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Persons in the News

Shri Arun Misra presently Deputy CEO- Hindustan Zinc Limited (HZL), has been appointed as Chief Executive Officer - Hindustan Zinc Limited (HZL). Shri Misra brings with him a vast experience of 31 years having held several leadership roles. Prior to joining Hindustan Zinc, Mr. Misra was associated with Tata Steel as Vice President - Raw Materials. He is also the Vice President of Indian Institute of Mineral Engineers. Shri Misra completed his Bachelor in Electrical Engineering from IIT-Kharagpur with Diploma in Mining and Beneficiation fron New South WAles Sydney, and another diploma in General Management from CEDEP, France.

Shri Manoj Kumar presently Director (Technical) Operation, Western Coalfields Limited, has been appointed for the post of Chairman & Managing Director, Western Coalfields Limited. Prior to elevation as Director (Technical) he had served various capacities in WCL/SECL and ECL since 1985. Shri Kumar did his B.Tech (Mining Engineering) from IIT (Indian School of Mines) in 1985 and in 1989 obtained First Class Mine Managers' Certificate of Competency. He also did M.Tech in Rock Excavation Engineering from IIT (ISM). Shri Kumar joined Coal industry in the year 1985 in Old Rajnagar Colliery of Hasdeo Area.

Shri Sumit Deb presently Director (Personnel), National Mineral Development Corporation Limited (NMDC Limited), has been appointed as Chairman & Managing Director (CMD) in NMDC Limited for a period from the date of his assumption of charge of the post on or after 01.08.2020. Shri Deb, was a graduate in

Mechanical Engineering from Orissa University of Agriculture and Technology, Bhubaneswar. He was Executive Director (Personnel and Administration) at NMDC. He was heading functions of Personnel, Human Resourcve Development, Rajbhasha, Administration of the Company, NMDC said. He started his career with Rashtriya Ispat Nigam Limited (RINL) as Management Trainee and worked with RINL for about 25 years accumulating rich and diverse experience in steel industry. Shri Deb had worked in different regions of the country, dealing with heterogeneous mix of both external as well as Internal customers and handling all domains of HR such as Manpower Planning, succession Planning, training and development. He has diverse experience in the field of Human Resources as well as Marketing and distribution of Steel and Iron Ore, Sponge Iron, Pellets and Diamonds. He was awarded with Jawahar Purashkar in the financial year 2007-08 by CMD, RINL for his outstanding performance.

Er. Akhilesh Joshi former CEO of HZL appointed as Director on its board effective August 1, 2020. Hindustan Zinc Ltd., a subsidiary of diversified natural resources company Vedanta Ltd. 1976 batch, MBM alumnus, Er. Akhilesh Joshi is a first-class mine manager, who began his career at HZL in 1976 and was appointed as COO and whole-time director in the period between 2008-2012. Further, he took over as the company's CEO and whole-time director in the period between 2012-2015. He was designated as President of Vedanta's Global Zinc Business during 2015-2016. He received the National Mineral Award 2006 by the Government of India for systematic exploration, increase in production and meeting the highest standards of mine safety. He has also been recognized by Business Today Best CEO Award (Core Sector) in 2013. Since joining the service in September 1976 Akhilesh Joshi has been consistently working in Hindustan Zinc.

Shri Santosa Kumar Pal presently General Manager, South Eastern Coalfields Limited, has been appointed for the post of Director (Technical), South Eastern Coalfields Ltd.

COAL NEWS

PRIVATISATION OF COAL SECTOR WILL TRANSFORM INDIA'S GROWTH TRAJECTORY, WRITES AMITABH KANT. By Amitabh Kant, CEO, NITI Ayog

I was in school when the coal sector was nationalised in 1973. This policy decision led to India becoming the second-largest importer of coal despite having one of the largest coal reserves in the world. It also created a scenario where it would take us another 35 years to complete even the detailed exploration of our potential coal-bearing areas. It has taken India almost 50 years to reverse this flawed policy decision, which has impacted its growth, progress, and employment creation. The government's decision to open the coal sector for private sector participation in commercial coal mining and gasification corrects a historical anomaly. It will bring investment opportunities for the private sector, competition and efficiency gains. Let me spell out why it is a transformative reform.

First, over the years, our coal imports have been steadily rising to meet our domestic demand. In 2018–19, we had to import 25% of our total coal demand, which is 235 MT of coal. This cost us Rs 1.7 lakh crore in 2018–19 and bears an enormous pressure on our import bill. In the wake of recent disruption of global supply chains and India's call for self-reliance, it is imperative that we allow our private sector to mine coal in India and for India. With nationalised coal mines failing to meet our demand, commercial coal mining is the only panacea for India to get rid of coal imports, achieve energy security and reduce import bill.

Second, commercial mining licences with regulatory oversight and monitoring will facilitate employment opportunities for tribal communities and local populations. There are many examples of responsible mining in India such as Hindustan Zinc, which has brought immense benefit to the local population while ensuring that the local life and traditions of the tribal community remain unperturbed. The district mineral fund and corporate social responsibility funds are invested in the local communities and have the potential to facelift the human and physical infrastructure in these areas.

Third, the revenues of states are bound to receive a substantial jump when commercial mining starts in these states. We cannot overemphasise the need for states to diversify their revenue sources as we have seen their resources dwindling during the Covid lockdown. Since the coal sector allows for 100% FDI, we will see major global and Indian investors pivoting to India's coal sector. This will give a major impetus to national and state revenues. Mining is a labour-intensive sector, which would mean that such mines will employ thousands of people, their families will live close by, and a supporting coal transport infrastructure will need to be developed, including rail junctions. The central government has already earmarked heavy investments for this coal and related transportation infrastructure. Since, many of these mines lie in central and eastern Indian states, which have a lower industrial base, these states will get a radical boost in infrastructure creation.

Fourth, entry of private sector in the coal sector has immense forward and backward linkages. The backward linkage of transportation and physical infrastructure is bound to create clusters of growth. In forward linkage, sectors such as cement, fertilisers, steel, and aluminium will bolster tremendous growth. They will be the biggest beneficiaries of the enhanced availability of coal. With universal rural electrification and expeditious work on household electrification, the energy demand is bound to grow, but energy-starved and insecure coal supply may act as a stumbling block. Besides, Indian mines have other minerals such as iron, bauxite, silver and those closer to coal mines. The positive reverberations will be felt in the entrapped mining sector as well.

Fifth, the entry of the latest global mining technology, management and competition is bound to revamp the sector from inside. Just like our public sector banks benefitted from the entry of private banks, Coal India Limited will also gain from the spillover effect in the industry. The government has laid specific focus on the gasification of coal, which will be used in sectors of transport and cooking, and will create further value addition in the sector. The real opportunity lies in value addition, in this case, the production of synthetic gas. All major economies are moving towards coal gasification as a cleaner and more efficient process. The new policy gives a special incentive for coal gasification. We have laid down ambitious coal targets of gasifying 100 million tonnes of coal by 2030. It is a cleaner process that benefits the community and has clear utility in sectors of transport and cooking.

Sixth, for many, the blanket objection is the adverse impact on the environment. They should realise that India continues to import coal. At least when we are mining coal within the country, we can take all the necessary precautions. In fact, the use of coal in power generation will help us balance the energy grid, which in turn will help us leverage the renewable energy capacity that is expected to cross 100 GW. Therefore, we need coal to provide quality, universal and year-round access of energy. Viable coal supply complements our efforts to use renewable sources of energy. Besides, as per the World Resources Institute, globally the average CO2 emission per capita is 4.8 tonnes, whereas for India the number stands at two tonnes per capita. This is a fraction as compared to other countries such as Australia (16.9), China (7.0), the EU (6.7) and the US (16.6). Advanced technologies of critical and super-critical power plants will control pollutants and increase the amount of electricity produced. It is possible for us to reconcile our growth aspirations while meeting our global commitments on the environment.

The socio-economic benefits of opening the coal sector for commercial mining are enormous. The impact on employment generation, infrastructure development, multiplier impact on other sectors, cluster development, and import bill reduction will go a long way in transforming India's growth trajectory. This move will revitalise the coal sector in the same way as the entry of private players changed the face of Indian banking. We are undoing the damage done to India and its economy five decades back.

WESTERN COALFIELDS OFFERS TO SUPPLY COAL TO POWER PLANTS OF COAL INDIA'S OTHER ARMS

Western Coalfields has offered four million tonnes of coal to power plants currently supplied by Coal India's other subsidiaries. Customers can shift their existing sale contracts to Western Coalfields, the company said in a notice. Many of its customers had shifted to mines that were further away as Western Coalfields' output fell. However, with output rising again, it has made the offer under its 'mine specific policy', which charges a 'small premium' while power generators in central, west, or south India can make substantial savings on transport due to proximity to its mines.

According to Western Coalfields, Mahagenco, one of its major customers, saved an average Rs 1,200 per tonne on freight in recent years. It has estimated Mahagenco's fuel requirement during 2020-21 at 35 million tonnes and has already submitted proposals for supplying the full quantity. State-owned generation companies of Maharashtra (Mahagenco), Madhya Pradesh (MPPGCL), Gujrat (GSECL) and Karnataka (KPCL) along with other private power producers were largely dependent on Western Coalfields for their coal requirement. "Due to larger distances, these consumers had to pay more on railway freight, making the landed cost of coal higher," the company said in a recent statement. The company invested in land acquisition and rehabilitation of affected people. It commissioned 20 new projects, which contributed 35.8 million tonnes during 2019-20. To meet additional demand from power consumers, it dedicated 11 mines for them.

It plans to ramp up production from 57.6 million tonnes in 2019-20 to 75 million tonnes in 2023-24 and further to 100 million tonnes by 2027-28 to meet the entire fuel requirements of its power consumers in central, west, and south India from the current year onwards. "With substantial growth in coal production over the last five years, Western Coalfields… has been able to provide cheaper landed price coal to state and private power generation companies of central, west and south India. This effort has helped power plants in reducing power cost, which will lead to cheaper power to its consumers," the company said.

COAL INDIA GIVES HARD-UP POWER PRODUCERS A MUCH-NEEDED BREATHER ON COAL USE

The power plants which had signed sale agreements with distribution companies but were unable to get enough coal from long-term contract auctions can now use the fuel meant for other plants of the same group, Coal India said in a recent notice. Industry executives said the plants which had participated in these auctions were relatively new and efficient but were stressed in the absence of secure fuel supply. However, the notice said, the plants which had secured fuel through these auctions would not be allowed to divert coal to plants which had signed supply agreements before the introduction of such auctions.

In the past four years Coal India has held three long-term supply contract auctions for these generators in which plants with a total capacity of nearly 15,000 MW participated. Bidding was based on discounts offered by generators on their contracted power sale prices with distribution companies. Each time, as part of the auction scheme Coal India offered 80% of their requirement as calculated by the Central Electricity Authority. According to a power sector executive, the scheme created a gap in supply with respect to requirement as Coal India offered only 80% of the requirement and some plants were barred from participating for additional supplies in the second and third rounds.

In December 2019, the independent power producers which had secured supply agreements prior to the introduction of auctions were allowed to burn coal at any plant of the same group if these plants held similar supply agreements. There are 40 such plants with a total installed capacity of about 45,000 MW. A coal industry executive said the government was trying to ensure that efficient plants produce more at lower costs to help consumers. "It will result in generation of cheaper power and lower bills for consumers," said Sabyasachi Majumdar, group head at ratings firm ICRA.

COAL INDIA MAY NOT SIGN NEW SUPPLY AGREEMENTS WITH CUSTOMERS TERMINATING EXISTING ONES

Coal India may not sign new fuel supply agreements with customers, for a period, who renege on contracts on frivolous grounds, the state-run firm said days after major customers walked out of deals to buy fuel, citing poor quality and high transport costs. It said efforts to supply coal of better quality and larger quantity than what is committed have increased revenue. The company had made a provision of Rs 1,365 crore for variation in coal quality in previous years, but it withdrew the provision in the last fiscal. "Coal India's supplies, above agreed annual contracted quantity to its customers… also netted the company… over Rs 1,760 crore under performance incentive during the previous two fiscals," it said.

