Feasibility of rooftop solar PV program for 9 tourism villages towards green village development in Bali

DK Halim¹ and AANS Wahyuni¹

¹ Politeknik Internasional Bali, Pantai Nyanyi, Beraban, Kediri, Tabanan, Bali, 82121, Indonesia

Corresponding Author: dk.halim@pib.ac.id

Abstract. Electricity in Bali majorly is supplied by power plants in Java which use fossil-fuelled. With petroleum and coal reserves to run out by 2025, Bali Government has issued Governor Ordinance No. 45/2019 concerning clean energy in encouraging Balinese to use rooftop solar photovoltaic (PV). As backboned tourism industry, Bali has drastically been declining due to COVID-19 causing most hotels and their supporting industries closed, the government then has changed the orientation from urban tourism to rural tourism. This paper proposes rooftop solar PV power plant program in the tourism village representing all 8 regencies and 1 municipality (Sudaji in Buleleng, Catur and others in Bangli, Tenganan in Karangasem, Kerta in Gianyar, Blimbingsari in Jembrana, Paksebali in Klungkung, Bongan in Tabanan, Bongkasa in Badung, and Sanur Kauh in Denpasar). Recent studies show huge potential for solar energy in Bali and the program is aligned with Sustainable Development Goals (Bali SDGs). The study elaborates problems in implementing the program since solar PV is still new and traditions could hinder the people in the tourism village to utilize it. Behaviour approach must be explored to make the program can be successfully done.

1. Introduction
The current rising global temperatures are the impact of Greenhouse Gas (GHG) emissions. GHG is caused by increased emissions of gases produced by fossil fuels such as carbon dioxide (CO₂), methane (CH₄), dinitro oxide (N₂O), and chlorofluorocarbons (CFCs) so that the energy resulted is also trapped in the atmosphere. The increasing global temperatures will be faster due to human activity, causing an oversupply of GHG emissions released into the atmosphere. Solar PV to reduce GHG emissions is in line with Nationally Determined Contribution (NDC) climate change mitigation efforts to build resilience in safeguarding food, water and energy resources. Indonesia shares its development towards low carbon and climate security as commitment to contribute to global efforts to achieve sustainable development goals. It is necessary to strengthen the climate resilience as stated in the NDC as a strong basis, particularly in renewable energy issues.

The potential of renewable energy in Indonesia comes from the sun, water and waterfall flows, wind, geothermal, bioenergy, movement, temperature differences in the sea layers, and hydrogen. Based on the results of technical studies for Bali’s Energy Planning, the greatest potential of energy generation comes from the sun, which can produce energy power of 1,254 MW, as shown in Table 1. With the presence of solar energy, which is the largest producer of energy compared to other sources, the utilization of solar needs to be developed into a power that can be utilized. Solar energy can be converted into electrical energy that can be utilized for daily life in the long term. The need for electrical energy
every year is increasing, where currently, the electricity spread to the entire archipelago is supplied by oil and coal power plants. Relying on national oil reserves, which run out in 2019, requires Indonesia to become a net importer of oil, while other coal reserves will run out in 2025 according to Government Ordinance No. 79/2014 on National Energy Policy. This critical condition, anticipated by the Government, resulted in the issuance of Ordinance No. 79/2014, revision of Presidential Regulation No. 5/2006 on National Energy Policy. Generating renewal of solar energy is highlighted to be a considerable potential as a transition to clean energy.

Table 1. Renewable energy potentials in Bali [1]

| No. | Type                                   | Potency MW (Megawatt) | Obstacle                        |
|-----|----------------------------------------|-----------------------|---------------------------------|
| 1   | Solar                                  | 1254.00               | Land & Economic Scale           |
| 2   | Wind                                   | 1019.00               | Technology & Economic Scale     |
| 3   | OTEC (Ocean Thermal Energy Conversion) | 320.00                | Immature Technology             |
| 4   | Geothermal                             | 262.00                | Socio-cultural values           |
| 5   | Hydro                                  | 208.00                | Water Crisis in Bali            |
| 6   | Biomass (incl. Waste to Energy)        | 146.90                | Tipping Fee                     |
| 7   | Biogas                                 | 44.70                 | Economic Scale                  |
| 8   | Microhydro & Minihydro                | 15.00                 | Ineffective usage               |
|     | Total                                  | 3269.60               |                                  |

