic on SDGs, the impacts can be grouped as the categories as shown in Table 6. Each category is
given a score on a scale of 5 (where 5 is the most urgent and 1 is the least urgent) which is allotted based
on the importance of the impact category that needs to be addressed immediately in the post-pandemic
environment. For instance, the economic impact is catastrophic and much of the society’s normal
functioning depends on recovering this impact. On the other hand, societal impacts such as widened
inequality need a long-term recovery period. Therefore, an urgency score of 5 and 1 are allocated for
economic impact and societal impact categories.

Table 6. Impact categories and the score of urgency.

| Impact Categories (based on pandemic impacts) | Score of Urgency (based on what society needs immediately in post-pandemic) |
|-----------------------------------------------|-------------------------------------------------------------------------|
| Economic Impact (E)                           | 5                                                                       |
| Impact on individual human (H)                | 4                                                                       |
| Industrial & Energy based Impact (IE)         | 3                                                                       |
| Environmental Impact (EN)                     | 2                                                                       |
| Societal Impact (S)                           | 1                                                                       |
A strategy might be able to address more than one category of impacts and to evaluate its capability to address the impacts, the impact addressal factor (IAF) is proposed and it is obtained by using Eq. (5).

\[ \text{Impact Addressal Factor (IAF)} = \sum \text{Score of Urgency for addressed impact by the strategy} \] (5)

Further, a strategy if it helps in progressing in numerous goals at the same time, then the priority factor is designed to give more weightage for it. To determine a strategy’s tendency to influence the progress in numerous goals, the SDG interaction factor is introduced which is calculated based on the SDG urgency score. This score indicates the level of urgency to focus on the progress of the considered goal and thus, weightage is given to more affected goal. The SDG urgency score is allotted based on the overall impact score of SDGs obtained in Section 2.13 and is shown in Table 7. This score is also varied on a scale of 0 to 5 where a score of 5 indicates a high level of urgency to direct the efforts towards the goal.
Table 7. SDG impact ranking and score of urgency.

| Overall Impact score range | Description                  | Categorized Goals | SDG urgency score |
|---------------------------|------------------------------|-------------------|------------------|
| 0.5 and above             | Long-lasting impact          | SDG 1,8           | 5                |
| 0.4 - 0.5                 | Massive temporary impact     | SDG 2,3,10        | 4                |
| 0.3 - 0.4                 | Indirect amplified impact    | SDG 6,7,4,9,5     | 3                |
| 0.2 - 0.3                 | Stalled progress impact      | SDG 11,12,17      | 2                |
| 0.0 - 0.2                 | Endurable impact             | SDG 16,13,15      | 1                |
| -ve - 0.0                 | Positive impact              | SDG 14            | 0                |

Then, the strategy for each goal is also analyzed for its ability to address other SDGs through the SDG interaction pipeline in terms of synergic or trade-off effect. The SDG interaction factor (SIF) is evaluated by using Eq. (6).

$$SDG \text{ Interaction Factor (SIF)} = \sum(\text{SDG Urgency score for synergic effect SDGs}) - \sum(\text{SDG Urgency score for tradeoff effect SDGs})$$ (6)

Based on the obtained score for IAF and SIF, the prioritization factor for a strategy can be obtained by using Eq. (7).

$$P(S) = \frac{(IAF+SIF)}{(\text{Maximum possible score})} , P(S) \in [0,1]$$ (7)

