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THE IMPACT OF TECHNOLOGY ON THE ENVIRONMENT OF BALOCHISTAN: AN INTERPLAY BETWEEN TECHNOLOGICAL INNOVATION AND SUSTAINABILITY DEVELOPMENT GOALS (SDGS) IN BALOCHISTAN AND THE INTEGRATION OF ENVIRONMENTAL IMPACT ASSESSMENT (EIA) IN PROPOSING A STRATEGIC MITIGATION FRAMEWORK FOR BALOCHISTAN

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ABSTRACT

Technology based innovation and advancement would subsequently be the use of progressing information to practical applications accompanied by the design of smart devices/equipment. In the current era in Balochistan, it is a time of phenomenal transformation that mankind right now lives in-one in which technology upgradation reshapes our way of living but at the same times causes irreversible environmental changes and also results in resource depletion. The advent of new innovations was introduced with the industrial revolution resulting in a paradigm shift from conventional to new assembling approaches in Europe and the US during the period around 1760 to 1840. This has been proceeded with augmented industrialization and further technology design alterations across the globe including Balochistan, Pakistan. However the ramifications of these innovation to the climate, biotic/abiotic component of the environment, natural/non-renewable resources, regional communities etc have incorporated in the exploitation and harming of our mother nature and our planet Earth. These advancements have infact unfavourably impacted Balochistan in two primary ways; pollution and the depletion of natural resources. Therefore, it is crucial to critically explore the impact of technology on the environment of Balochistan in order to comprehend and achieve the targets and goals of SDGs. In addition, it is crucial to implement Environmental Impact Assessment (EIA) which serves as an essential strategic tool to assess the likely natural outcomes of technology advancement, ensuring that both short-term and long-term impacts are understood and mitigated to attain sustainability for future generations.

KEY WORDS: Balochistan; Technology; Sustainability development; Environmental impact; Resource management.

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INTRODUCTION

Innovation adversely affects the climate around the world. In Pakistan, especially in the territory of Balochistan, technological advancements have contributed to resource management, renewable energy development, and environmental monitoring [1]. However, challenges such as resource extraction, pollution, and electronic waste also pose significant environmental threats [2]. This review examines these impacts, emphasizing on how technology affects Baluchistan's unique environment and underscores the importance of sustainable technological practices [3].

Globalization has undeniably brought both advantages and disadvantages to the environment. In Pakistan, including Balochistan province, technologies have enabled appropriate management of resources, renewable energy creation and environmental control but there are

also negative factors like resource scavenging, pollution or generation of electronic waste [4]. Balochistan, which is stark rich province, technology has influenced sizable changes in this province's environment, starting with early mining operations and continuing on to modern renewable energy installations [5]. Mining expanded significantly in the 20th century, with coal extraction and other perhaps more harmful activities causing a range of environmental problems such as deforestation, soil erosion and water pollution [6]. So, more recently alternative technologies such as solar energy and techniques to make agriculture more efficient have been introduced to combat this issue [7]. It helps when contextualizing the implications of related strategies adopted for technology (though this), along with their history course, can establish where past experiences suggest have shown promises or have failed [8].



Figure 1: Technology and Innovation with integration of EIA to achieve SDGs in Balochistan

POSITIVE IMPACTS OF TECHNOLOGY ON THE ENVIRONMENT IN BALOCHISTAN

The development of renewable energy sources is one of the positive effects of technology in Pakistan. In Balochistan, the extensive use of solar power has helped mitigate the energy crisis while reducing carbon emissions [9]. Pakistan has been progressing with the development of renewable energy resources as one of the effects of technology [10]. Balochistan province in general and Government High School Khanozai in particular benefited from the least effort made towards this

energy crisis while still contributing towards the global effort of reducing carbon footprints. There provision of large plains and plenty of sunshine in the province provides a great opportunity for the development of solar energy. So, it is considered a viable solution to the use of fossil fuels which are predominately used for energy generation in the area [11]. Besides, there has been improvement in resource management in Balochistan as a result of the advancement of technology. Drip irrigation and solar water pumps are agricultural technologies which have enhanced water use efficiency in

Balochistan which is a very dry area [12]. Such innovations have further contributed to sustainable agricultural techniques in water stressed regions thus saving the very scarce resource [13]. Environmental control technologies like satellite and remote sensing have also been effective in controlling deforestation and land degradation in Balochistan and therefore improving the environmental policies [14].