The electrical energy in Bali Island is majorly supplied by the National Electricity Company (PLN) from fossil fuel power plants in Java Island. With petroleum inventories running low and coal inventories to run out by 2025, PLN-Bali has prepared a projection planning to anticipate the energy crisis as well as modeled the Energy Mix. This projection is important in assisting Bali's transition to renewable energy sources before all fossil fuels run out. According to the Global Solar Atlas, Bali is well-positioned to generate 1286 kWp on average, as shown in Figure 1, with its peripheral areas in the south, northwest and northeast providing the best value. The value kWp (kilo Watt peak) refers to kWh (kilo Watt per hour) is the unit used for solar PV because the solar flux is not stable or intermittent, sometimes disturbed by the cloud & rain. While PLN-Bali’s 2020 target for photovoltaic output was 159 MW, the CORE (Centre of Renewable Energy, Udayana University) study suggested this might be compromised due to climatic variability and will increase up to 182 MW in 2022 for Hotel/Tourism, Government/Publics, Business/Commercials, Housing, and others. Nevertheless, the CORE predicted the number achieved was only 108 MW due to the intermittent nature of solar power [2].
2. The Program

Bali province has 8 local regencies (Badung, Tabanan, Bangli, Karangasem, Klungkung, Jembrana, Buleleng, Gianyar) and 1 municipality (Denpasar). The need for large electrical energy encourages PLN to construct a coal-fired power plant in Bali through its continuing development which unable to meet the needs of 1200 MW or more. Recent studies show that there is significant potential to produce renewable energy in Bali. A joint study by CORE and Greenpeace had set a Road Map of Solar Power Plants throughout the island [2]. The Rooftop PV program aligns with NDC for energy security and strategic issues with SDGs of Bali Province in the Medium-term Development Plan Year 2018-2023.

Barriers to holding of the Rooftop PV program from the market aspect usually are the lack of public education on the importance of the use of Rooftop PV for household needs and the availability of tools and land/space to place solar panels. In Bali, the barriers even more complicated due to Socio-cultural aspect such as tradition and local politics because of leadership dualism between Traditional Village management (Banjar Adat) and Government-structured Village management (Banjar Dinas). Although legal aspects already empower the program as the utilization of energy by installing Solar Power Plants on the roof (PLTS) such as stipulated in the Regulation of the Minister of Energy & Mineral Resources of the Republic of Indonesia No. 16/2019 concerning the 2nd Amendment to the Regulation No. 49/2018 concerning the Use of Rooftop Solar Power System by Public Consumers of PLN, Governor Ordinance No. 45/2019 concerning Bali Clean Energy, and other regulations governing a number of cost for holding solar panels. These regulations provide the importance of renewable energy to be realized that will result in the increasing number of uses of solar panels, especially in tourism which is the largest industry on the island of Bali. Currently, the development of the tourism industry on the island of Bali is drastically decreasing due to Covid-19, which caused hundreds of hotels and their supporting industries closed as the visiting tourists has declined from 6,275,210 in 2019 to 1,069,473 in 2020 and only 43 in 2021 until July [3]. This forced the Government to change the tourism orientation from urban tourism to rural tourism as it allows social distancing. Thus, it will greatly influence investment in the uptake of domestic renewable energy infrastructure. This program is a pilot project of the Solar PV rooftop power plant (PLTS) implemented in the tourism village.

![Figure 2](image1.png)

**Figure 2.** Nine targeted tourism villages in the program

![Figure 3](image2.png)

**Figure 3.** Solar PV package

As shown in Figure 2, the solar PVs would be distributed for nine tourism villages as follow: (1) Sudaji in Buleleng, (2) Catur in Bangli, (3) Tenganan in Karangasem, (4) Kerta in Gianyar, (5) Blimbingsari in Jembrana, (6) Paksebali in Klungkung, (7) Bongan in Tabanan, (8) Bongkasa in Badung, and (9) Sanur Kauh in Denpasar. The realization of the application of solar PV can only be done through cooperation with partners, including financial partners, village stakeholders, governments, and organizations related. The partners are tasked to prepare supporting components, to form special bodies, to monitor and care when activities have been realized. Applying renewable energy to tourist villages on the island of Bali will encourage economic recovery, such as encouraging small and medium
enterprises, encouraging digital technology development, all of which require reliable and sustainable energy.