A sample calculation is presented in Appendix A2. As a whole, the prioritization factor is obtained as a cumulative function of a strategy’s tendency to address the pandemic impacts and also, its influence in directing towards sustainability. From Table 8, the strategies that possess a prioritization factor greater than 0.5 should be given special attention in the post-pandemic environment. Focusing on the strategy that regains economy especially, creating jobs or increasing employment opportunity, investing more in start-ups that promise sustainable technologies, reskilling of workers is the most urgent societal need that can ultimately reduce the menaces imparted by the pandemic and also, it would form a strong foundation for progressing in the direction of sustainability. Note that this analysis is carried out only to determine the strategies that ultimately help to minimize the impact of the pandemic and at the same time to direct towards sustainability. Hence, after the recovery period, every strategy should be focused on implementation.
Table 8. Comprehensive Strategies to accelerate the progress towards SDGs in the post-pandemic environment with prioritization factor (Impact addressal category: E – Economic Impact, H – Impact on individual humans, IE – Industrial and energy-based impact, EN – Environment Impact, S – Societal Impact).

| SDGs | Post-COVID strategies | Synergic effect of strategy with | Trade-off effect of strategy with | Impact addressal category | Impact addressal factor (Max: 15) | SDG Interaction factor (Max: 15) | Prioritization factor |
|-------|------------------------|--------------------------------|--------------------------------|--------------------------|----------------------------------|----------------------------------|----------------------|
| SDG 1 | Improvement in the income of low- and middle-income workers | SDG 2,8,11 | - | H | 4 | 11 | 0.50 |
|       | Creating Jobs, support pay equity, establish work schedules, eliminating chronic economic insecurity. | SDG 5,8,10,11 | - | E,H,S | 10 | 14 | 0.80 |
|       | Invest in affordable, high-quality child care and early education | SDG 4 | - | H | 4 | 3 | 0.23 |
|       | Providing awareness about existing supporting policies and increasing the implementation effectiveness. | - | - | H | 4 | 0 | 0.13 |
| SDG 2 | Enhancing the market opportunities, minimizing the trade restrictions on agricultural commodities. | SDG 8,11,17 | - | E,H | 9 | 9 | 0.60 |
|       | Resilient agricultural practices to increase productivity and progress towards sustainable agriculture | SDG 8,13,15 | Sometimes with SDG 12 | E | 5 | 5 | 0.33 |
|       | Improve producer’s knowledge, expanding the financial services for agricultural needs, investments or loans with low interest. | SDG 17 | - | E | 5 | 2 | 0.23 |
| SDG 3 | Focus on vaccine development and antiviral drugs for COVID-19 after which distribute to every individual | SDG 9,10,11 | - | H | 4 | 9 | 0.43 |
|       | Vaccine development is also needed for already existing diseases such as AIDS, tuberculosis, malaria, and other non-communicable diseases. | SDG 9,11 | - | H | 4 | 5 | 0.30 |
|       | Access to quality healthcare services for the poor and vulnerable and for accessing affordable medicines | SDG 5,10 | - | H,S | 5 | 7 | 0.40 |
|       | Improve the healthcare infrastructure and strengthen the risk management strategies for the national and global health crisis. | SDG 11 | - | H | 4 | 2 | 0.20 |
| SDG 4 | Upgrade education facilities and promote digital learning | SDG 9,11,17 | - | H | 4 | 7 | 0.37 |
|       | Increase the internet accessibility across the globe | SDG 9,11 | - | H | 4 | 5 | 0.30 |
|       | Focus on quality education than quantity education | SDG 8,11 | - | H,S | 5 | 7 | 0.40 |
|       | Equitable education for both boys and girls, expanding the scholarships for talented and skilled young minds especially in developing countries. | SDG 5,10,11 | - | S | 1 | 9 | 0.33 |
| SDG 5 | Stringent rules and policies for eliminating all forms of violence emerged due to gender inequality. | SDG 16 | - | S | 1 | 1 | 0.07 |
|       | Enhance the equity in economic, political and public life especially in decision-making. | SDG 8,11,16 | - | S | 1 | 8 | 0.30 |