NEGATIVE IMPACTS OF TECHNOLOGY ON THE ENVIRONMENT IN BALOCHISTAN

On the contrary, owing to the use of technology, certain adverse actions have been seen especially in the case of Balochistan. The area is blessed with coal, copper and natural gas, it's very obvious why this province attracts resource-based industries [15]. The utilization of mining and drilling technologies has impacts on the environment across the entire process from habitat removal to soil erosion and pollution of water bodies [16]. The changes, for example, coal mining changes the landscape of places but this also brings about the problem of air pollution and increases greenhouse gases in the atmosphere [17]. Moreover, the growing popularity of technology in Pakistan, especially in cities, has also led to growing electronic waste [18]. E-waste is often improperly discarded which may include materials dangerous to human health and the environment such as lead and mercury [19]. For instance, in Balochistan capital city of Quetta, the poor handling of E-waste has led to contamination of ground and surface water [20]. This draws attention to the gaps that still remain regarding policies and technologies that seek to address E-waste effectively. In addition, such technological development activities like roads and urbanisation in Balochistan employ land clearing and cutting down of trees [21]. Consequently, natural habitats and the diversity of biota in such regions are lost, which in turn alters the subtle ecological equilibrium

in the area [22]. Among the several projects slated for development under the China Pakistan Economic Corridor (CPEC), is the Gwadar Port which has raised fears on environmental issues such as coast erosion due to exacerbated shipping movements [23].

Some of the negative impacts of technological advancement on the environment of Balochistan is discussed in detail below:

- **Air and water pollution:** Air pollution results when harmful or excessive quantities of gases such as carbon dioxide, carbon monoxide, sulfur dioxide, nitric oxide and methane are introduced into the earth's atmosphere [24]. All the major sources have to do with technologies which came after the industrial revolution such as the combustion of fossil fuels, factories, power stations, mass agriculture and vehicles [25]. The consequences of air pollution include harmful health impacts to human beings and animals and global warming, where the increased amount of greenhouse gases in the atmosphere traps thermal energy in the Earth's atmosphere, raising the overall temperature of the world [26]. Water pollution, on the other hand, is contamination in water bodies, including lakes, rivers, oceans, and groundwater, mainly caused by human actions [27]. Generally, common water pollutants include domestic wastes, industrial effluents, and insecticides and pesticides [28]. One of the examples is the wastewater especially inadequately treated one that has been released into natural water bodies, degrading the ecosystems there [29]. Other effects include the incidence of diseases such as typhoid and cholera, eutrophication, as well as the destruction of ecosystems, which adversely affect the food chain [30].



Figure 2: Air and water pollution in Balochista

- Contribution of depletion of natural resources:** The other negative impact of technology on the environment is resource depletion. Resource depletion refers to the rate at which a resource is consumed far faster than it can be replenished [31]. Natural resources include those in existence without humans having created them and may either be renewable or non-renewable [32]. There are different forms of depletion of resources. The most alarming are the depletion of aquifers, depletion of trees through deforestation, fossil fuel depletion, and mineral extraction, resource contamination, loss of soil, and overdraw of resources. These are brought about mostly by agriculture, extraction of minerals, water use, and consumption of fossil fuel, all of which have been made possible by advances in technology [33]. The higher global population also enhances the intensity of degradation of natural resources. This has resulted in the estimation of the world's eco-footprint to be one and a half times the ability of the earth to sustainably provide each individual

with enough resources that meet their consumption levels [34]. Since the industrial revolution, large-scale mineral and oil exploration has been increasing, leading to more and more natural oil and mineral depletion [35]. Combined with development and research coupled with the improvement in technology, exploiting minerals has become easier thus humans dig deeper for more, and it has led to many resources entering into production decline [36]. The consequence of deforestation has never been more severe as it has been reported that between 1990 and 2015, a net loss of global forest was recorded at 1.3 million km² [37]. This is done solely for farming but also as a source of timber for fuel as well as creating space for residential places, which is boosted by increased pressure from the population [38]. Besides losing these priceless trees, which absorb carbon dioxide in the air, thousands of plants and animals have lost their natural habitats and become extinct [39].