2.1. Sustainable Tourism Development Potentials.
As shown in Figure 3 above, the program would give a package of two (2) units of solar PV panel @ 375 Wp/panel (1038 mm x 1755 mm) and one inverter to an individual who wants to take the offers, so that the total electricity will be max. 750 Wp for one house. The cost of installation is about USD 1500 and would be given incentives by the Government but must be borne by the community, which can be cash or in a form of soft loans given by appointed Cooperative Bodies. The tenor can be arranged up to 5 years with a special low-interest scheme as an incentive. With associated indicators, and baseline and target values, this project covers all areas as follows:

2.1.1. Economic co-benefits. The creation of jobs by using local people as manpower source for solar PV installation and maintenance and help the community to save money regarding cut the cost of electricity in enhancing community welfare.

2.1.2. Social co-benefits. To improve community resilience for people can give a common concern to maintain energy source, to intensify village security because of good lighting, facilitate and accelerate communication among rural communities in obtaining information from internet and other media.

2.1.3. Environmental co-benefits. Solar PV does not produce pollution and in line with governments program to reduce GHG emissions by 29-41% to reduce microclimate and global warming widely.

3. The Resistance
Some barriers create resistance among the community to implement this program, and those are the lack of public education, the availability of tools and land/space to place solar panels, money to buy, and local politics because of leadership dualism between Traditional Village management (Banjar Adat) and Government-structured Village management (Banjar Dinas). Some theories can be applied to solve the problems as described below.

According to the Theory of Reasoned Action (TRA), behavior that changes is the results of behavioral intention, and behavioral intention is influenced by social norms and individual attitudes toward behavior [4]. Subjective norms describe individual beliefs about normal and acceptable behavior in society, while individual attitudes toward behavior are based on individual beliefs about that behavior. The theory states that the best predictions of a person's behavior are based on that person's interests. Behavioral interest is based on 2 main factors: 1) individual belief that resulted from his/her behaviors, 2) individual perception of the closed people to him/her regarding his/her behavior [5].

Theory of Planned Behavior (TPB) is the extension of the Theory of Reasoned Action (TRA), and TPB has been widely accepted as a tool to analyze the difference between attitudes and intentions and behaviors. In this regard, attempts to use TPB as an approach to persuade people, or embrace the Solar PV program, can overcome the resistance, and provide a means of understanding the gap between attitudes and behavior [6].

4. Methodology
The survey was used for this research as data collected through a questionnaire by taking samples from the population. This research was a descriptive study to analyze the socio-cultural dynamics of the tourism village communities by gathering facts without employing any hypotheses testing. Data collection was done online by collecting primary data thru Google form. The approach was to describe the results of the data obtained in the form of tables and diagrams. Secondary data such as documents, and Forum Group Discussion (FGD) that involving 9 respondents whom representing each tourism village, were used to describe the tourism villages’ condition.

The number of respondents was 324 living in 9 tourism villages mentioned above that randomly and voluntarily participated, consisting of 37 of Tenganan people, 22 of Sudaji people, 66 of Bongan people, 44 of Paksebali people, 17 people of Blimbingsari, 40 of Kerta people, 4 Bongkasa people, 68 of Sanur Kauth people, and 26 people of Catur and Other tourism villages surrounding as shown in table 2. The
number of respondents in this research required representative sample size to represent the population [7]. It can be calculated that about 380 samples are ideally needed to represent population above 50,000 up to indefinite numbers with normal distribution assumption. Therefore, 324 samples were considered sufficient for this research.

Table 2. Samples of 9 tourism villages

| No | Tourism Village       | Regency / Municipality | Population | Sample | Percentage (%) |
|----|-----------------------|------------------------|------------|--------|----------------|
| 1  | Catur & Others        | Bangli                 | 2,079      | 26     | 8.02           |
| 2  | Tenganan              | Karangasem             | 4,627      | 37     | 11.42          |
| 3  | Sudaji                | Buleleng               | 9,852      | 22     | 6.79           |
| 4  | Bongan                | Tabanan                | 8,058      | 66     | 20.37          |
| 5  | Paksebali             | Klungkung              | 5,531      | 44     | 13.58          |
| 6  | Blimbingsari          | Jembrana               | 1,300      | 17     | 5.25           |
| 7  | Kerta                 | Gianyar                | 4,940      | 40     | 12.35          |
| 8  | Bongkasa              | Badung                 | 6,107      | 4      | 1.23           |
| 9  | Sanur kauh            | Denpasar               | 15,167     | 68     | 20.99          |