| SDGs | Post-COVID strategies | Synergic effect of strategy with | Trade-off effect of strategy with | Impact addressal category | Impact addressal factor (Max: 15) | SDG Interaction factor (Max: 15) | Prioritization factor |
|------|-----------------------|---------------------------------|---------------------------------|--------------------------|---------------------------------|---------------------------------|----------------------|
| SDG 6 | Impart awareness to change the societal view about women by appealing psychologically. | - | - | S | 1 | 0 | 0.03 |
| SDG 6 | Eliminate dumping wastes into water bodies, minimize water pollution, encourage treating of industrial effluents and wastewater treatment. | SDG 9 (Innovation), 13,14 | SDG 9 (Industrial development) | EN | 2 | 1 | 0.10 |
| SDG 6 | Frame solutions with a long-term vision to reduce water scarcity with sustainable consumption and supply of freshwaters. | SDG 3 | - | H | 4 | 4 | 0.27 |
| SDG 6 | Promote integrated water resource management, desalination plants and protect natural eco-system. | SDG 14,15,17 | SDG 15 - for integrated water resource | H,EN | 6 | 2 | 0.27 |
| SDG 7 | Digitalization of the energy sector, improve reliability, flexibility and efficiency. | SDG 9,11,17 | - | IE | 3 | 7 | 0.33 |
| SDG 7 | Focus on renewable energy penetration for both power and heat as well as decrease the share of non-renewables | SDG 8,9,11,13 | SDG 12,15 | IE,IE,EN | 10 | 8 | 0.60 |
| SDG 7 | Engage research activities towards clean energy and technology and also, optimize the existing system in terms of affordability. | SDG 9,13 | - | IE,EN | 5 | 4 | 0.30 |
| SDG 7 | Investing more in start-ups dealing with renewables and drives the world towards sustainable modernization. | SDG 8,9,11,13,15,17 | - | IE,IE,EN | 10 | 14 | 0.80 |
| SDG 8 | Shifting the concentration towards a green economy | SDG 13,14,15 | - | IE,EN | 7 | 2 | 0.30 |
| SDG 8 | Expanding the agricultural markets | SDG 2 | - | E,H | 9 | 4 | 0.43 |
| SDG 8 | Widening the employment opportunities and emphasis on work from home opportunities | SDG 1,11 | - | E,H | 9 | 7 | 0.53 |
| SDG 8 | Reskilling of employers | SDG 7,9,11,17 | - | E,H,IE | 12 | 10 | 0.73 |
| SDG 8 | Improving the trade relationships and partnerships, and promoting foreign investments | SDG 9,17 | - | IE,IE | 8 | 5 | 0.43 |
| SDG 9 | Sustainable manufacturing, effective supply chain management, value chain management and automation is the key towards SDG 9 | SDG 8 | - | IE,IE | 8 | 5 | 0.43 |
| SDG 9 | Development of industries by reducing energy intensity and carbon intensity | SDG 8,11 | - | IE,IE,H | 12 | 7 | 0.63 |
| SDG 9 | Diversification of global manufacturing sectors and interdependencies among industries | SDG 17 | - | IE,IE | 8 | 2 | 0.33 |
| SDG 9 | Investments in research concerning innovations, optimization and technological capabilities | SDG 7,11 | - | IE | 3 | 5 | 0.27 |
| SDG 10 | Ensure equal opportunity in jobs and reduce inequalities of outcome | SDG 4,5 | - | S | 1 | 6 | 0.23 |
| SDG 10 | Provide awareness to drive equality in the people mindset or behavior | - | - | S | 1 | 0 | 0.03 |
| SDGs | Post-COVID strategies | Synergic effect of strategy with | Trade-off effect of strategy with | Impact addressal category | Impact addressal factor (Max: 15) | SDG Interaction factor (Max: 15) | Prioritization factor |
|------|-----------------------|---------------------------------|---------------------------------|--------------------------|---------------------------------|----------------------------------|----------------------|
| SDG 11 | Enhance the equity in economic, political and public life especially in decision-making. | SDG 5,8,11,16 | - | S | 1 | 11 | 0.40 |
| SDG 11 | Sustainable agriculture, sustainable energy production and management, sustainable manufacturing are the foundation for sustainable cities. | - | - | - | - | - | - |
| SDG 11 | Refer strategies in SDG 7, 8, 9. | - | - | - | - | - | - |
| SDG 12 | Promoting optimization techniques in industries for reducing material consumption and waste generation. | SDG 9,11,14,15 | - | EN,IE | 5 | 6 | 0.37 |