Figure 3: Positive and Negative impacts of technology on the environment of Balochistan

REVIVAL OF TECHNOLOGY AND ITS CURRENT IMPACTS AROUND THE GLOBE

Some of the beneficial impacts of technological advancement on the environment of Balochistan and around the world are discussed in detail below:

- **Renewable energy:** Renewable energy, also known as 'clean energy,' is energy recovered from renewable resources that can be replenished. These resources replace themselves within a short

period of time. They include sunlight, wind, rain, tides, waves, and geothermal heat [40]. With modern environmental technology, we can harness this available natural energy and convert it into electricity or useful heat by means of devices like solar panels, wind, and water turbines; which has reflected very positive impact of technology on the environment [41]. Having overtaken coal in 2015 to become our second largest generator of electricity, renewable sources

currently produce more than 20% of the UK's electricity, and EU targets means that this is likely to increase to 30% by 2020 [42]. Renewable technologies are not only suited to large-scale development but also to remote areas and developing countries where energy is often crucial in human development. This is on renewable

energy technologies, such as solar panels and wind turbines, whose cost is declining while government investment is increasing [43]. The funds have gone towards rooftop solar installation in Australia, which skyrocketed from around 4,600 households to over 1.6 million within a period of ten years between 2007 and 2017 [44].



Figure 4: Renewable energy around the globe

- **Smart Technology:** Smart home technology employs devices such as link sensors and other appliances connected to the Internet of Things (IoT), which it can monitor and program from a distance to be as energy-efficient as possible, as well as to respond to the needs of the users [45]. IoT is a network of internet-connected things that collect and exchange data through embedded sensor technologies. Through this data, devices in the network are capable of making decisions on their own, based on current information [46]. For instance, intelligent lighting systems only allow

illumination when necessary, and a smart thermostat keeps homes at specific temperatures at precise hours of the day, thereby reducing wastage [47]. This environmental technology has been made possible by the growth in connectivity to the internet resulting from increased availability of Wi-Fi, Bluetooth, and smart sensors in buildings and cities [48]. According to experts, cities in the near future will be places where each car, phone, air conditioner, light, and much more will all be connected, bringing about the concept of energy-efficient 'smart cities' [49].