Total: 57,661 324 100.00

In planning a program, the step taken after determining the main problem was identifying the cause of the problem. This process could be done by several methods such as Problem Tree, Flow Chart Diagram, Fish Bone Diagram, organizational elements, and others. A problem tree was employed in this research to find solutions by mapping the anatomy of cause and effect around the problem in a similar way to a Mind Map but in a more structured way. The problem tree has three parts: trunk, roots, and branches. The trunk represents the main problem; the root is the cause of the core problem, while the branches represent the impact. The use of this problem tree was related to project planning. It happened because the causal component in the problem tree would affect the design of possible interventions. Figure 4 below is an example of a problem tree chart regarding renewable energy like Solar PV.

A problem tree provides an overview of all the known causes and effects of a problem becoming a problem. This overview was important in planning a community integration or behavior change project because it established the context in which a project occurs. Understanding context helps reveal the complexities of life, and this is essential in planning a successful change project [8].

A problem tree includes writing the causes in negative form. Inverting the problem tree by replacing negative statements with positive ones creates a solution. This method provides a means of reviewing the existing understanding of problem causes and how to solve it. It will reveal the branches that will lead us to the main problem. This very valuable existing intervention may not overcome the existing factors. The objectives to use the problem tree are: 1) to identify the cause of the problem, 2) to show the main problems that exist to villagers and decision-makers related to tourism village, 3) to facilitate decision-making or the next step in the planning [9].
5. Results
The profile of respondent could be described as follows: 233 males (71.9%) and 91 females (28.1%) participated based on gender, with 27 people (8.3%) graduated from elementary school (SD), 4 people (1.3%) from junior high school (SMP), 127 people (39.2%) from high school (SMA/SMK), 164 people (50.6%) from college, 2 (0.6%) from postgraduate (master/doctoral) (Figure 5). Of role/position in the tourism village, 34 people (10.5%) are village government officers, 12 people (3.7%) are community organization activist, 47 people (14.5%) tourism village managers, 231 people (71.3%) villagers. Based on Age are 72 people (22.2%) aged 17-24 y.o., 89 people (27.5%) aged 25-34 y.o., 66 people (20.4%) aged 35-45 y.o., and 97 people (29.9%) aged over 45. Based on Occupation, 26 (8%) are civil servants, 124 (38.3%) private employees, 58 (17.9%) self-employed, 13 (4.05%) farmers, 38 (11.7%) unemployed, and 52 (16%) are others. Of the 324 respondents, 311 people (96%) recognized that their village is a Tourism Destination, 13 people (4%) did not know that their area is Tourism Destination. The low percentage of farmers and largest percentage of private employee as respondents explained that many villagers have been moving to the city and turn their job into tourism industry that is dominated by private sector. As Bali economy backbone is tourism, so that the island suffers the most (minus 12.3% of economic downturn) when Covid-19 is come.
5.1. Community Participation.

Regarding participation in tourism development activities, 250 villagers (77.2%) participate, and 74 (22.8%) do not participate. 180 (55.6%) said there are barriers to participation, and 144 (44.4%) said no barriers (Figure 6). This might because of the power and politics among village leaders, along with poor public communication, have hindered community participation on tourism development in the village. On homestay business, 53 villagers (16.4%) own homestay, and 271 (83.6%) did not own homestay. On willingness to make their house for a homestay, 196 villagers (60.5%) will do, and 128 (39.5%) do not want to. Furthermore, 219 villagers (67.6%) want to change their rooms according to the standard of a healthy homestay, and 105 (32.4%) do not want to change it. On the Rooftop Solar PV, 278 villagers (85.8%) want to install it, and 46 (14.2%) do not want to.
5.2. Dynamics of Solar PV Program.