| SDG 12 | Prioritize reduce, recycle, reuse, refurbish, remanufacture, repurposing and reduction at design strategies. | SDG 11,15 | - | EN,IE | 5 | 3 | 0.27 |
| SDG 12 | Effective use of fossil fuels and gradually decreasing their use especially in the energy sector. | SDG 7 | - | EN,IE | 5 | 3 | 0.27 |
| SDG 12 | Measures for minimizing food losses in the supply chain and encouraging the distribution of excess foods to the poor and needy. | SDG 2 | - | H,S | 5 | 4 | 0.30 |
| SDG 13 | Framing new policies and effectively implementing the existing policies related to SDG-13 | SDG 7,9 | - | EN | 2 | 6 | 0.27 |
| SDG 13 | Upcoming technologies and developments must be strictly given importance by considering the environmental effects. | SDG 14,15 | - | EN | 2 | 1 | 0.10 |
| SDG 13 | Focusing on harvesting renewable sources of energy and emphasis on decarbonization strategies | SDG 7,9 | Sometimes SDG 12,15 | EN,IE | 5 | 3 | 0.27 |
| SDG 13 | Integrate measures to mitigate environmental pollution and also impart those in the human behavioral patterns by constant awareness through various means. | SDG 3,6,9,14,15 | - | EN | 2 | 11 | 0.43 |
| SDG 14 | Effective management to avoid empty shipping containers traversing through the sea. | SDG 13 | - | EN | 2 | 1 | 0.10 |
| SDG 14 | Eliminate the dumping of plastic waste into the oceans and more importantly, the COVID-19 medical wastes such as masks, PPE. | - | - | EN | 2 | 0 | 0.07 |
| SDG 14 | Restricting the destructive fishing practices, protect coral reefs and conserve the coastal and marine areas to the maximum extent. | SDG 13 | - | EN | 2 | 1 | 0.10 |
| SDG 15 | Technological focus on ocean acidification and address the root cause for the same. | - | - | EN | 2 | 0 | 0.07 |
| SDG 15 | Restore degraded land and fertility, promote afforestation and sustainable agricultural practices. | SDG 2,13 | - | EN | 2 | 5 | 0.23 |
| SDG 15 | Promote native species, ensure that cities infrastructure and design support sufficient greeneries. Identify key species in promoting biodiversity in different geographical regions and conserve the same. | - | - | EN | 2 | 0 | 0.07 |
| SDGs | Post-COVID strategies                                                                 | Synergic effect of strategy with | Trade-off effect of strategy with | Impact addressal category | Impact interaction factor (Max: 15) | SDG Interaction factor (Max: 15) | Prioritization factor |
|------|---------------------------------------------------------------------------------------|---------------------------------|---------------------------------|---------------------------|-------------------------------------|---------------------------------|----------------------|
| SDG 16 | Refer strategies in SDG 12, 13.                                                        | -                               | -                               | -                         | -                                   | -                               | -                    |
|       | Rules should be verified for their existing purpose and optimization strategies are also applicable for justice | SDG 11                          | -                               | S,H                       | 5                                   | 2                               | 0.23                 |
|       | Eliminate corruption and bribery in all aspects.                                      | SDG 11                          | -                               | S                         | 1                                   | 2                               | 0.10                 |
|       | Transparency to the public, justice acts, promoting the right to express, information and equality will favor a peaceful society. | SDG 11                          | -                               | S                         | 1                                   | 2                               | 0.10                 |
| SDG 17 | Promote partnerships in all aspects and direct the investments towards sustainability. | SDG 7, 8, 9, 11                 | -                               | IE,E                      | 8                                   | 13                              | 0.70                 |
5.2. An outlook on effecting the strategies in the post-pandemic environment