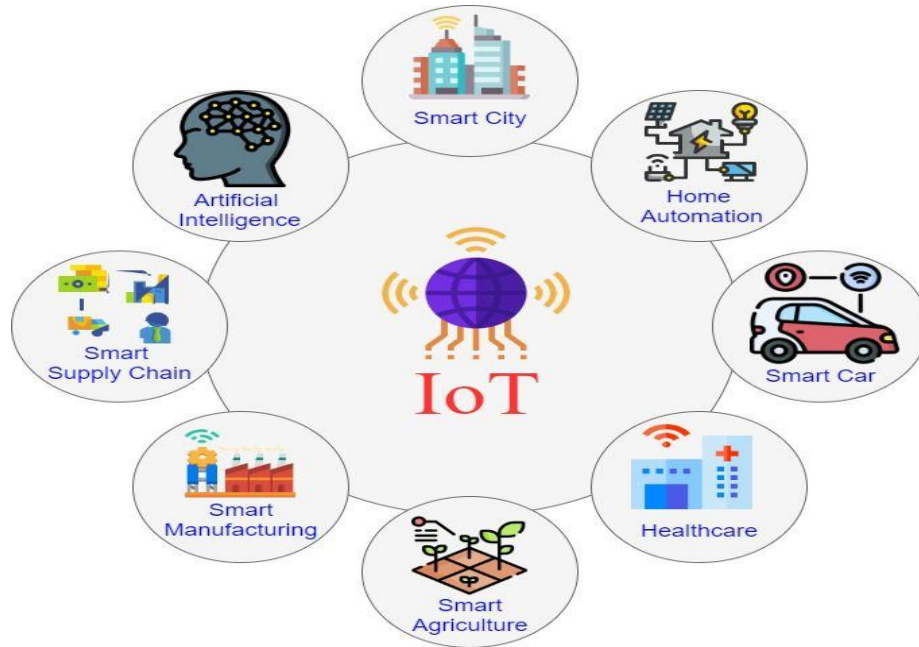


Figure 5: Smart technology i.e. IoT around the globe

- Electric car:** The energy stored in rechargeable batteries is used by one or more electric motors to power the electric vehicle [50]. From 2008, there has been growth in the production of electric vehicles because people have demanded clean surroundings free from air pollution and greenhouse gases in the atmosphere. Electric cars give out no carbon emissions and, therefore, do not contribute to the greenhouse effect and global warming [51]. It does not contribute to air pollution, meaning that their contribution to air pollution is lesser compared to other modes of transportation, and therefore, it

promotes human health, animals, plants, and water [52]. There are several government incentives the past years for environmental technologies in supporting plug-in vehicles, tax credits, and subsidies encouraging the adoption and introduction of electric cars [53]. Electric vehicles might yet be the future of a better greener world because Bloomberg has forecasted that it could get even cheaper than a car that runs on gasoline by 2024, and Nissan claimed that there are already more electric car charging stations in the UK than fuel stations [54].

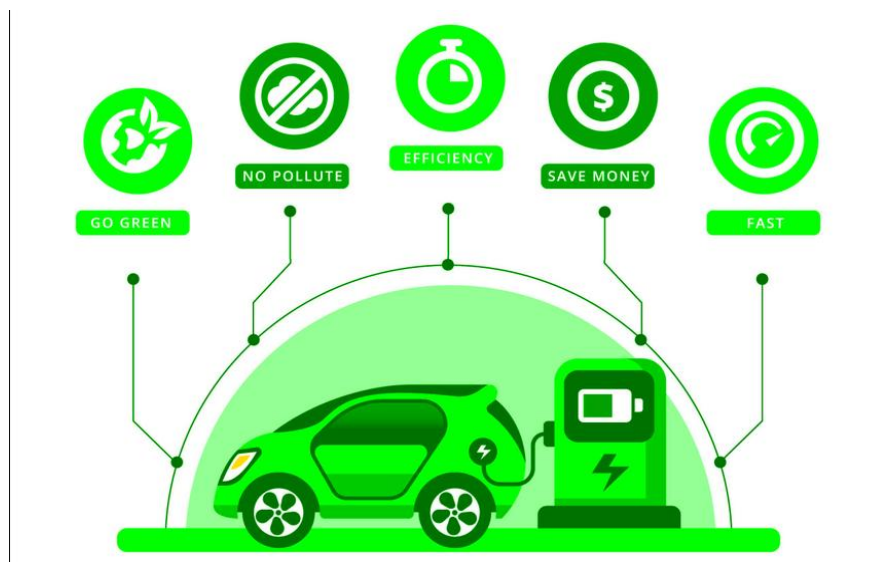


Figure 6: Electric car technology around the globe

- **DAC (Direct Air Capture):** Another only slightly more ambitious technology to take as a conclusion is pulling CO₂ directly from the air- a notion that's been stewing in the research world of climate change mitigation for years, but now has only just begun being implemented [55]. The environmental technology is called 'Direct Air Capture' (DAC) and refers to the capturing of carbon dioxide directly from ambient air in the generation of a concentrated stream of CO₂ for sequestration or use [56]. Many large fans push air through a filter, where CO₂ is removed. It was assumed that this technology would be applicable in managing emissions in distributed sources, such as car

exhausts [57]. Full-scale DAC operations can absorb the amount of carbon equivalent to the annual emissions of 250,000 average cars. Some arguments claimed that DAC is highly needed for the fight against climate change since it can meet the set goals of the Paris Climate Agreement, as carbon dioxide in the air has been proven to be the one that causes the problem after all [58]. However, the high cost of DAC means that as yet, it cannot be an option on a large scale and some believe that reliance on this technology would pose a risk as it may reduce emission reduction as people may be under the pretense that all of their emissions will simply be removed [59].