On companies cancelling contracts for poor quality and high transport cost, a company executive said: "We feel these are lame excuses. The company takes a serious cognizance of its coal quality. Transportation costs being high is a frivolous reason to pull out as customers willingly obtain linkage (coal supply contract) for road mode with full knowledge of the distances". "Customers have paid premiums for securing coal through auctions in the past without complaints. Now, with Covid-19 induced slowdown when the demand for coal is low and the floor prices for coal are relatively lower, some of the customers are moving away citing reasons that are not tenable," said Coal India. Coal India has a third-party sampling system and independent consultants to test quality. The statement mentions that coal quality variance has come down due to these efforts and prices are charged in line with the actual grades of coal supplied to consumers. Credit or debit notes are issued in case of variation in grade, if any, and there is a redressal mechanism to settle these issues amicably. "During the pandemic, we stood by our customers offering them a slew of friendly measures, sops and concessions and continued supplies," the executive said.

WEST BENGAL COAL MINING PROJECT IN BIRBHUM'S DEOCHA-PANCHAMI

The Bengal government has decided to tweak its plan to kick off the coal mining project in Birbhum's Deocha-Panchami.The government intends to kick off ground work on the site from January 2021.The state government has decided to start the project from an area spread over 600 acres in three mouzas — Chanda, Harinsingha and Deocha — of Mohammadbazar block, instead of Harinsingha from where the project had been slated to be launched earlier.

There are about 100 meters to 350 meters of stone overburden and there is a reserve of 400 million tons of coal reserves in the area. The Deocha-Panchami area has a coal reserve of two billion tons. But a major problem of extracting coal from the area is the huge overburden of stones that is up to 3km in some areas.

The area that has been selected for the first phase of the project has about 100 meters to 350 meters of stone overburden.

Recently, Chief Secretary, Rajiva Sinha, along with land reforms commissioner Manoj Pant and the managing director of WBPDCL (West Bengal Power Development Corporation Ltd) had visited Mohammadbazar and held a meeting with the landowners of the area.

MINING NEWS

BEML BAGGED ORDER FOR SUPPLY OF 1,512 MINE PLOUGH FOR T-90 TANKS FROM MOD

BEML LIMITED, a 'Schedule A' Company under the Ministry of Defence (MoD) received order from MoD for supply of 1,512 Track Width Mine Plough (TWMP) for T-90 S/SK Tanks at an approximate cost of Rs. 557 crore.

Under 'Make in India' policy the contract has Buy and Make (Indian) categorisation with a minimum of 50 % indigenous content in make portion of the contract. The system will be manufactured at BEML facilities with the help of M/s. Pearson Engineering, UK.

Out of 1,512 Mine plough BEML will supply 100 nos. within 12 months, 250 nos. in subsequent years and order will be completed within 7 years.

These mine ploughs will be fitted on T-90 Tanks of Indian Armoured Corps which will facilitate individual mobility to Tanks while negotiating mine fields. Mobility of the Tank

Fleet will enhance manifold, which in turn would extend the reach of Armoured Formation deep into enemy territory without becoming mine causality.

This De-mine equipment is time tested for different soil conditions in Indian desert and customized for Indian operations

“We are proud to be associated with MoD to enhance the combat capability of the Indian Army. This is another example of BEML’s capability to meet the specific requirements of our armed forces. BEML signifies the true spirit of ‘Make in India’ and enabler for ‘Atmanirbhar Bharat’,” said Dr. Deepak Kumar Hota, CMD, BEML Limited.

ALUMINIUM INDUSTRY PEGS 12-13% TAX REFUND RATE UNDER NEW EXPORT SCHEME CITING HIGH BURDEN OF UNREBATED TAXES

India's key aluminium industry body has sought a top tax refund rate of 12-13% under a proposed export scheme, compared to the 2% it receives under an existing one. The Aluminium Association of India counts Hindalco Industries, Bharat Aluminium Company, National Aluminium Company and Jindal Aluminium Ltd among its members. The lobby group has urged the commerce and industry ministry for an initial 5% refund rate, subsequently going up to 12-13%, citing the high burden of unrebated taxes and duties, which are about 15% of production cost.

India’s top aluminium exports include unalloyed and alloyed aluminium ingots, billets, slabs, wire rods and plates. The country exported aluminium products worth $5.5 billion in the previous fiscal year. The government had asked the industry to come up with refund rates for various sectors. “The RoDTEP (Remission of Duties and Taxes on Exported Products) scheme rates will be decided after consultations among the ministries of commerce and industry, finance, respective line ministries and industry,” a government official said. Indian exporters are currently covered under the Merchandise Export from India Scheme.

“Indian exports are suffering due to the measures taken by the US to impose 10% tariffs on aluminium imports and granting exemption to Australia, Argentina, Canada and Mexico, which constitutes almost 50% of the US’ aluminium imports,” said an industry representative. Chinese companies have cornered more than half of the global market share in aluminium due to the large subsidies given by its government, he added. Further, with the US withdrawing the Generalized System of Preferences (GSP) benefits to India, India’s aluminium exports are now subject to an additional 2.6-6% duty over and above the 10% tariffs, while the same product from Canada, Mexico, Argentina and Australia are imported into the US at zero duty.

“Being in the government’s priority list, fast-track implementation of the RoDTEP scheme for aluminium will boost exports by reducing the burden of unrebated taxes and duties and entail global cost competitiveness in international markets,” said Rahul Sharma, president of the Aluminium Association of India. The Union Cabinet had approved RoDTEP in March. This is a scheme for exporters to reimburse taxes and duties paid by them, such as value added tax, coal cess, mandi tax, electricity duties and fuel used for transportation, which are not exempted or refunded under any other existing mechanism.

ARCELORMITTAL INDIA COMMENCES OPERATIONS AT THAKURANI IRON ORE MINE IN ODISHA

ArcelorMittal India Private Limited (AMIPL), the holding company of ArcelorMittal Nippon Steel India (AM/NS India) said it has commenced mining operations at its Thakurani iron ore mine in Keonjhar district of Odisha. The Thakurani block, with estimated reserves of around 179 million tonne, is expected to make a significant contribution to AM/NS India’s long-term raw material requirements. "The block has annual production capacity of 5.5 million tonne, which can be scaled up to 8 million tonne and its mineral reserves are expected to increase once detailed exploration is complete," an official statement said. AMIPL, which subsequently signed a Mine Development and Production agreement, executed a lease deed with the state government, has since acquired all valid rights, approvals, clearances and licenses, the statement added.

In February 2020, AMIPL was selected preferred bidder for the Thakurani iron ore mine license following an auction process conducted by the Odisha state government, in which AMIPL agreed to pay a 107.55% premium per tonne, as well as other royalty and duties. Commenting on the development, Dilip Oommen, CEO, AM/NS India said: "ArcelorMittal India and AM/NS India are pleased to have commenced operations at this strategically important captive raw material site." Thakurani was the first mining lease deed executed in Keonjhar district after the recent auctions, which is testament to the transparent and efficient process run by the Government of Odisha, he added. “The ore produced at Thakurani will feed AM/NS India’s steel manufacturing facilities and support our long-term ambition to significantly grow our production capacity in India with a secure, integrated supply chain," he said. Sharing the company's longer term plans Oommen said: "Over time, our plan is to connect Thakurani to our plants in Odisha through a slurry pipeline, which ensures both a cost effective and environmentally friendly mode of mineral logistics."

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Environment Impact Assessment Progress Journey: World & India

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The importance of environmental protection and conservation measures has been increasingly recognized during the past two decades. It is now generally accepted that economic development strategies must be compatible with environmental goals. This requires the incorporation of environmental dimensions into the process of development. It is important to make choices and decisions that will eventually promote sound development by understanding the environment functions. Environmental impact assessment (EIA) is a mature process implemented around the globe to identify significant impacts from development and provide mitigation measures to reduce these impacts. In India, the process has undergone a series of transitions since its inception in 1994 and has been accepted as an integral part of any project implementation. The present article scripts the evolution of the concept of Environment Impact Assessment in India and its development over the years.

ORIGIN & HISTORY OF ENVIRONMENTAL ASSESSMENTS

Rachel Carson's Silent Spring, published in 1962, in which the harmful effects of pesticides were first brought to the attention of the public, is often credited for launching the modern environmental movement.

THE RISE OF NEPA

After decades of continued failure of the political establishment in the United States to recognize the degradation of the environment, two events in the beginning of 1970 laid the foundation for environmental awareness:

- First was the National Environmental Policy Act (NEPA), signed into law on New Years' day of that year. It required federal agencies to integrate environmental values into their decision-making processes, by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions.
- The second was a massive Earth Day demonstration – planned by Senator Gaylord Nelson in April – in which 20 million people across the country participated. The success of this event led to the creation of the Environmental Protection Agency (EPA) in July 1970.

Environmental quality was established as a leading national priority in NEPA

- Environmental protection was made part of the mandate of all federal agencies, establishing procedures for the incorporation of environmental concerns into agency decision-making.
- A Council on Environmental Quality (CEQ) was established in the Executive Office of the President to oversee and coordinate all federal environmental efforts

RECOGNITION OF THE ROLE OF EIA AT RIO DECLARATION ON ENVIRONMENT &DEVELOPMENT

The United Nations Conference on Environment and Development also, known as Rio 92 or Earth Summit, was a landmark gathering concerning the international consolidation and acknowledgement of environmental impact assessment (EIA) as a universal approach to inform and influence decision-making on crucial socio-environmental matters.

The Conference has resulted in three documents very important for the consolidation of EIA:

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- Principle 17 of the Rio Declaration on Environment and Development states: Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.

- Article 14 of the Convention on Biological Diversity, titled Impact Assessment and Minimizing Adverse Impacts

Agenda 21 refers to EIA in several different chapters.

ENVIRONMENTAL IMPACT ASSESSMENT DEFINITION

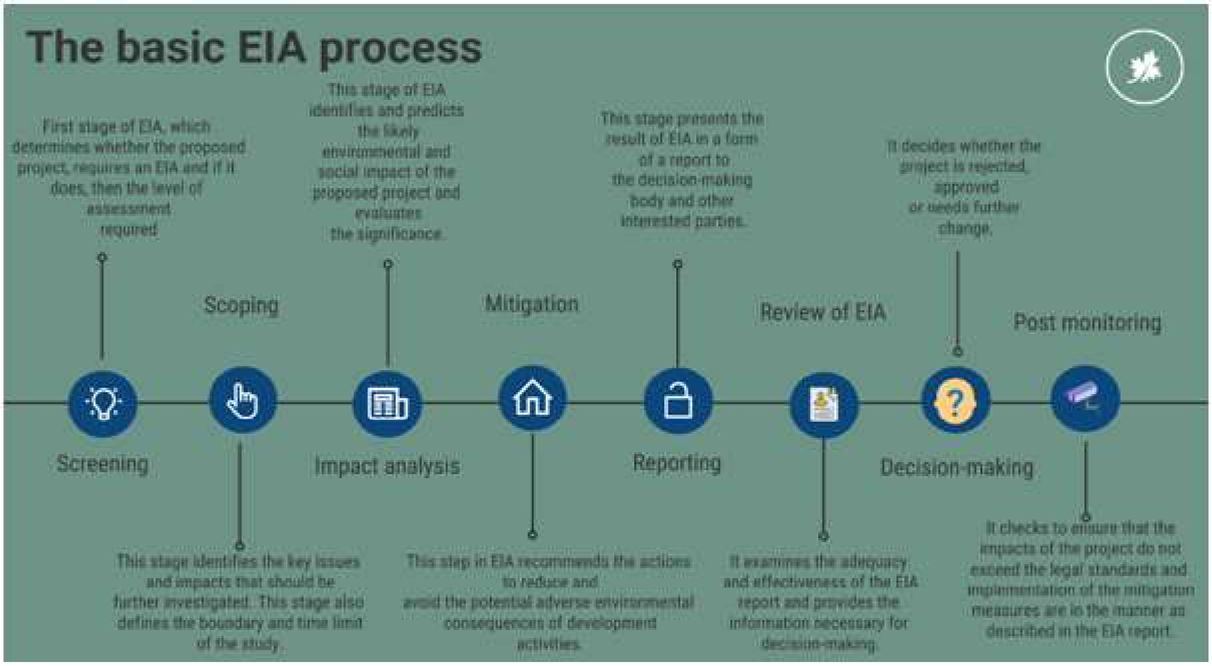
Two definitions of EIA, indicating the nature of the process exists,
"… an assessment of impacts of a planned activity on the environment" (as per United Nations),
and that it
"… the process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made" (as per International Association for Impact Assessment).