Apart from the various strategies corresponding to each goal, it is desirable to have a direction or roadmap for the effective implementation of strategies such that the goals can probably be achieved in a short stretch of time. Detailed mapping of SDGs in terms of strategical implementation is presented in Fig. 11. In this figure, the degree of randomness parameter (the value is shown near each SDG) and SDG interaction is used to construct this figure such that the efforts invested in the goal become more effective and efficient. The implementation based-goals mostly occupy the radially outward position. The authors propose that by progressing through the goals having a low degree of randomness from radially outside to inside in this SDG roadmap, an effective way for progressing through all the SDGs can be achieved in a short time. In Fig. 11, the goal influence (pathway) is classified based on the locus of the goals such as technology-centred, environment-centred, economy centred, social-centred and multi-fold factor centred (meaning, a blending of above-stated factors).

If the degree of randomness is low, the implementation of strategies (assuming the execution is well-established) can be expected to be effective and vice-versa. This is because the degree of randomness parameter is based upon the depending factors of the goals and in the case of advancement in high randomness goal, a strategy is required to support the multi-fold depending factors of the goal which is less likely. Hence, if a strategy addresses only a few depending factors, it is possible that the effectiveness of the implemented strategy can be pulled down through the other depending factors that are not addressed. Further, the goals possessing a low degree of randomness and that are extensively interrelated to other goals should be prioritized. From the analytic representation of SDG interaction illustrated in Fig. 9, the highly interrelated SDGs belong to the prime circle and among which SDG 7 & 9 possess a low degree of randomness. Thus, in a post-pandemic environment, after the economy is regained, focusing on SDG 7 & 9 followed by the environment-centred goals would prevail as a better way for effectuating the strategies.

Also, super-prioritizing the strategies that have the highest prioritization score in Table 8 corresponding to SDG 7 and 9 is necessary. On focusing the SDGs 7 & 9 from the technological aspect with the aid of partnerships, these goals can have a positive impact on the rest of the goals and when the approaches are blended with the environmental concerns, the foundation for the sustainable world is laid. For instance, the major environmental concerns are the need for minimal degradation of resources, optimized consumption and the addressal of key causes for climate change. Without integrating these concerns with the progress, the green pathway will be completely obstructed and severe aftereffects would be seen in the black pathways as well since the environmental concerns also influence them. Directing the developments relevant to SDG 9 in an economically beneficial approach and also, in an environmentally favourable way is crucial (IRENA, 2020b, Kynclova et al. 2020). On the other hand, SDG 7 is on the right path progressing towards renewables but the progress further needs to be hastened and affordability has to be imparted in the energy sector.

As the progress in SDG 7 and 9 happens in the post-pandemic world, large employment opportunity prevails but it requires reskilling of workers to grasp the opportunities (IRENA, 2020b). With sufficient progress in SDG 7 and 9, SDG 8 will rebound from the pandemic impact and if the restructuring of the labour market, as well as reskilling, is carried out, then SDG 1 would again witness a revamped progress. This will minimize the pandemic impact to a greater extent. The progress in SDG 6, 5, 10 and 16 are less interactive with other SDGs and they need lots of effort and focus to gain significant progress. Further, implementing the strategies based on the prioritization factor under each goal will
Fig. 11. Mapping of SDGs in terms of strategical implementation.
accelerate the progress towards sustainability. Therefore, the authors claim that initiating the presented strategies based on the prioritization factor and the degree of randomness would ultimately enhance the effectiveness in the implementation which will result in a shorter period of achievement of all SDGs from the management perspective. Besides, monitoring and evaluating the progress are pivotal. A study by (Allen et al., 2020) adopted a multi-criteria analysis on the various SDGs to assess and prioritize the targets based on urgency, systematic impact and policy gap in 22 countries of the Arab region. The study intends to analyse the strengths and weaknesses of baseline assessment and benchmarking of indicators, systems and network analysis of target interlinkages, and mapping of policy alignment and gaps. Also, it highlights how they can be applied together. Such studies are encouraged as they give an idea of where we have currently headed and the loopholes for the improvement can also be identified through such analysis. Hence, mapping provides an effective direction while analysis helps us to monitor whether the propagation is in alignment with the direction.