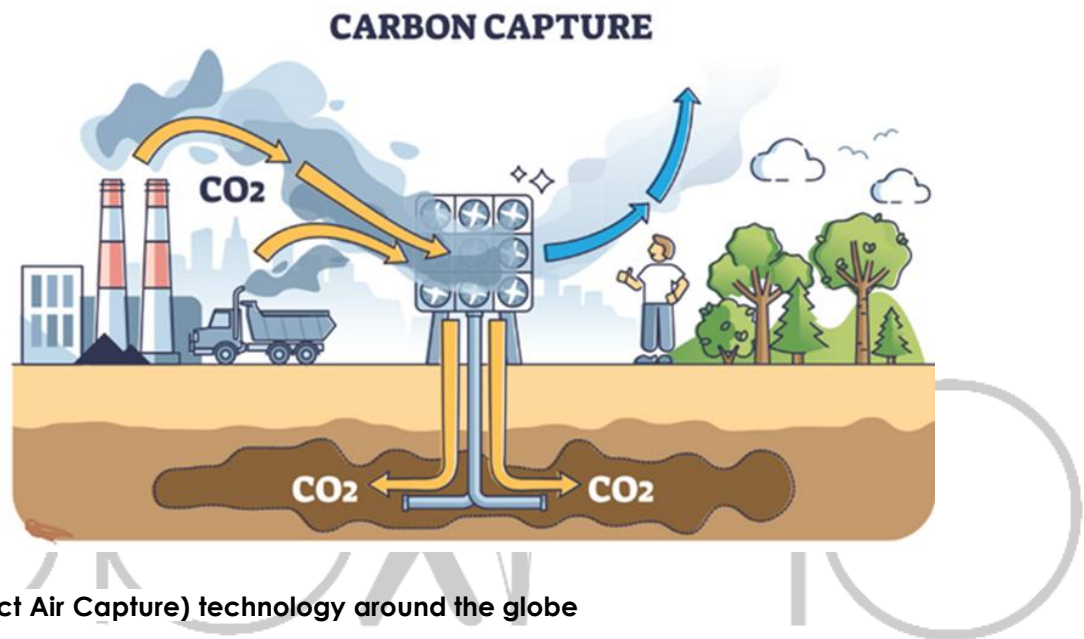


Figure 7: DAC (Direct Air Capture) technology around the globe

IMPACT ON LOCAL COMMUNITY

The influences of the technology development on communities have been significant in Balochistan. The development opened the door for large-scale projects — such as mines, or giant industrial solar and wind energy installations — that have uprooted centuries-old ways of life [60]. These practices include displacement of communities, damage and change to local ecosystems, and impact on water sources affecting health and livelihood [61]. The adoption of renewable energy projects, on the other hand, has brought new economic activities — for example from solar farms — that make electricity accessible or more reliable to communities close by [62]. The impacts are analysed so as to get a better understanding of the interaction between technological break-through,

and social dynamics in the context of community aspects.

ROLE OF EIA (ENVIRONMENTAL IMPACT ASSESSEMENT) IN TECHNOLOGY IMPACT ANALYSIS IN BALOCHISTAN

Possibly, never has the intersection of technology and environmental stewardship been more crucial than in the realm of Environmental Impact Assessments. As two worlds are struggling, between horns, to develop and to sustain, effective EIA has emerged as a cornerstone in the planning and execution of projects across sectors galore [63]. This holistic process is meant to make predictions on potential environmental impacts of proposed activities prior to their commencement, and thereby reducing the detrimental impacts of these activities [64]. This process is sophisticated as

well as data intensive, and in such a scenario, technology steps in and serves as a crucial tool and methodology to ensure that an assessment is as honest as possible and carried out with the required accuracy [65]. This review delves into the multiple functions of technology as an enabler in the EIA process and follows five key subtopics on Data Collection and Analysis Tools, Geographic Information Systems (GIS), Modeling and Simulation Software, Remote Sensing and Satellite Imagery, and Public Participation and Information Dissemination Technologies [66, 67].