ROLE AND NEED FOR EIA

EIA has two roles, namely, legal & educational.

The legal role of EIA ensures that development projects have a minimal impact on the environment in its entire 'lifecycle', EIA facilitates in educating everyone involved - professionals and users included, of the potential environmental impacts of a project.

Environmental Impact Assessment (EIA) is used to identify and assess the environmental and social impacts of any proposed major activity (project, plan, programme or policy) prior to its implementation. It aims to predict environmental impacts at an early stage in project planning and design, find ways and means to reduce adverse impacts, shape projects to suit the local environment and present the predictions and options to decision-makers.



EIA is anticipatory, participatory, and systematic in nature and relies on multidisciplinary input. By using EIA both environmental and economic benefits can be achieved, such as reduced cost and time of project implementation and design, avoids treatment/clean-up costs and impacts of laws and regulations.

EIA PROCESS IN INDIA

MoEF has developed guidelines for the preparation of EIA reports along with questionnaires and check lists for the different sectors.

- Can the local environment cope with the additional waste and pollution that the project will produce?
- Will the project location conflict with the nearby land use or preclude later developments in surrounding areas?
- Can the project operate safely without serious risk of accidents or long-term health hazards?
- How will the project affect economic activities that are based on natural resources?
- Is there sufficient infrastructure to support the project?
- How much of the resources (such as water, energy etc) will the project consume, and are adequate supplies of these resources available?
- What kind of human resources will it require or replace and what will be its social impacts in the short/long-run?
- What damages will it inadvertently cause to the national/regional assets such as natural resources, tourist areas, or historic or cultural sites, etc ?

Source: UNEP (The United Nations Environment Programme is responsible for coordinating the UN's environmental activities and assisting developing countries in implementing environmentally sound policies and practices)

PHASES OF EIA PROCESS IN INDIA

1. Screening

Screening is done to see whether a project requires environmental clearance as per the statutory notifications. Screening Criteria are based upon:

- Scales of investment;
- Type of development; and,
- Location of development.

A Project requires statutory environmental clearance only if the provisions of EIA notification and/or one or more statutory notification released under it cover it.

2. Scoping

Scoping is a process of detailing the terms of reference of EIA. It has to be done by the consultant in consultation with the project proponent and guidance, if need be, from Impact Assessment Agency.MoEF has published guidelines for different sectors, which outline the significant issues to be addressed in the EIA studies.

Quantifiable impacts are to be assessed on the basis of magnitude, prevalence, frequency and duration and non-quantifiable impacts (such as aesthetic or recreational value), significance is commonly determined through the socio-economic criteria.

3. Baseline data collection

Baseline data describes the existing environmental status of the identified study area. The site-specific primary data should be monitored for the identified parameters and supplemented by secondary data if available.

4. Impact prediction

Impact prediction is a way of 'mapping' the environmental consequences of the significant aspects of the project and its alternatives. Environmental impact can never be predicted with absolute certainty and this is all the more reason to consider all possible factors and take all possible precautions for reducing the degree of uncertainty.

5. Assessment of alternatives, delineation of mitigation measures and environmental impact statement

For every project, possible alternatives should be identified and environmental attributes compared. Alternatives should cover both project location and process technologies. Alternatives should consider 'no project' option also. Alternatives should then be ranked for selection of the best environmental option for optimum economic benefits to the community at large.

Once alternatives have been reviewed, a mitigation plan should be drawn up for the selected option and is supplemented with an Environmental Management Plan (EMP) to guide the proponent towards environmental improvements.

The EMP is a crucial input to monitoring the clearance conditions and therefore details of monitoring should be included in the EMP. An EIA report should provide clear information to the decision- maker on the different environmental scenarios without the project, with the project and with project alternatives.

6. Public hearing

Law requires that the public must be informed and consulted on a proposed development after the completion of EIA report.Any one likely to be affected by the proposed project is entitled to have access to the Executive Summary of the EIA.The affected persons may include:

- bonafide local residents;
- local associations;
- environmental groups: active in the area
- any other person located at the project site / sites of displacement

They are to be given an opportunity to make oral/written suggestions to the State Pollution Control Board.Most EIA processes are undertaken through public consultation rather than participation.The public consultation process ensures an equitable and fair decision-making process resulting in better environmental outcomes.

7.Environment Management Plan

The Environment Management Plan (EMP) is prepared by theImpact assessmentauthority after all the above provisions have been complied with.

8. Decision making

Decision making process involve consultation between the project proponent (assisted by a consultant) and the impactassessment authority (assisted by an expertgroup if necessary)

9. Monitoring the clearance conditions

Monitoring should be done during both construction and operation phases of a project. This is not only to ensure that the commitments made are complied with but also to observe whether the predictions made in the EIA reports were correct or not. Where the impacts exceed the predicted levels, corrective action should be taken. Monitoring will enable the regulatory agency to review the validity of predictions and the conditions of implementation of the Environmental Management Plan (EMP).

Development Journey of EIA in India

EIA prior to 1994

The first major instance of incorporating provisions for the assessment of environmental impact of a project in any legal instrument was seen in the case of Central Water Commission (CWC).In the guidelines issued by CWC in 1975, the Commission provided for conducting investigations regarding major irrigation and hydroelectric projects.

The actual EIA process in India was started in 1976-77 when the Planning Commission asked the then Department of Science and Technology to examine the river-valley projects from environmental angle. This was subsequently extended to cover those projects, which required approval of the Public Investment Board.

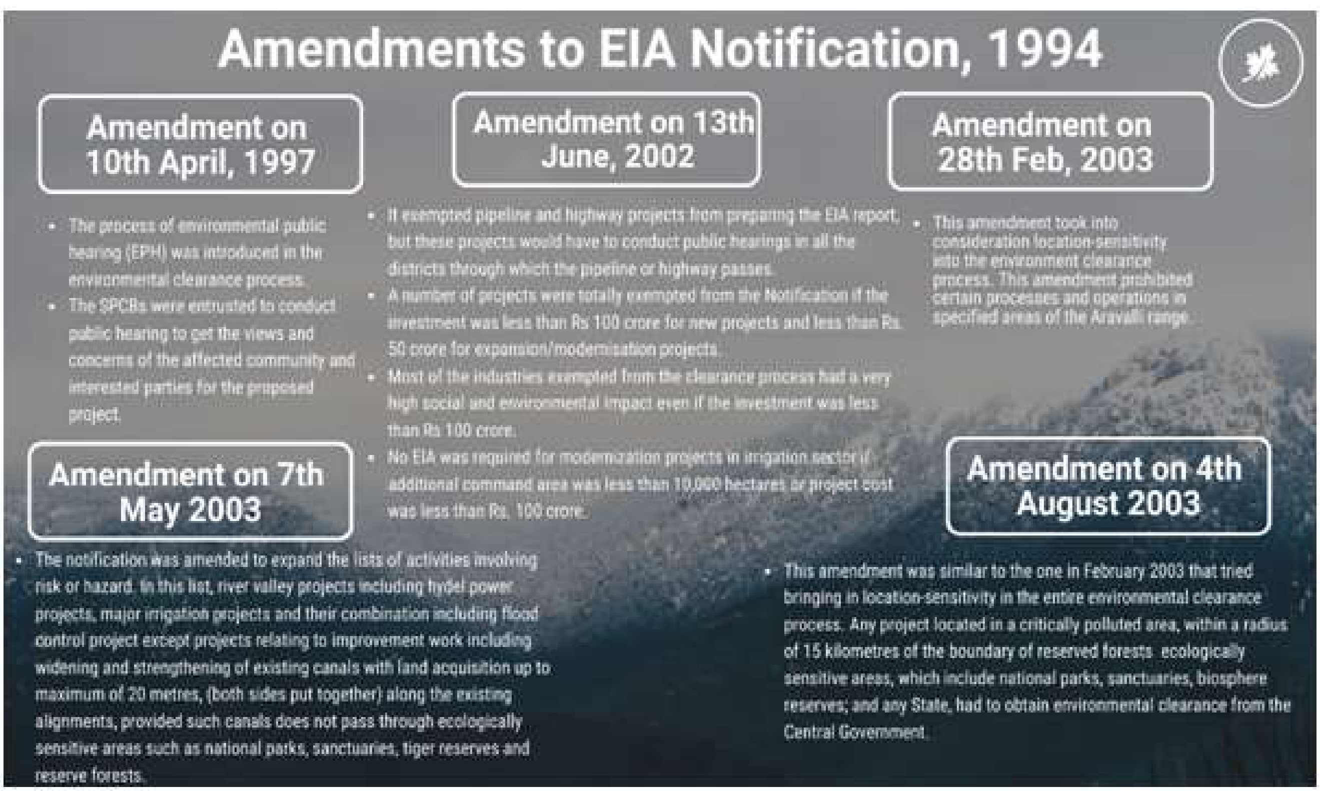
Initially, up till 1994, in India, EIA clearances existed in form of 'Environmental Clearances' and appraisals which were an administrative requirement only for big projects undertaken by the Government or public-sector undertakings.

EIA Notification 1994

The Government of India enacted the Environment (Protection) Act on 23rd May 1986. To achieve the objectives of the Act, one of the decisions that were taken is to make environmental impact assessment statutory. On 27th January 1994, the MoEF notified mandatory EIA's under Rule 5 of the Environment (Protection) Rules, 1986 for 29 designated projects. This is the principal piece of legislation governing environmental impact assessment.

The notification made it obligatory to prepare and submit an EIA, an Environment Management Plan (EMP), and a project report to an Impact Assessment Agency (Agency) and was required to consult a multi-disciplinary committee of experts. The notification specified the process of obtaining Environmental Clearance (EC) for such projects, and also made public participation mandatory. The Notification legislated under the Environment Protection Act, 1986 was responsible for ensuring that developmental projects (industries and infrastructure like dams, mines, refineries, large commercial complexes, highways, power projects, etc.) account for their environmental impacts as part of their planning and design processes.

Amendments to EIA Notification, 1994



EIA NOTIFICATION 2006

It was an outcome of the Govindarajan Committee recommendations.

The Govindarajan Committee was constituted to examine the procedures for investment approvals and project implementation.It found that the environment clearance causes. maximum delay to projects and recommended that some of the cumbersome procedures be modified.