5.3. A conceptual framework to define SDG-aligned business practices

Apart from the strategies to achieve the goals, aligning the business practices with the SDGs which works in a decentralized methodology would also ultimately lead to the path of sustainability. It is obvious that current business practices harm the environment and is not on par with sustainability. Thus, this section is allocated to define the steps to inculcate the SDGs into business practices.

At present, the entire world is under an acute economic and social crisis with no way of knowing when the normality will return (UN Environment Programme, 2020). In the post-COVID-19 scenario, the organizations will face difficulties with capital gains and growth. Due to which the business practices in the post-COVID-19 world might experience a significant change. This can be considered as an opportunity to direct the changes towards sustainability. Thus, the proposed conceptual framework to align the business practices with the SDGs would promote sustainability and also enhances the

![Fig. 12. The four key themes of business practice.](image)
Business practices in the post-pandemic world. But such practices need a strategic action that can only be achieved with proper planning that is in line with the SDGs engagement. In general, any business practice revolves around four key themes, which include Purpose, Capital, Growth, and Risk, as shown in Fig. 12. If the business practice should be aligned with SDGs, the organizations should integrate the goals into their strategic management process. For such integration, the following framework that is built upon the SDG Compass is proposed for post-COVID-19 world business practices (SDG Compass, 2020). The SDG Compass is mainly based on the five steps discussed as shown in Fig. 13.

The five steps are briefly described below (SDG Compass, 2020):

**Step-1:** In the first step, every organization that is planning to have SDG aligned business practices should have complete knowledge of all the 17 SDGs and their target indicators. Apart from having knowledge of the SDGs, the organization should understand its business case and development perspectives to possibly align with the SDGs by respecting the business responsibilities.

**Step-2:** In the second step, priorities are defined. But before defining the priorities, the organization should have a complete view of the value chain (e.g., from the raw material to the end of life) based on the product or service offered. In this step, the mapping of SDGs with the organization value chain is to be carried out. It should be noted that not all 17 SDGs can be mapped. Once the mapping is done, specific indicators and data should be selected. These indicators and the data are mainly based on the value chain.

**Step-3:** In the third step, goal setting is ensured. In any business practice, goal setting is more crucial and enables the organization to have certain baseline goals and ambitions upon which the organization would demonstrate its commitment to sustainable development.

**Step-4:** The fourth step primarily focuses on integrating sustainability into the “core business and governance and embedding sustainable development targets” across all functions within the value chain of the organization. In this step, organizations need to have effective engagement with partnering organizations across the product or service value chain.

**Step-5:** In this step, information related to the SDGs performance based on set priorities considering the indicators selected throughout the value chain is reported. This reported information is further communicated within the stakeholder’s group.

---

**Fig. 13.** A five-step SDGs Compass framework for SDGs aligned business model.
A careful assessment of the value chain involved in the organization and integrating various possible SDGs with the process of organization is vital and a challenging task. A detailed framework to aid in integrating the goals with the business case is illustrated in Fig. 14. Apart from the voluntary alignment of SDGs into business practices by the organizations, it should be more welcomed by the stakeholders and capitalism for environmentalism should be prioritised for lending investments to the respective businesses. Through these approaches, the penetration of SDGs into various sectors can be enhanced.

Fig. 14. Conceptual framework to align business practices with SDGs.
The tax system for the business can be also extended to expect contribution from the companies to focus on establishing a sustainable society.