- **DATA COLLECTION AND ANALYSIS TOOLS:** The foundation of any EIA is the data collection and analysis tools for the environmental professionals to obtain reliable data and conduct powerful analyses. A portion of the tools can be applied for quantifying and qualifying the baseline conditions, which are the basis for understanding all the potential impacts [68].
- **GEORAPHICAL INFORMATION SYSTEMS:** Geographic Information Systems (GIS) provide a dynamic platform for the visualization and interpretation of environmental data [69]. GIS technology allows for the precise detailed spatial representation of environmental information important for identifying sensitive areas and assessment of spatially dependent impacts [70]. It enables predicting various environmental impacts resulting from different scenarios through modeling and simulation software. It is such a software where a project's possible effects related to environment, say air quality, water flow, or any of the general ecological systems could be modeled hence helpful in designing more environment-friendly projects [71]
- **REMOTE SENSING AND SATELLITE IMAGERY:** Remote sensing and satellite imagery provide an eye in the sky which could continuously monitor environmental changes over large and off inaccessible areas. It captures a lot of details on pictures that are invaluable for assessing landscapes and ecosystems before, during, and after the execution of a project [72].

BALUCHISTAN ENVIRONMENTAL PROTECTION AGENCY

Minimization of effluents of industrial activities, all kinds of wastes and pollution bad to public health, safety, and welfare-which is going to bring an important role towards the improvement of

common people's plight and a perceptible change in society through the Environment Protection Department of Government of Balochistan [73]. The Department enforces qualitative and quantitative standards for discharge of effluents, waste, air pollutants, or noise either for general applicability or for a particular area or from a particular source in the form of National Environmental Quality Standards (NEQS) and other standards established under the Pakistan Environmental Protection Act, 1997, and any rules and regulations framed thereunder [74,75]. The department is directed to work under the Pakistan Environmental Protection Act, 1997 [76].

Service and Functions:

- Risk and vulnerability assessment related to environmental hazards and resources [77].
- Work in coordination with PDMA and devise any feasible measure to minimize the vulnerabilities of hazards [78].
- Enforce laws, rules and regulation in the province related to the environmental field.
- Check EIA/IEE of new projects and issues NOC [79].
- Raising awareness among public and disseminations of information relating to environmental matters.
- Enforce National Environmental Quality Standards (NEQS) to control pollution [80].
- Establish systems for surveys, surveillance and monitoring of the pollutants and maintain laboratory for testing and monitoring [81].
- Provide measures conducive to sustainable development as well as information on environment friendly technology [82].
- Incorporate Natural Disaster Risk Assessment in the Environmental Impact Assessment guidelines
- Develop technical capacities of the staff of department to undertake disaster risk assessment and disaster risk reduction activities in the environment sector [83].
- Evaluate the vulnerability of natural resources (forest, lakes, streams, mangroves, coral reefs, protected areas, coastal areas) against hazards of natural and human-induced origin [84].
- Implement conservation and rehabilitation programs for natural resources to mitigate hazards associated with natural events; such as reforestation, plantation of mangroves, desertification control and protection of special

natural resources; wetlands, lakes, reefs, mangroves, coastal areas [85].

CONCLUSION

In Pakistan, technological impact on the environment (especially in Balochistan) can be a double-edged sword. Although renewable energy projects, sustainable resource management, and environmental monitoring technologies can pave a way towards sustainable development, current challenges like the extraction of resources, e-waste, or infrastructure expansions could be very harmful for the environment. A holistic approach is needed to tackle these challenges: technology should be harnessed to help sustainable development and cancelled out as much as possible from its adverse impact on the environment. However, to me the most important compared to all of these measures in a specific context is reduced technology's environmental footprint by recycle-friendly technology, as well recycling-friendly electricity initiatives, and also no small matter Green Consumption (what we could call ecosleep). With this complete understanding of the technology based impact in Balochistan, policymakers will start strategizing more smartly to ensure technologically sustainability development along with environmental development.

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