EIA Notification 2006	EIA Notification 1994
Projects in Schedule-1 have been divided into two categories, Category A and B. Category A project will require clearance from Central Government (MEF). Category B will require clearance from State Government. However, the state government will first classify if the B project falls under B1 or B2 category. B1 projects will require preparation of EIA reports while remaining projects will be termed as B2 projects and will not require EIA report.	Proponent desiring to undertake any project listed in Schedule-1 had to obtain clearance from the Central Government.
Well defined **screening process** with projects divided into two categories: Category A: All projects and activities require EIA study and clearance from central government. Category B: Application reviewed by the State Level Expert Appraisal Committee into two categories - B1 (which will require EIA study) and B2 (which does not require EIA study).	In **screening**, the project proponent assesses if the proposed activity/project falls under the purview of environmental clearance, then the proponent conducts an EIA study either directly or through a consultant
Scoping has been defined in the new notification. The entire responsibility of determining the terms of reference (ToR) will depend on the Expert Appraisal Committee. This will be done in case of Category A and Category B1 projects. However, the finalisation of ToR by the EACs will depend on the information provided by the project proponent. There is however a provision that the EACs may visit the site and hold public consultation and meet experts to decide the ToR. However, if the EACs do not specify the ToR within 60 days, the proponent can go ahead with their own ToR.	**Scoping** was not applicable. The terms of reference were completely decided by the proponent without any public consultation.
Public Consultation:All Category A and Category B1 projects or activities have to undertake public consultation except for 6 activities for which public consultation has been exempted. Some of the projects exempted include expansion of roads and highways, modernization of irrigation projects, etc. The public consultation will essentially consist of two components – a public hearing to ascertain the views of local people and obtaining written responses of interested parties. No postponement of the time, venue of the public hearing shall be undertaken, unless some untoward emergence situation occurs and only on the recommendation of the concerned District Magistrate. This was not a part of the earlier Notification. The SPCBs or Union Territory Pollution Control Committee shall arrange to video film the entire proceedings. This was also absent in the earlier notification and may be considered as a good move to ensure that public hearing is proper.	**Public Consultation:** The project proponent has to write to State Pollution Control Board to conduct public hearing. It was the responsibility of the State Boards to publish notice for environmental public hearing in at least two newspapers widely circulated in the region around the project, one of which shall be in the vernacular language of the locality concerned. In screening, the project proponent assesses if the proposed activity/project falls under the purview of environmental clearance, then the proponent conducts an EIA study either directly or through a consultant

DRAFT EIA 2020

MoEFCC has been engaged in the process of revamping the Environment Impact Assessment (EIA) Notification 2006 for the past one year. Finally, after extensive consultation with the State Governments and then with the Industry Associations, the Ministry has finalized a draft for formal consultation with stakeholders. This latest draft proposes substantial changes from the earlier ones.

Salient features of Draft EIA 2020

- The document has been made more exhaustive with inclusion of a section on Definitions and detailing of the various Committees under the Notification including eligibility conditions for members of these Committees.
- A new 10-member Technical Expert Committee has been proposed to primarily undertake categorization or re-categorization of projects on scientific principles including any streamlining of procedures, other tasks assigned to the committee for the purpose this notification, by the Ministry from time to time.
- The 4-stage process consisting of Screening – Scoping – Public Consultation – Appraisal has been modified into a 6-stage process of Scoping - Preparation of Draft EIA Report - Public Consultation - Preparation of Final EIA – Appraisal - Grant or Rejection of Prior Environment Clearance. While the above would be followed for Category A and B1 projects for Category B2 the stages would just Preparation of EMP - – Appraisal - Grant or Rejection of Prior Environment Clearance.
- The amendment process for ECs has been streamlined. Moreover, for mining projects, as long as the peak production capacity, mining lease area, mine closure conditions remain unchanged and have been put in place by the project proponent, nature and extent of mitigation measures, as committed in the prior-EC granted, are in place corresponding to the quantum of excavation being made at that point in time the project proponent can produce up to a maximum of peak production capacity permitted in the prior-EC and change in the sequence of operations of mining is also allowed. However, the project proponent must report such change in the scheduled production and or/ sequence of operations along with corresponding mitigation measures in the periodic compliance report.
- The Validity of the Prior EC has also been elucidated in detail with reference to the 3 phases of a project, namely, Construction/ Installation – Operational – Redundancy/ Closure. While the max permissible validity for Mining Projects has been increased to 50 years, the mandate of compulsorily commencing mining within 10 years of grant of EC has been included. For all other projects, the Prior EC validity has been proposed at 10 years to commence production and then perpetual for the Life of the project. It has also been clarified that this perpetuity is EC is only confined to the completed project, i.e. only completed part of the project shall be considered as perpetual for the remaining life of the project where the project is implemented partially, within the period specified above.
- A section on Dealing with Non-Compliances has been added to the EIA framework. All non-compliances, whether declared Suo-moto or reported by agencies, would be appraised by the applicable EAC which would make categorical recommendations to the project proponent for time bound action plan for compliance of the conditions of prior-EC conditions and the amount of the bank guarantee deposited as an assurance for the purpose of compliance. The bank guarantee will be released after successful implementation of the action plan.
- A Framework for dealing with Violation Cases has been included with differentiation of the cases in 4 distinct Categories namely

1. Suo moto application of the project proponent; or
2. reporting by any Government Authority; or
3. found during the appraisal by Appraisal Committee; or
4. found during the processing of application, if any, by the Regulatory Authority.

- These cases will be dealt by the EAC (Expert Appraisal Committee), who would ascertain whether the project is environmentally sustainable and then take a call whether to recommend Project Closure or take it forward for appraisal after grant of ToR (Terms of Reference).

A scheme of exemptions from stages have been proposed even for Category A and B1 projects as detailed in the table below:

Slabs	Intended increase in production capacity through modernization	Application in form through online portal	Requirement of Scoping	Requirement of revised EIA report	Requirement of revised EMP	Whether refer to Appraisal Committee	Requirement of Public Consultation
I	Modernization without increase in the production capacity	Form-2	No	No	No	No	No
II	Up to 10 percent	Form-2	No	No	Yes	No	No
III	More than 10 and up to 25 percent	Form-2	No	No	Yes	Yes	No
IV	More than 25 and up to 50 percent	Form-2	No	Yes	Yes	Yes	No
V	More than 50 percent	Form-I	Yes	Yes	Yes	Yes	Yes

UNADDRESSED CRITICISMS TO EIA NOTIFICATION, 2006

- **State Environment Impact Assessment Authority**
  The handing over of the responsibility of granting clearance to a large number of projects to the state governments without any system of checks and counter checks is not acceptable. In many instances, the state government is directly involved in seeking investments.

- **No provision to Crosscheck and poor consultation**
  In the present situation where fraudulent EIAs have been exposed at public hearings and decisions to clear the project have also been made on the basis ofsuch reports, it is rather ironic that the Ministry believes that any decision can be made on the basis of the application form, which may not be done after someamount of investigation by an environment consultant.There should be some cross-check mechanism before screening stage. Consultations on the draft notification were held only with representatives of industry and central government agencies, as per the Ministry's own submission. State governments, Panchayats and municipalities, NGOs, trade unions and local community groups were partially or completely kept out of the process.

- **Issues with Public Hearing Process**
  Only a draft EIA report will be available to the locally affected persons at the time of the public hearing. Citizens will now not get to see the final EIA document on the basis of which the decision on the project will be made.
  The notification should have either laid down details of the degree of information that the draft report should contain or should have introduced clauses of punitive action if the draft allows only an ineffective public hearing due to being uninformative or less informative.
  Cancellation of Public Hearing: This clause which requires the public hearing to be cancelled if the local conditions are not conducive is subject to severe misuse by the project proponents and regulatory

authorities.No quorum required for attendance to start the proceedings

Who can attend public hearings? The notification states that the public hearing will be primarily for the purpose of ascertaining concerns of local affected persons. Other concerned persons who have plausible stake in the environmental impacts can make submissions in writing. This clearly limits the participation of people's groups, and civil society organizations.

DIGITAL ENVIRONMENTAL IMPACT ASSESSMENT PROCESS: A USER-CENTRED APPROACH TO DESIGN AN EIA PROCESS FOR THE FUTURE IN EUROPEAN UNION & UK

Background

Funded by Innovate UK, The Digital EIA project is a collaboration between Connected Places Catapult (led by their Digitising Planning Programme), Quod, Temple, ODI Leeds and Liquorice Marketing with an aim to digitalise the entire EIA process in UK/EU

Why Digital EIA?

Environmental Assessments are often criticised for being an administrative burden, ending with a bloated, inconsistent and inaccessible report replete with technical jargon that is difficult to navigate, understand and even simply to read. Furthermore, digital technology is not being exploited to capture data or deliver more efficient and effective ways of producing assessments.

Sneak peak in to the digital EIA Process platform

1. AUTOMATED SCREENING

A semi-automated tool that helps developers to understand if they need to undertake an EIA or not

Benefits

- Reduces unnecessary screening requests and therefore local authority time and resource
- Increased transparency of decision-making and EIA screening requirements
- Increased certainty for applicants
- Reduces risk-averse decision-making
- Ensures direct alignment between proposals and the EIA Regulations and Government guidance

2. ASSISTED SCOPING

A digital tool that generates scoping recommendations, consolidates scoping feedback and builds a custom Digital EIA Workspace structure.

Benefits

- Efficiencies and cost savings for LPA's through automation of low value, resource intensive tasks such as collation of consultee responses

- Increased transparency and efficiency of scoping reports through standardized templates
- Reduced over-scoping and inclusion of topics that do not need to be assessed.

3. IMPACT MODELLING

A plug-in tool to test and model different impacts and scenarios within a digital environment.

Benefits

- By working in real-time, the Impact Modelling plugin will facilitate immediate and direct impact reporting from a scheme from the early stages of development, effectively making the 'design freeze' process more streamlined and simpler.
- Environmental experts will be able to easily demonstrate to designers how various changes will impact the environment

4. ENVIRONMENTAL STATEMENT

A digital and interactive output of the EIA process that allows users to easily locate and understand information relevant to them.

Benefits

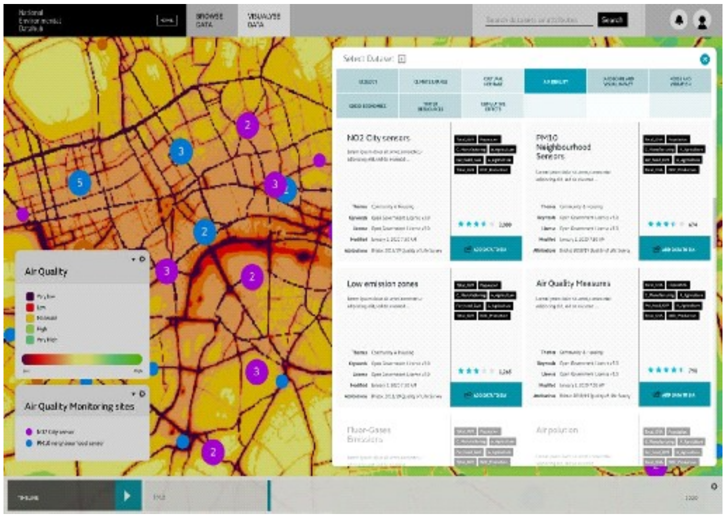
- Increased transparency and inclusiveness by involving, more effectively, the public and other stakeholders throughout the process, in particular harder to reach members of the community
- Reduced lengths and complexities of an ES
- Increased accessibility and potential savings on printing costs and resources.

5. NATIONAL ENVIRONMENTAL DATAHUB

One open and accessible hub for all environmental data:A central and standardised open data portal where users can discover, access, analyse and contribute raw data for use and in the Environmental Impact Assessment process.

Impact

- Drives efficiencies in the process, reducing the time to locate and access data, and enabling the re-use of data by others
- Opens up opportunities for SMEs and other businesses to develop new tools and innovations from the data that has been opened up
- Gives greater transparency to the data used in decision making.



6. DIGITAL EIA WORKSPACE

The Digital EIA Workspace can be used when completing an EIA for a project. It enables users in various locations and organisations to access standard templates and methods, use pre- populated policy and legislation text, collate and assess information and data.

Impact

- Provides transparency of working and promotes a culture of collaboration between specialists
- Reduces 'obesity' in reporting through standardised methods, and restricted word counts and formats
- Reduces hours currently spent on tracking changes and consolidating comments

7. POST-APPLICATION MONITORING

A 'must-do' process that will improve the quality of mitigation and data

- During construction and following completion of a development, data is rarely collected about the actual impact of a development and whether mitigation measures were successful or not. Thismeans there is no feedback loop detailing whether the tools and methods used to predict the effects during There are, however, various benefits associated with encouraging post-application monitoring, could be encouraged, **collected** and **utilised**.
- Promotes accountability in the EIA processes and predictions. Currently, EIA experts estimate that only approximately 10% of developments monitor impacts during the operational phase
- Improved trust from the public in the EIA process through the sharing of this data.