### 7. Discussion and conclusions

The progress towards sustainable development goals is significantly impacted due to the COVID-19 pandemic. A detailed investigation on the impact of the pandemic on each SDGs is drawn. Quantified impact analysis is performed by assessing the impact that occurred in each target of the goals. The results indicate that SDG 1 is the most-impacted goal followed by SDG 8 with a score of 0.69 and 0.55, respectively. In the aftermath of the pandemic, the human response in regaining the economy will be the ultimatum for the extent of poverty rise. Only SDG 14 has managed to possess a little positive impact with an overall impact score of -0.04.

The brief concepts of SDGs are formulated from their elemental nature and the factors such as nature of the goal, depending on factors, sensitive dependency factor, locus of goal is defined for each goal. The nature of goal, dependency factor and the locus of goal are considered to analyse the SDG interaction. Meanwhile, the depending factor and sensitive dependency factor is used to quantify the proposed novel degree of randomness factor with the designed modified weighted ranking method. It is seen that SDG 1, and 11 possesses a high degree of randomness with scores of 0.952 and 0.951, respectively. On the other hand, the goals that have the least degree of randomness include SDG 7 and SDG 9, sharing an equal score of 0.343.

The impact interaction between the SDGs is insightful in understanding how the SDGs depends or influence each other, meaning it paves a way for understanding the dynamics of SDGs interaction. It can be inferred from the analysis that SDGs 7,8,9 and 11 have the most interaction with other goals (the prime goals) and is crucial in manipulating the advancement in every other goal. The SDG interaction through the impact nexus figure is explained which include influencing, dependent, interdependent types of SDGs interaction. Further, the synergic and trade-off nature of the interaction is established. Interdependency is a special case of SDG interaction and is further analysed to determine which SDG has more influence among two interdependent goals using the degree of randomness. It shows that in the interdependent goal, the goal which has a low degree of randomness influence the other goal to a higher extent. All these analyses and observations provide us with a big picture of SDGs interaction and deep insight regarding the nature of goals.

To carry out the progress in each goal in the post-pandemic period, the strategies are framed and presented. The prioritization factor is designed and is formulated based on multi-criteria analysis. This factor indicates the strategy’s ability to address the impact caused by the pandemic and simultaneously direct the progress right in the path of sustainability. According to the results of the prioritization factor, the strategies such as expanding employment opportunities with equality, investing more in start-ups dealing with renewables and modern sustainable technologies, reskilling of labours, promoting partnerships and investment towards sustainability are the top strategies that should be prioritized in the post-pandemic period.

By blending all the analyses made in the study (such as SDGs interaction, degree of randomness of the goal, framing the strategies with prioritization factor), the mapping of SDGs for effectively implementing the strategies to attain a sustainable world is presented. The results emphasised that
the progress in SDG 7 and 9 should be focused in the post-pandemic environment through which the advancement towards the other goals can be expedited if the approach is environmentally favourable and also, supports the economic development. Further, when implementing the strategies based on the prioritization factor for each goal, sustainability is favoured in all aspects and can be achieved in a short period of time.

Further, the conceptual framework for aligning the business practices with respect to SDGs is elaborated. The biggest challenge in aligning them is that it requires greater understanding to yield proper planning as well as to find an optimal way to balance the synergic and trade-off effect that would possibly occur in a firm. As a whole, this study will be supportive to policymakers, governments, researchers, industrialists, business analysts and professionals in terms of providing directions in sustainability, incorporating the proposed concepts, making solid decisions and the like, related to SDGs. A novel insight related to SDGs is well-established to continue the developments in human society. To conclude, we should look at this as an opportunity to tune ourselves to impart actions and developments that ultimately leads us to a sustainable world.