The program for tourism villages was related to socio-cultural dynamics of the community as the results show that 154 villagers (47.5%) use 450-900 KVA for their homes, 147 (45.4%) use 1,300-2,200 KVA, and 23 (7.1%) use 3,500-6,600 KVA (Figure 7). They were also asked if the monthly electricity cost could be cut by >50%, and the panel durability was guaranteed up to 25 years, 297 villagers (91.7%) were willing to invest about USD 350-700, and 27 (8.3%) were willing to invest more than USD 700. If they were given soft loan, the instalments duration expected by 76 villagers (23.5%) were within 1-2 years; 119 (36.7%) were within 3-5 years; 95 (29.3%) were within 5-10 years, and 34 (10.5%) > 10 years. The instalment value expected by 238 villagers (73.5%) is <USD 35/month; 61 (18.8%) within USD 35-70/month; 25 (7.7%) >USD 70/month. On financial institution preferred to provide soft loan/credit, 176 villagers (54.3%) chosen bank, 69 (21.3%) chosen cooperative, 49 (15.1%) chosen vendor, and 30 (9.3%) chosen non-bank/others.
5.3. The Obstacles.

The survey also shows that 257 villagers (79.9%) would be happy if their houses were installed with solar PV so they could save electricity costs, 63 (19.4%) were not sure, and only 2 (0.7%) was not happy. However, this research revealed a paradox as 115 villagers (35.5%) perceive that would be obstacles, 121 (37.3%) thought oppositely, and 88 (27.2%) were not sure (Figure 8). The obstacles were varied: 104 villagers (32.1%) thought there would be costly, 120 (37%) thought the community do not understand the energy crisis in Bali and do not care, 62 (19.1%) thought about maintenance and technology, 38 (11.8%) thought of politics among leaders, customs, and others.
Respondents also preferred to have electricity from solar farming managed by PLN or local government-owned company (Perusda) rather than to have it on their house roof with 162 villagers (50%), but only 21 (6.4%) preferred to have it privately, while 53 (16.4%) were okay with either way, and 88 (27.2%) are not sure.

6. Analysis and Discussion

Based on a survey of 8 tourist villages, namely Sudaji, Kerta, Blimbingsari, Catur, Bongkasa, Paksebali, Tenganan, Bongan in Bali regarding the planning of the Rooftop Solar Power Plant (PLTSA) program, the electricity generated currently installed in the Tourism Village community was around 450 - 2,200 VA. The cost of installing solar PV (solar panels/solar power) was around Rp. 5,000,001-10,000,000 (USD 350-700), and most people wanted to take advantage of soft loans/credit facilities with instalments scheme below Rp. 500,000/month (USD 35/month)

As problem tree analysis shown in Figure 4, the core problem was electricity would be hampered in 2025, as the coal resource will be run out in Indonesia while the oil reserves have been depleted since 2019, if Bali did not anticipate this issue because electricity for Bali has majorly supplied from the Java that is powered by fossil fuels. The villager would be the most suffered group as their purchasing power was the lowest to afford, so the Provincial Government of Bali has initiated this Solar PV program. There were also two other immediate causes that trigger the core problem: high-cost investment to build Renewable Energy Power Plant in Bali in providing about 1200-1500 Megawatt (as calculated by PLN-Bali, the state-owned electricity company), and low demand of solar PV. The underlying causes were the production cost which was still high, and low willingness to pay as there were no incentive given to those who install solar PV at their homes. Besides, for Tourism Village, this is usually located in remote or rural area that creates geographical challenge in logistics and after sales issues, eventually created only small market.

The unsolved core problem would create at least three effects, 1) the use of diesel generator set, which produces 2 consequences such as limited supply and GHG emission and air pollution, 2) low productive activity, which creates insufficient basic services and poor tourism facilities, and 3) lesser local products, along with low productive activity will result in low economic growth. These would affect villagers’ income and lower the community climate resilience, for eventually tourism village would be undeveloped.

Figure 9. The problem tree of the rooftop solar PV program in tourism village
Regarding the Theory of Reasoned Action (TRA) [5], describing behavior that changes based on the results of behavioral intentions, which is influenced by social norms and individual attitudes towards behavior [4], the Governor Regulation No. 45/2019 concerning Bali Clean Energy that regulates all buildings to install Rooftop Solar PV by 2025 of at least 20% of the subscribed power to PLN would create a new social norm and would affect the behavior of the villagers, particularly because most of them were happy if their houses were installed with solar PV panels. The happiness would be the best prediction for a person's behavior based on that person's interests. As behavioral interest was based on 2 main factors, namely individual belief in the results of the behavior carried out and individual perceptions of the views of those closest to the individual on the behavior carried out, the views and the testimonies of influential figures in the targeted villages regarding the planning of the program who use solar PV for electricity for their personal and household purpose presumably will encourage villagers to follow the step. Particularly because God blesses the whole region with abundant in sunlight as Balinese is a religious community. These figures’ efforts at the village level could answer Bali’s challenges in realizing energy independence. Bali can harvest sunlight to become an unlimited source of electricity starting from the household scale. This belief will strongly support the Rooftop Solar PV program, as the survey results also reveal that people are happy to save electricity costs.