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Different Methods for Removal Fe ions from Mine Waste Water and Impact of Overdose on Human: A Review

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ABSTRACT

The present study enlightens about the crucial importance of maintenance of Fe ions in the human body and summarizes the impact of overdose of iron on human health and marine environment. For the need of removal of iron from the mine waste water, different methods have been enunciated and compared. The different methods i.e Ion Exchange Method, Oxidation with oxidizing agents, Supercritical Fluid Method, Membrane Filteration, Bioremediaion, Adsortpion ,Coagulation and Floccolation and Electrochemical Oxidation are explained .The most economical and efficient one are Menbrane filteration and adsorption as they are cost effective and efficient, and amount of waste generated through these process is less as compared to other processes.

Keywords— Fe ions, Waste water, Adsorption, Water treatmemt methods.

INTRODUCTION

The regulation of a particular substance is vital for proper functioning of human body. The effect of an element is determined by several characteristics, including absorption, metabolism, and degree of interaction with physiological processes [Abbaspur et al, 2014]. Iron is vital component for the proper functioning of the human body as well as other living organisms as it effectuate in number of metabolic processes, synthesis of DNA and hemoglobin and transportation of oxygen in blood [Abbaspur et al, 2014]. Presence of iron ion in huge amount in drinking water, lakes and river is very harmful for human beings, plants, and animals. The presence of free iron is toxic because of its propensity to induce the formation of dangerous free radicals which has capability to damage the cell tissue causing the rare disease hereditary hemochromatosis and lipid peroxidation and increases cardiovascular risk in human beings [Toxqui et al, 2010]. The removal of excess iron from the waste water, streams and drinking water is very vital for the society.

The production of iron ore constituting lumps, fines and concentrates was 200.95 million tonnes in the year 2017-18 [ISBN, 2019]. Accoring to the India Brand Equity foundation India was fourth largest producer of iron ore in Financial Year 2018. This high amount of production of iron ore degrades the large quantity of water and environment surrounding the mine area by flowing with surface as well as the ground water and ultimately mixing the human and animal food cycle. The present study emphasizes on review of the efficiency of different methods used for the removal of iron from the mine waste water. The different methods i.e Ion Exchange Method, Oxidation with oxidizing agents, Supercritical Fluid Method, Membrane Filteration, Bioremediaion, Adsortpion, Coagulation and Floccolation and Electrochemical Oxidation are explained .

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IMPACT OF IRON OVEROSE ON HUMAN HEALTH

Iron is a major component of hemoglobin, which is used to transport oxygen and carbon dioxide in the blood. Iron in drinking water is classified as a secondary contaminant according to the EPA. This is because iron often carries with it bacteria that feed off the iron to survive. These small organisms can be harmful when digested. Low level of iron isn't harmful for human health but it can cause anemia to extreme low level.

Over consumption of iron causes Iron overload which is caused by a mutation in the gene that digests iron. Iron overload can lead to hemochromatosis, which can lead to liver, heart and pancreatic damage, as well as diabetes [Passaic Bergen Water Softening, 2017]. Early symptoms include fatigue, weight loss, and joint pain. The ingestion of large quantities of iron can damage blood vessels, cause bloody vomitus/ stool, and damage the liver and kidneys, stomach problems, nausea, vomiting and even cause death.

However, because iron ingestion is regulated, body tissues are generally not exposed to high-level concentrations. The deleterious effects of iron include DNA damage, lipid peroxidation (LPO) and oxidation of proteins. [Toxqui et al, 2010].

HUMAN REQUIREMENTS

A. Infant

During early infancy, iron requirements are met by the little iron contained in the human milk. The need for iron rises markedly 4-6 months after birth and amounts to about 0.7-0.9 mg/day during the remaining part of the first year. Between 1 and 6 years of age, the body iron content is again doubled.

B. Adolesent

Iron requirements are also very high in adolescents, particularly during the period of growth spurt. Girls usually have their growth spurt before menarche, but growth is not finished at that time. In boys there is a marked increase in hemoglobin mass and concentration during puberty. In this stage, iron requirements increase to a level above the average iron requirements in menstruating women.

C. Adult

The average adult stores about 1-3 g of iron in his or her body. A fine balance between dietary uptake and loss maintains this balance. About 1 mg of iron is lost each day through sloughing of cells from skin and mucosal surfaces, including the lining of the gastrointestinal tract. Menstruation increases the average daily iron loss to about 2 mg per day in premenopausal female adults. The augmentation of body mass during neonatal and childhood growth spurts transiently boosts iron requirements.

IMPACT OF IRON OVEDOSE ON MARINE ECOSYSTEM

There are two main reasons why iron is more bio-available (Biological availability is the amount of a substance, which can be utilized by aquatic life.) at low pH in the marine ecosystem.

- In extremely acidic environments, both natural and man-made are often associated with the oxidative dissolution of sulfide minerals, many of which contain iron (pyrites; FeS_2).
- Both ionic forms of iron are far more soluble (especially ferric ion) at low pH than at circum-neutral pH. Iron solubility in water depends on pH, oxidation-reduction potential, temperature, oxygen and the presence of substances to which it will bind such as OH^- , SO_4^{2-}, Cl^- and humic substances.

Ferrous Iron can precipitate at lower pH than aluminum and can be present in water with a pH of less than 4.5 making the separation of the effect of iron from the effect of low pH difficult. The precipitate of ferric hydroxide may result in a complete blanketing of the ocean or stream bottom, adversely affecting both macro invertebrates and fish . The severity is dependent on the ocean/stream pH and the thickness of the precipitate. The toxicity of iron depends on the species and the size of fish. The gills of fish act as mechanical filters, the small particles of iron with dimensions of a few microns are trapped in the gill lamella. This is why the species and size of the fish are of importance. The presence of the small ferric iron particles cause irritation of the gill tissues leading to gill damage and secondary bacterial and fungal infections. Iron acts like a catalyst in water and does promote the dissociation of oxygen molecules into free radicals. The free radicals are extremely reactive and short lived. However, on the surface of the gills, the free radicals formed by the iron causes oxidation of the surrounding tissue and this leads to massive destruction of gill tissue and anemia. Iron has been shown to induce oxidative stress on the marine life [Tembo Rostern N, 2017].

DIFFERENT METHODS USED FOR THE REMOVAL OF IRON IONS FROM WATER

There are various methods for removing Fe cations from the mine waste water including ion-exchange method, oxidation by oxidizing agents such as chlorine and potassium permanganate, activated carbon and/or other filtering materials, supercritical fluid extraction, bioremediation, and treatment with limestone. Some of these methods are simple and economic while the others are complicated and expensive . In oxidation treatment, oxygen, chlorine or potassium permanganate (KMnO4), is generally used for Fe (II) oxidation.

A. Physical Method

Physical separation consists of mechanical screening, hydrodynamic classification, gravity concentration, floatation, magnetic separation, electrostatic separation, and attrition scrubbing. The efficiency of physical separation depends on various soil characteristics such as particle size distribution, particulate shape, clay content, moisture content, humic content, heterogeneity of soil matrix, density between soil matrix and metal contaminants, magnetic properties, and hydrophobic properties of particle surface [Gunatilake S.K, 2015].

B. Ion Exchange Method

Iron removal by the ion exchange process using a sodium forming strong acid cation resin has been used in various applications for a number of years with varying degrees of success. The process is viable with clear well waters devoid of oxygen and other oxidizing agents, as the iron must exist as the soluble divalent ion. In addition, the process should be limited to waters containing small quantities of iron.

Although this process has been used successfully for iron removal there are some definite design and operating considerations that should be followed in order to minimize the two main problems frequently encountered—fouling and attrition.

These design and operation considerations include:

- Raw water characteristics (including concentration and form of iron and manganese present);
- Ratio of iron to total divalent cations;
- Resin capacity;
- Regeneration techniques;
- Method for chemical and physical cleaning of the resin.

C. Oxidation By Oxidizing Agents

· Oxidation with chlorine

Iron in water can also be oxidized by chlorine, converting to ferric hydroxide, the precipitated material can then be removed by filtration. The higher the amount of chlorine fed, the more rapid the reaction. Most treatment plants use 1 – 2 parts of chlorine to 1 part of iron to achieve oxidation.

· Oxidation with permanganate

Potassium permanganate is typically more effective at oxidizing iron than aeration or chlorination. When oxidizing with potassium permanganate, the operation of the filters becomes important since the reaction also continues to take place in the filter media. The normally-used filter media (sand) will remove iron if the combined concentration is below 1 ppm. Higher concentrations require different type of filter materials (greens and others) and different methods of operation. Potassium permanganate is often used with manganese greensand, a granular material that is charged with potassium permanganate after the backwashing process. This method allows the oxidation process to be completed in the filter itself and is a buffer to help avoid pink water in distribution. After the filter is backwashed, it regenerates for a period of time with a high level of permanganate before it is put back into operation [Minnesota Rural Water Association Publications, 2014].

D. Supercritical Fluid Extaction

Supercritical fluid technology is in use from late 19th centrury for the extraction of different chemical constituents. It generally utilizes CO_2 as the mobile phase, the whole chromatographic flow path is pressurised. A fluid is said to be supercritical, when its pressure and temperature exceed their respective critical value. [Shinde et al, 2019].

A special apparatus is needed to carry out Supercritical Fluid Extraction, basically consisting of a solvent pump, a pressure cell to contain the sample, a means of maintaining pressure in the system, and a collecting vessel. Carbon dioxide is pumped to a heating zone, where it reaches supercritical conditions, then it passes to the extraction vessel, and, behaving as a gas, can rapidly diffuse into the solid matrix and, as a liquid, dissolve a large quantity of lipids from the extracted material. The dissolved lipids are removed from the extraction cell into a separator at lower pressure, and the extracted material settles out. The extraction can be selective to some extent by controlling the density of the medium, and the extracted material is easily recovered by simply depressurizing, allowing the supercritical fluid to return to gas phase and evaporate leaving little or no solvent residues.

The most common supercritical fluid is carbon dioxide (CO_2), which affords very good recoveries for non polar lipids, unlike polar lipids are scarcely soluble in fluid, and may remain partially un-extracted. To this purpose, the addition of organic modifiers as co-solvents to the primary fluid is very common, to enhance the extraction efficiency. The addition of 1–10% of methanol or ethanol to CO_2 typically expands the extraction range to include more polar lipids.

E. Coagulation And Flocculation

Coagulation is a set of physical and chemical reactionsin which the coagulant(s) added to the water, which results in the formation of insoluble flocs. These are agglomerations of the particulate suspended matter in the raw water, the reaction products of the added chemicals, as well as colloidal and dissolved matter from the water adsorbed by these reaction products. The mixing of coagulant and the raw water to be treated, is referred to as flash mixing. The primary purpose of the flash mix process is to rapidly mix and equally distribute the coagulant chemical throughout the water. The entire process occurs in a very short time (several seconds). The chemicals hydrolyze and neutralize the electrical charges on the colloidal particles, which begin to form agglomerations termed floc which will be removed by clarification and filtration.

The coagulation-flocculation mechanism is based on zeta potential (æ) measurement as the criteria to define the electrostatic interaction between pollutants and coagulant-flocculant agents. Flocculation process continually increases the particle size to discrete particles through additional collisions and interaction with inorganic polymers formed by the organic polymers added. Once discrete particles are flocculated into larger particles, they can be removed or separated by filtration, straining or floatation. Production of sludge, application of chemicals and transfer of toxic compounds into solid phase are main drawbacks of this process [EPA, 2002].

F. Electrochemical Oxidation

Electrochemical oxidation of iron in water can occur through two different oxidation mechanisms, first the direct oxidation and the second is indirect oxidation (Anglada et al., 2009). Direct oxidation involves two steps:

(1) diffusion of pollutants from the bulk solution to the anode surface, and

(2) oxidation of pollutants at the anode surface.