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Appendix A

A1. Degree of randomness calculation

Let us consider SDG 2 as an example. The depending factors are environmental factors, human development factors, economic factors, political factors, technological factors. The sensitive dependency factors are human development factors, environmental factors, economic factors. Therefore, in this case, \( n = 5 \) and \( x = 3 \). Substituting \( n \) and \( x \) values in Eq. (2) and (3) and solving them would yield the values of \( a \) and \( b \).

\[
a = 0.250
\]

\[
b = 0.125
\]

The degree of randomness can be calculated from Eq. (4) which is given as follows:

\[
\text{Degree of randomness (DOR)} = \frac{n \times [a \times \sum_{i=1}^{x} (S_i) + b \times \sum_{i=1}^{n-x} (D_i)]}{\sum \text{Randomness score of all depending factors}}
\]

From Table 4, the randomness score for the factors can be allocated.

The randomness scores for sensitive dependency factor (\( S_i \)) are as follows:

- Human development factors, \( S_1 = 4 \)
- Environmental factors, \( S_2 = 6 \)
- Economic factors, \( S_3 = 2 \)

The randomness scores for the non-sensitive dependency factor (\( D_i \)) are as follows:

- Political factor, \( D_1 = 3 \)
- Technological factors, \( D_2 = 1 \)

Note that the denominator indicates the summation of all the randomness scores of all depending factors and it does not mean it is limited to the factors that the goal under consideration depends on.

Denominator value = \( 6 + 5 + 4 + 3 + 2 + 1 = 21 \)

\[
\text{DOR} = \frac{5 \times [0.250 \times (4 + 6 + 2) + 0.125 \times (3 + 1)]}{21} = 0.833
\]

Table A1. The values of \( n, x, a \) and \( b \) for calculating the degree of randomness.

| SDGs | \( n \)  | \( x \)  | \( n-x \) | \( a \)  | \( b \)  |
|------|---------|---------|---------|--------|--------|
| SDG 1 | 5      | 5       | 0       | 0.200  | 0      |
| SDG 2 | 5      | 3       | 2       | 0.250  | 0.125  |
| SDG 3 | 4      | 2       | 2       | 0.333  | 0.167  |
| SDG 4 | 3      | 3       | 0       | 0.333  | 0      |
| SDG 5 | 3      | 2       | 1       | 0.400  | 0.200  |
| SDG 6 | 3      | 3       | 0       | 0.333  | 0      |
| SDG 7 | 3      | 2       | 1       | 0.400  | 0.200  |
| SDG 8 | 4      | 3       | 1       | 0.286  | 0.143  |
| SDG 9 | 3      | 2       | 1       | 0.400  | 0.200  |
Let us consider a strategy in Table 8, “Investing more on start-ups dealing with renewables and those drives the world towards sustainable modernization” under SDG 7. When analyzing what type of impacts this strategy would address, it can be seen that it addresses the impact categories such as the economy (E), environment (EN), and industry and energy (IE). The impact addressal factor (IAF) can be evaluated using Eq. (1) and the impact scores corresponding to each impact category can be extracted from Table 6.

\[
\text{IAF} = 5 + 2 + 3 = 10
\]

This strategy though directly helps in progressing towards SDG 7, it also helps in other SDGs such as SDGs 8, 9, 11, 13, 15, 17. This indicates a synergic effect in these goals and the trade-off effect is not reflected in any of the goals.

Depending on the SDG urgency score as represented in Table 7, the cumulative scores for synergic effect can be obtained as follows:

\[
\text{Synergic effect score} = \text{scores of (SDG 8 + SDG 9 + SDG 11 + SDG 13 + SDG 15 + SDG 17)}
\]
\[
= 5 + 3 + 2 + 1 + 1 + 2
\]
\[
= 14
\]

\[
\text{Trade-off effect score} = 0
\]

The SDG interaction factor (SIF) score can be evaluated as follows:

\[
\text{SIF} = \text{synergic effect score} - \text{trade-off effect score} = 14
\]

The maximum possible score is 30.

\[
\text{Prioritization factor} = (\text{IAF} + \text{SIF})/30 = (10 + 14)/30 = 0.8
\]

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