Another theory known as Theory of Planned Behavior (TPB), has been widely accepted as a tool for analyzing the differences between attitude and intention as well as intention and behavior and can overcome some of the limitations of previous theory as well as to provide a means of understanding the observed gaps between attitude and behavior [6]. In the program, there were also differences between attitude and intention that become an obstacle. The obstacle was that people do not fully understand the energy crisis in Bali and do not care about the situation, as they might think it is not their responsibility. There were also a mental block barrier on the maintenance costs and solar technology knowledge issues. The community also preferred a Solar Farming power plant managed by PLN/Perusda (local government owned company) rather than rooftop solar PV installed in their house to avoid further problems.

7. Conclusions
The survey of 324 respondents, based on variables gender, education, tourism awareness, role in the village, age, and occupation of the respondents, can be concluded as follows:
1) Of the development of tourism villages, 250 people (77.2%) have participated, although they encountered obstacles that is conveyed by 180 people (55.6%). 271 villagers (83.6%) do not have homestays, but most of them 196 (60.5%) also want to rent out their house for tourists as well as complying with the standard of healthy homestay by 219 villagers (67.6%), and about 278 villagers (85.8%) want to have a green homestay by installing solar PV.
2) With electricity subscribed 450-2,200 VA, solar PV installation cost is expected to be US$ 350-700 by utilizing soft loans or credit of 3-5 years instalment with USD 35/month preferred from the Bank.
3) The program is very welcome by the community because it can cut electricity costs as revealed from the Forum Group Discussion (FGD) among 9 representatives of respective tourism village. However, there are indeed obstacles caused by the Social aspects, such as socio-cultural dynamics of the community related to the fact that the community is not so familiar with solar panels, lack of energy sense of crisis, lack of solar PV knowledge as well as technological phobic, power and politics among village leaders, along with poor public communication, that hinders community participation of tourism development in the village. Economic aspects related to procurement as most components are still imported, installation and maintenance cost, costly advance solar PV technology, access to get the finance particularly in the Covid-19 era nowadays where the Bali economy has been declining to -12% because tourism, as the backbone of Bali is suffering the most. Environmental aspects related to reducing air pollution and GHG emissions, are positive from the villagers’ point of view.
It is recommended that public education on solar PV program for the communities in tourism villages through workshops and seminars should be carried out in a more intense way, and the Bali Government
must facilitate soft loans with long tenor installments, as well as provide incentives for those who install the solar PV, such as subsidy/special low price, and deduction on land and property tax.

References
[1] Halim DK and Setiawan IB 2020 Bali: Towards A Green Island (Proceedings 56th ISOCARP World Planning Congress) pp 1446-1457
[2] CORE 2019 Peta Jalan Pengembangan PLTS Atap: Menuju Bali Mandiri Energi. (Denpasar : Udayana University & Greenpeace Indonesia)
[3] Badan Pusat Statistik Provinsi Bali 2021. https://bali.bps.go.id/
[4] Eagle L et al 2013 Social Marketing (London: Pearson Prentice Hall)
[5] Fishbein M and Ajzen I 1975 Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research (Reading, MA: Addison-Wesley)
[6] Park H and Blenkinsopp J 2009 Whistleblowing as Planned Behaviour – A Survey of South Korean Police Officer Journal of Business Ethics 85 pp 545-556
[7] Krejcie RV and Morgan DW 1970 Determining Sample Size for Research Activities. Educational and Psychological Measurement 30 pp 607-610
[8] Asmoko H 2014 Memahami Analisis Pohon Masalah http://www.bppk.depkeu.go.id/
[9] Dillon LB 2014 Problem Tree Analysis http://www.sswm.info/
[10] E.Co Ltd 2021 The project logic and Problem tree analysis Section B.2 of GCF concept note