During indirect electrochemical oxidation, a strong oxidizing agent is electrochemically generated at the anode surface and this oxidizes the contaminants. The indirect oxidation mechanism is more favorable in contaminant removal processes and is used frequently in the water treatment applications. While convenient, electrochemical methods have not found widespread application in water treatment because of the high cost of electrodes, high voltages and high power consumption[Langdon et al, 2010].

G. Bioremediation

Bioremediation is a process that uses mainly microorganisms, plants, or microbial or plant enzymes to detoxify contaminants in the soil and other environments. Bioremediation is employed in order to transform toxic heavy metals into a less harmful state using microbes or its enzymes to clean-up polluted environment . The technique is environmentally friendly and cost-effective in the revitalization of the environment. The direct use of microorganisms with distinctive features of catabolic potential or their products such as enzymes and bio surfactant is a novel approach to enhance and boost their remediation efficacy [Igiri et al, 2018]. Bioremediation of heavy metals has limitations i.e production of toxic metabolites by microbes and non-biodegradability of heavy metals.

H. Membrane Filtration

Depending on the size of the particle that can be retained, various types of membrane filtration such as ultrafiltration, nanofiltration and reverse osmosis can be employed for iron removal from mine waste water.

Ultrafiltration (UF) utilizes permeable membrane to separates heavy metals, macromolecules and suspended solids from inorganic solution on the basis of the pore size (5–20 nm) and molecular weight of the separating compounds (1000– 100,000 Da).

Depending on the membrane characteristics, UF can achieve more than 90% of removal efficiency with a metal concentration ranging from 10 to 112 mg/L at Ph ranging from 5 to 9.5 and at 2–5 bar of pressure. UF presents some advantages such as lower driving force and a smaller space requirement due to its high packing density.

Polymer-supported ultrafiltration (PSU) technique adds water soluble polymeric ligands to bind metal ions and form macromolecular complexes by producing a free targeted metal ions effluent. Advantages of the PSU technology are the low-energy requirements involved in ultrafiltration, the very fast reaction kinetics and higher selectivity of separation of selective bonding agents in aqueous solution [Gunatilake S.K, 2015].

Reverse Osmosis (RO) is a process that uses semi-permeable spiral wound membranes to separate iron from water. Feed water is delivered under pressure through the semi permeable membrane, where water permeates the minute pores of the membrane and is delivered as purified water called permeate water. Impurities in the water are concentrated in the reject stream and flushed to the drain is called reject water. The materials used for RO membranes are made of cellulose acetate, polyamides and other polymers. The membrane consists of hollow-fiber, spiral-wound used for treatment depending on the feed water composition and the operation parameters of the plant [Garud et al, 2011].

I. Adsorption

Adsorption is a separation process where molecules tend to concentrate on the surface of the adsorbent as a result of Van der Waals force which exists between the molecules. The adsorbability of a compound increases with: increasing molecular weight, a higher number of functional groups such as double bonds or halogen compounds, increasing polarisability of the molecules. The adsorption force is the sum of all the interactions between all the atoms

If accumulation of gas on the surface of a solid occurs on account of weak van der Waals' forces, the adsorption is termed as physical adsorption or physisorption. When the gas molecules or atoms are held to the solid surface by chemical bonds, the adsorption is termed chemical adsorption or chemisorption. The chemical bonds may be covalent or ionic in nature [A. A.Ujile, 2014].

The key ingredient in the process of adsorption is adsorbent which can be a waste material, or a material recycled reducing the cost of the process. The amount of sludge produced is directly proportional to the dosage of adsorbent making the process highly efficient as it produces little amount of waste. The process is economical as it uses the waste material as adsorbent.

Adsorption using activated carbon is an effective technique to remove iron from wastewater, that is due to that activated carbon has a pore size distribution which control its adsorption capacity, a chemical structure that influences its interaction with polar and non-polar adsorbates, and active sites which determine the type of chemical reactions with other molecules [Fathy et al, 2013].

CONCLUSIONS

The removal of iron overdose is important so that it does not affect the marine ecosystem and the quality of the environment and quality of food we eat and does not pose a threat of disease to the human body.

Among the different methods, the physical methods are feasible to a particular state and form of iron present in water. The ion exchange method is constrained to be used on the clear water and water free from oxidizing agents and the problem in recovery of resins used.

Huge investments are required for the construction of tanks for the use of the flocculation process.

The primary disadvantage of Supercritical Fluid Extraction is that the extraction must be operated at the high pressure which requires higher capital and operating costs.

The electrochemical oxidation process is highly uneconomical as the electrodes used in the process are highly expensive.

The membrane filtration techniques are highly efficient and used widely. The adsorption process is dependent on the selection of adsorbent for the removal of iron from the water but it is highly cost-effective. Insitu-Bioremediation is quite effective technique for the treatment of Fe ions from the mine waste water but not commonly used.

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Model Development to Study the Impact of Tunnelling Near Coal Mining Areas

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ABSTRACT

Most of the coal mine areas near the cities are under-utilized because of ongoing extraction of coal. With the detailed study of ground behaviour, this space can also be utilized for transportation purposes such as roadways, railways etc. In urban areas, mostly partial extraction methods are used to extract the coal avoiding the trough and sinkhole subsidence. For this, the detailed modeling is to be done before and after the excavation of the tunnel near the working coal mine areas. The prepared model is analyzed for the stresses which will exceed their elastic state. The location of the stresses is noted and sufficient control measures are to be adopted. The main problems which are encountered in the tunnel are discontinuities, underground water and gas emissions from the coal mines. This paper emphasizes on the numerical modeling of the tunnel and coal seam which is extracted partially.

Keywords—Partial Extraction Method, Numerical Modeling

INTRODUCTION

Due to increase in the population in urban areas, there is a need to increase the transportation of people and goods. For this, underground tunnel is the best option in urban areas. When the area belongs to Coal mining, then there is a need to study the performance of the ground surface and surroundings of the coal seam. The soil or rocks are in equilibrium state at rest. When the excavation or underground opening is made, the equilibrium of the surrounding rock mass is disturbed causing the stresses to redistribute around the opening. In urban areas, mostly partial extraction methods are used to extract the coal because the structure will be more stable and there will be less settlement on the surface when compared with the full face excavation methods of coal and therefore avoiding the trough and sinkhole subsidence. The partial extraction methods are Non-effective width (NEW), Chess Board, Goaf Pillar, wide and stall, splitting of pillar with stowing, splitting of pillar with side bolting and Harmonic Mining (Lokhande et al., 2005).

The depth between the tunnel and the working coal seam also plays a prominent role in the stabilization of structure. If the distance is less, it may result in sinkhole subsidence. The minimum distance should be 3 times the diameter of the tunnel. After the construction of the tunnel, when the coal seam is extracted completely using partial extraction methods, the performance of the ground needs to be monitored otherwise the tunnel may collapse into the coal seam whenever there is a stress redistribution or heavy water inflow into the tunnel. The parameters such as geological discontinuities, underground water and gas emissions plays a major role in deciding the whether the rock will withhold the tunnel or not. This paper emphasizes on the numerical modeling of the tunnel and coal seam on the basis of geometrical and geological data. This paper also presents the difference of ground reaction before and after the modeling of the tunnel.

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GEOTECHNICAL AND GEOLOGICAL PROBLEMS

For designing the tunnel, the main parameters which create the problems for the stability of the structure are geological discontinuities, underground water, gas emissions and others.

A. Geological Discontinuities

Mostly design the structure such that there should not be any major geological discontinuities otherwise, the stability of the structure will deteriorate. If there are any discontinuities within the designed structure, then there is a need to study the effect of the discontinuities in the surrounding strata. Here geological discontinuities are joints, faults, fractures etc. Generally these are due to the release of tensile stresses of the surrounding rock. In this paper, continuum modeling is considered (assuming no major geological discontinuities) avoiding the minor geological discontinuities.

B. Underground Water

The groundwater is the biggest problem while designing the underground structure. If there is a heavy ground water inrush, then the pore water pressure increases resulting in breaking the bonds of the soil or rock which ultimately leads to the crack development and causing instability to the designed structure. When the groundwater encounters geological discontinuities, the water tends to widen the discontinuity because of high pressure and causing the structure to collapse. The groundwater becomes problematic during construction of the tunnel. The only way to escape this situation is to drain the water using drain holes, if it becomes the difficult task to do breakage of the bonds of the soil or rock so, then grout the surrounding rock mass of 5-10 times the diameter of the tunnel using the water repellent material.

The selection of the grout depends on the quantity of water in rush into the tunnel.

C. Gas Emissions

Mine gases may be explosive (methane), toxic (Carbon Monoxide and hydrogen sulphide) or asphyixiant (blackdamp; which is oxygen depleted air). The migration pathways for gases are permeable rock formations, faults, joints, fractures, manmade cuttings, excavations, boreholes, adits, shaft. Mine gas emission may be a significant issue during the construction because they are normally inflammable and explosive. Therefore imposes a high risk to the people working on the site (Tong et al., 2013).

D. Others

Blasting also instigates cracks during their operation and it enhances the joints, fractures and faults to an extent. Residual voids such as galleries, shafts, adit, storage platforms with and without fill (gas, water and other materials) is a great danger to the tunnel structure.

Table. 1: Material properties

Material Name	Unit Weight (MN/m^3)	Poisson's Ratio	Young's Modulus (MPa)	Material Type	Peak Tensile Strength (MPa)	Peak Friction Angle	Peak Cohesion (MPa)	Residual Tensile Strength (MPa)	Residual Friction Angle (°)	Residual Cohesion (MPa)	Porosity Value
Soil	0.0196	0.29	1500	Plastic	0.05	24	0.074	0	24	0.074	0.5
Sandy Mudstone	0.024	0.22	2000	Plastic	1.6	33	2.5	1.6	33	2.5	0.4
Siltstone	0.0252	0.25	1600	Plastic	1.6	28	4.5	1.6	28	4.5	0.3
Medium Mudstone	0.025	0.23	3100	Plastic	5.03	37	10.1	5.03	37	10.1	0.35
Quartz Sandstone	0.0267	0.24	3730	Plastic	2.3	41	11	2.3	41	11	0.2
Coal	0.0137	0.23	1200	Plastic	1.1	20	0.8	1.1	20	0.8	0.25
Argillaceous Siltstone	0.0245	0.16	2500	Plastic	1.8	30	5.66	1.8	30	5.66	0.25
Medium Sandstone	0.0254	0.134	2200	Plastic	5.14	40	8.5	5.14	40	8.5	0.15
Silty Fine Sand Rock	0.025	0.14	1500	Plastic	3.12	33	5.5	3.12	33	5.5	0.25

MODEL PREPARATIONS

A. Model before excavating the tunnel

A Model is Prepared in RS2 9.0. This model consists of different layers which are soil, Sandy mudstone, Siltstone, Medium mudstone, Quartz sandstone, Coal, Argillaceous siltstone, Medium Sandstone, Silty fine sand rock. The material properties are given in Table.1. In this model, partial extraction method used for extracting the coal is wide and stall method. The Bore hole section of the model is given below:

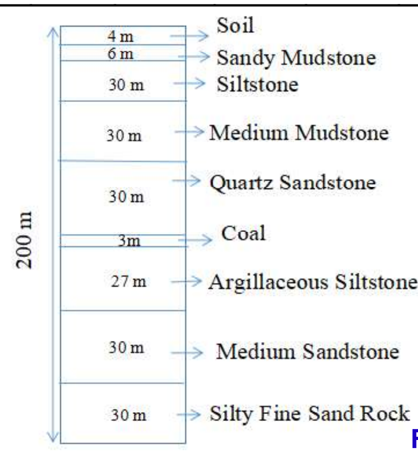

Fig. 1: Borehole section

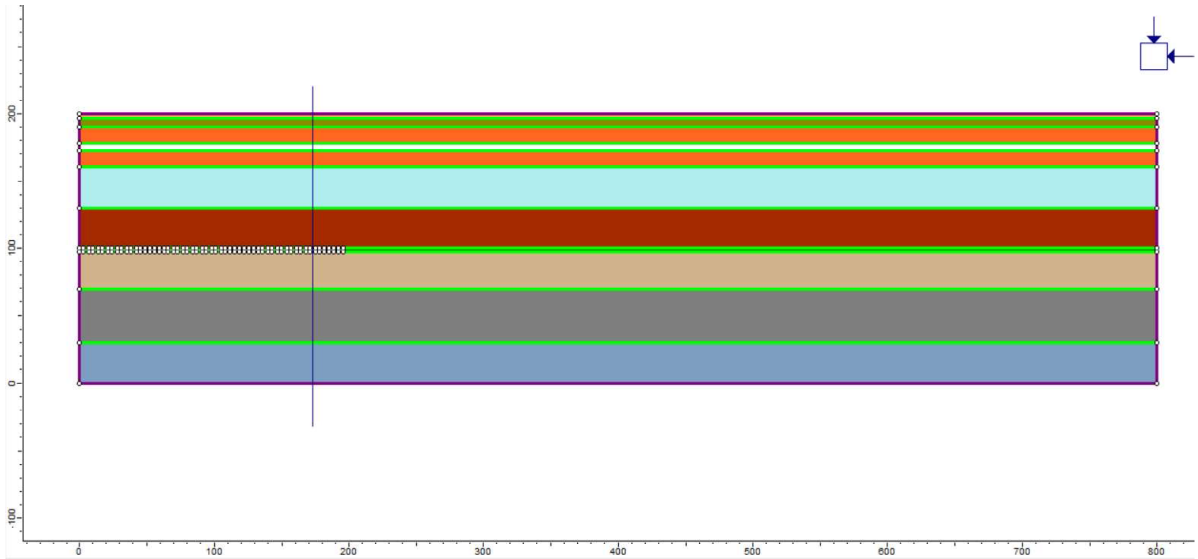

Fig. 2: Model in Longitudinal direction

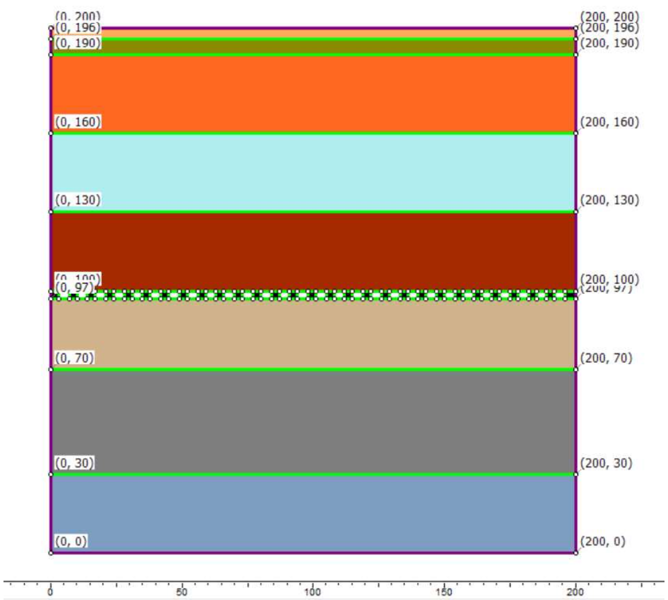

Fig. 3: Model before excavating the tunnel

B. Model after excavating the tunnel

The tunnel is located at 15 m from the ground surface. It is a horseshoe tunnel with radius of 3.125 m and tunnel width of 6.25 m. The area of the tunnel is approxiamtely 32 m^2.

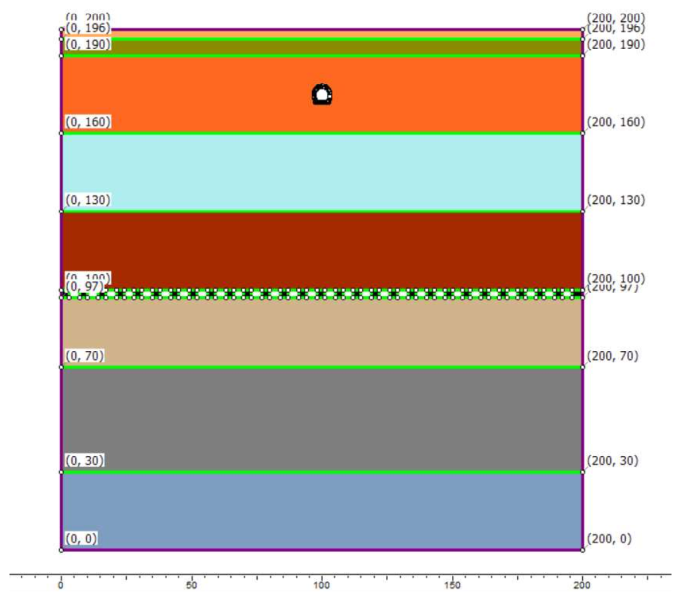

Fig. 4: Model after excavating the tunnel

IV. RESULTS

The main Problem near the coal mines is redistribution of stresses. Due to this, settlement or subsidence on the surface, volumetric strains, stresses etc will change. This paper emphasizes on vertical displacement and stresses.

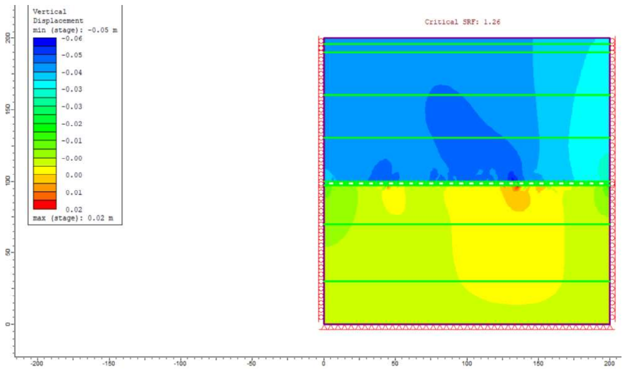

Fig. 5: Vertical displacement of the model before excavating the tunnel

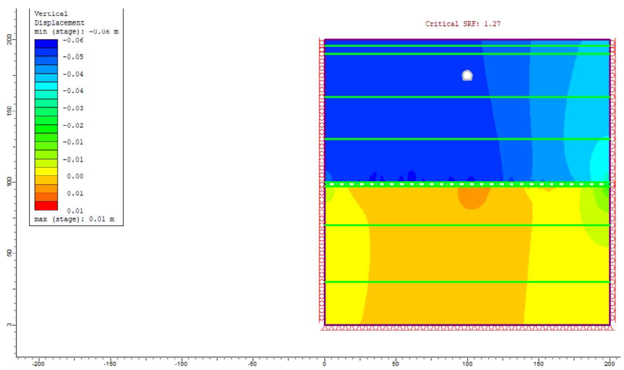

Fig. 6: Vertical displacement of the model after excavating the tunnel

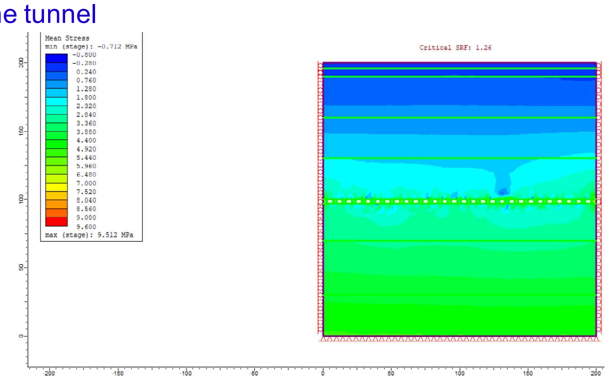

Fig. 7: Mean stresses before excavating the tunnel

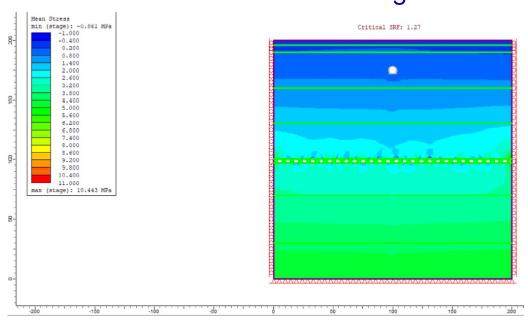

Fig. 6: Mean stresses after excavating the tunnel

The settlement and mean stresses are slightly increased after excavating the tunnel when compared with before. Here there are trivial changes in the settlement and mean stresses. Even the strength reduction factor remains almost similar. So, the structure may not have any specific problems but however when working in real situations some problems may arise because the ground strata is unpredictable (not same) even at small distances. If any problem encounters, then the following control measures are to be followed:

V. CONTROL MEASURES

A. If groundwater is the problem then

- De-watering or controlled Pre-drainage.
- Waterproof grouting should be done in the surroundings of the tunnel.
- Drain Holes and Curtain grouting from the tunnel face is to be employed.

B. If Voids, joints are the problem then,

- Foam grouting.
- Lining should be reinforced by increasing reinforcement percentage.

C. If soft strata is problem then,

- Forepoling should be done.

D. If subsidence is the problem then,

- Backing filling with the help of sand or other waste materials in the partially extracted areas.

  Curtain grouting is commonly required to prevent the potential sinkhole development.

CONCLUSIONS

To construct a tunnel near the working coal mine areas, the complete data of lithology and geometry of the extracted and extracting coal seams, goaf areas, ground water table, discontinuities, gas emissions and others should be available in detail. It becomes expensive and difficult to construct a tunnel above the working coal seams because of geo-technical and geological problems. Here the distance is too large between the tunnel and the working coal seam, hence there are trivial changes in settlement and stresses. The monitoring instruments are to be installed in the extracted coal seam, inside the tunnel and at working face, to keep a check on ground or strata behaviour.

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Aravalli- the Mother of Mineral Zones

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ABSTRACT

This article deals with a quick method to explore deep- seated mineral deposits based on strike and dip of the pegmatite beds of the Aravalli range.

Pegmatite is the main intruded body in the Aravalli mountain range which has given rise to about 58 minerals. For example, lithium is found in the form of spodumene or lithiophilite, both of which occur from pegmatites. Similarly, cesium is found in pollucite and beryllium is sourced from beryl which are found within pegmatite. The presence of these rare earth elements make pegmatite a potential source of valuable ore.

It is observed that the strike direction of the Aravalli range is NE-SW and the mineral deposits also follow the same trends. A cross section of the Rajasthan indicates that the western part of the state has limestone whereas the central part is dominated by base metals and the eastern part is rich in fertilizer minerals. It is also observed that the quality of the minerals reduces while we proceed from west to east, which might be due to the intrusion activity. The trend of the mineral deposits and the Aravalli mountains is being confirmed in the field with the strike and dip directions measured in the working mining areas. Since the continuity of occurrence of these deposits have not been proved at many places, many gaps in exploration exists. As per the National Mineral Exploration Policy,2018, the mineral exploration for important minerals must be completed for the entire country, and its data must be published within three years.

So, for search of new areas of deposits of rare earth elements the trend of the pegmatites in Aravalli's should be followed for exploring the deep- seated deposits which may be vital source of rare earth minerals.

Keywords: provide Strike - dip; Aravalli; Pegmatite; Mineral trend.

INTRODUCTION

Mineral survey and exploration activity is the first and foremost activity for the mineral development and management. Mining and recovery of mineral resources has been known since long. In early Palaeolithic era man found the minerals flint for arrow heads, whereas clay for potteries. Tin and copper extraction started during Bronzeage while gold , silver and gem stones adorned the wealthy era early civilisations and iron mining introduced in recent age of man. All these indicate the importance of minerals from ancient times, as minerals play an important role in the development of economy by providing inputs for industrial growth. The minerals thus been and will ever be the life line of human beings. The complex modern society is built around the exploitation and use of mineral resources.

Future of human development depends on mineral resources, but these resources have their own limitations as the known resources of minerals are fast depleting. Minerals are finite assets and can not be replenished like other natural resources. So, it needs scientific approach and continuous efforts for search and evaluation of mineral deposits with their proper conservation. Thus, the search for mineral s and mineral zones is the need of the hour.

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Mining of minerals in Rajasthan is pre-eminent sector next to agriculture. Every mineral facet of Rajasthan is unique and fascinate, so as its geology and occurrence of mineral deposits. Rajasthan state is encompassing an area of 2.4 lakh Sq.km. out of which nearly two-thirds area with desert sand and soft sediments of Quaternary age. The different provisions from east to west are the Banded Gneissic complex, the Aravalli- Delhi fold belt and the Trans Aravalli provinces.

The State has 79 varieties of minerals of which 58 are being mined. The state has leading production in Wollastonite and Jasper(100%), Zinc concentrate (99%), Fluorite (96%), Gypsum(90%), Ball Clay(90%), Soap stone(87%), Rock Phosphate(79%), Calcite (60%) and Feldspar(80%) of country's production. The sector provides employment around 20lakh workers throughout the state.

It is the second largest mineral producing state in the country and houses about 90% of the total mineral reserves. It shares 24% of the aggregate national production of non-metallic minerals. The state ranks in first three top cement producing states.

GEO-STRATIGRAPHY

The Geological sequence of the state is highly varied and complex, revealing the co-existence of the most ancient rocks of Pre-Cambrian age and the most recent alluvium as well as wind blown sand. The Aravalli mountain system runs across the state from the north of Delhi in the north east to the Gulf of Cambay in the south west. The Archaeans consist of Delhi & Bhilwara Super groups (Bundelkhand Gneiss and the Banded Gneissic Complex). The Aravalli's are vast formation composed of basal quartzites, shales, conglomerates, composite gneisses and slates. The Central part of the Aravalli ranges is occupied by a great synclinorium composed of Aravalli and Delhi rocks. The delhi super group overlies the Aravllies and is divided into lower Rialo group, middle Alwar group and upper Ajabgarh group. Rialo group is rich in crystalline limestones, grits, schistose rocks and quartzites. The famous marble of Makrana (in Nagaur district) belongs to this group. Alwar group and Ajabgarh group consist mostly of calc-silicates, quartzites, grits and schistose rocks,

The western and north western parts of the state are covered by vast blanket of young unconsolidated deposits including the blown sand of the Thar Desert (Marushal) of western Rajasthan. The remaining area exposes vide variety of hard rocks, like metamorphic schists, quartzites, marbles and gneisses of pre-cambrian age with associated acid and basic intrusive rocks.The sedimentariesinclude the rocks of Aravalli Super group, Delhi super group, upper pre-cambrian Vindhyan Super group and of Cambrian o Jurassic Cretaceous and Tertiary ages.The south eastern extremity of the state is occupied by a pile of basaltic flows of Deccan Traps of cretaceous age. Several mineral deposits of economic importance occur in association with the above rock units.

The other important lithological formations consist of a thick series of sedimentary rocks comprising sandstone, limestone and shales. The deposition of these rocks in western Rajasthan was preceded by igneous activity, designated as Erinpura granite and Malani igneous suit, which included a thick pile of lava, mostly of an acidic nature. The plutonic equivalent of these lava are seen in the form of granite batholiths and sills in Jalore, Siwana, Mokalsar and in Jodhpur areas.

Jurassic formations are distinctly noticeable in a vast area around Jaisalmer and some of the fossils of this age are found in these rocks. The out crops of these rocks are, partly covered by wind blown desert sands. Of special interest are the Bap (Jodhpur district) and Pokhran (Jaisalmer district) beds of upper Carboniferous age, which have now been exploited for ground water. During Eocene times, marine transgression seems to have inundated a large part of western Rajasthan with the deposition of thick beds of fossiliferous limestone. To the north of Jaisalmer the jurassics are overlapped by nummulitic limestone.

Pleistocene sand alluvium, blown sand kankar (calcium nodules) carbonate beds and evaporite deposits of recent and sub-recent age are found over a large area of western and eastern Rajasthan. The great boundary fault , through which the river Chambal has curved its course , passes through south eastern parts of the state.This fault is visible in Begun (Chittorgarh district) and northern parts of Kota. It appears again in Sawai Madhapur and Dhaulpur districts. Besides this several mega lineaments also traverse in the state.

MINERAL DISTRIBUTION IN THE STATE

Rajasthan state is important for metallic minerals with which the name of the State is intimately associated are lead, zinc, Copper. It is also richly gifted with a variety of non-metallic minerals. The state has also enormous deposits of building stones like sandstone, marble, different varieties of granites, serpentine asbestos etc. it is a leading producer of soapstone/ steatite, gypsum, rock phosphate, calcite, feldspar, clay etc and presently the state enjoys a monopoly in the production of wollastonite, emerald, jasper and semi precious garnets. The rocks of Bhilwara, Aravalli and Delhi supergroups (Archaeans to Proterozoic age) are known repositories of basemetals and gold (Agucha, Pur-Banera, Dariba-Bethumbi, Zawar, Kayar-Ghugra, Alwar, Khetri, Jagpura-Bhukia, Birantiya-Kalabar, Pindwara-watera, Deri ambaji belts) as well as phosphorite (jhamarkotra) gold in association with sulphides occurs in Bhukia area in the Aravalli belt and is being explored since then. Rajasthan is the only wollastonite producing state in India. The extensive deposit is located near Khera-Uparia in paliSirohi districts with in Erinpura Granite massive . Significant deposit is also found in Belka Pahar near Khila in Sirohi district. Large deposits have been located in Gola-Alipura area in Ajmer district. Well known occurrences of Tungston at Degana and Balda which are related to the late Proterozoic to early Palaeozoic anorogenic malani magmatism.

Tungsten mineralization syntectonic with the Delhi Orogeny have been identified in central rajasthan. The total resources of different types of tungsten ore as estimated are of the order of 3550 tonnes of 65% WO3 grade. The china clay is found to occur in Bhilwara, Bundi, Chittorgarh, Jaipur, Jhalawar, Sawai Madhopur, sikar, pali and Nagaur districts while ball clay occurs in Alwar, Bikaner and Bundi districts.

Recently GSI has reported 22km long copper belt extending through Mina ka Nangal, patan, Dokan, BaniwalakiDhani, Dariba and Toda (nimka Thana-Patan belt) along the western flank of the Alwar- Jaipur basin of the North Delhi fold belt. Also, copper-gold mineralization is reported from the archaean basement complex at DhaniBasri area in the Todi ka bas area with in the Raialos in the North Delhi fold belt. Besides, a 20km long copper belt (Nim-ka-thana belt0 starting from Nimod in the south to Mina ka nangal in the North and further extending uptogangutana in Haryana. With the total ore reserves estimated about 85.26million tonnes containing an average grade of 0.3% Cu with minor amount of silver (Ag). A substantial copper ore has been established in MundiyawasKhera area in Alwar Basin. The iron ore deposits are located mainly in Jaipur, Jhunjhunu, Bhilwara and Sikar districts and are found associated with the Delhi Super group of rocks.

Rajasthan is the prime producer of soapstone in India.Occurrences have been reported from Dagotha-Jharna and Geejgarh in Jaipur, Dausa, Gewria and Chaipura in Bhilwara and Dhaota, Dwain, kamalpura, Rajauli, Garhi, Pura and Morra in Sawai Madhopur districts whereas in Udaipur, Dungarpur and Banswara districts. Talc deposits are associated with Rakhabdev ultrabasic belt. Rajasthan amounts for about 90% of total production of gypsum in the country. Reserves of gypsum have been located mainly in Bikaner, Nagaur , Barmer, Jaisalmer, pali, hanumangarh and Ganganagar districts. The most important deposits cover about 58.31 sq km area between Bhadwasi and Dhakoria in nagaur district. The state has a large number of occurrences for small deposits of fluorite in Ajmer, Dungarpur, Jalore and Sirohi districts. Rajasthan contributes a major share in the production of rock phosphate/phosphorites in india. It occurs in diverse lithological formations ranging in age from lower Proterozoic to Tertiary. The phosphorite deposits in Udaipur and banswara districts are located within the rocks of Aravalli supergroup of lower Proterozoic age. Rajasthan is the leading producer of calcite and feldspar in the country. Occurrences of calcite have been recorded from sikar, pali, Udaipur, sirohi and Jaipur districts. Feldspar occurrences have been reported from ajmer, Bhilwara, rajasmand, tonk, Alwar, Jaipur, pali and Sikar districts.

Rajasthan has the main deposits of emerald and garnet in the country. Emeralds are available mostly in ajmer, Rajasmand and Udaipur districts. The garnet occurrences are recorded from Ajmer, Bhilwara and Tonk districts. Aquamarine is mainly recorded from Toda Raisingh and hanotia in the Tonk district. Amethyst is reported to occur near Kishangarh in ajmer district and from bidera, Girota, didwana and Choup in Jaipur district. Chrysoberyl occurs in pegmatites of ajmer, rajasmand and Bhilwara districts.
The Mesozoic and Cenozoic geological sequences are represented by sand stone, shale and limestone found in Jaisalmer. The lower Proterozoic sedimentary basins contain industrial mineral deposits including potash bearing evaporite sequence in Hanumangarh district. Minerals of evaporite sequences of Quaternary sediments are known to occur in the Thar desert.

OBSERVATIONS

The plan-1 showing major mineral zones of Rajasthan indicates that the Aravallis are extending in NE-SW direction.Since, the trend of the Aravallis are in NE-SW direction, the mineral zones are also following the same trend. If a cross section is taken from East to west of the state the clay and limestone deposits are occurring in alternate bands in the western most part of Aravallissanu limestone deposit of SMS grade occurring in Jaisalmer district whereas fire/china/ball clays are in Bikaner district followed china clay deposits of nagaur and pali districts occur. In between wherever lagoons were existing in those areas the evaporitic deposits of gypsum, selenite are there. Whereas close to western part of Aravallis-cement grade and SMS grade limestone occurs in Nagaur (Gotan), Jodhpur (Borur), Palin (Sojat, Ras babra), Ajmer (Sheopura, Kesarpura), Sirohi. The kyanite, quartz, feldspar deposits are also found in the same trend where pegmatitic intrusions were taken place. It is being confirmed by the strike and dip directions observed in the field of these districts. On the other hand eastern part of Aravallis towards south-east the iron ore and the basemetal deposits occur in the south. Since the formations have folded nature the primary clay deposits were found in the synclinal portions of the folding whereas in the anticlinal portions of the fold axis it got washed away. The south eastern part of the state is again rich inlimestone deposits eg in sawai Madhapur, Kota, Bundi and Banswara districts.

A map of Rajasthan on which some of the major mineral zones are marked and given as annexure. From the map it is clear to interpret that the Aravallis are extending in NE-SW direction and divides the Rajasthan state into twoparts which is found along Sirohi and Udaipur districts. It is seen that only on the western part far from Aravallis SMS grade limestone occurs.The mineral zones of clay, china clay, copper ore, lead zinc and cement grade limestone are marked.

If we take a cross section from north west to south east across the Aravallis first Sonu belt followed by Chamundiya, Moonva, Gotan belt further followed by Shivapura , Kesarpura(Ajmer), sirohi limestone belt occur. The grade changes from SMS to cement . The major cement plants are located along this belt. The occurrence of limestone in sawai Madhapur, Kota, Bundi, Chittorgarh and Banswara districts is mainly of Vindhyan Rocks. It is also observed in the field that near the close contact of Aravallis the quality of limestone deteriorates. It may be due to the intrusion of pegmatites/dykes/sills having more silica content in the associated rocks. This type is mostly found in Central Rajasthan ieSirohi, Pali and Ajmer districts. It is believed that the mineral siliceous earth has derived from lighter clayey siliceous matter by metamorphic process. These deposits are found in fatehgad in Jaisalmer, Shival and Barmer districts. These clayey deposits are repeated in the form of china clay, ball clay, siliceous earth etc across Aravallis. It may extend further south uptokutch in Gujarat.

About 40km west of Aravallis the intrusions of pegmatite and Erinpura granite have been noticed. The building masonary stones found in Burr (Pali), Ranakpur, Mount Abu areas might have been derived from Erinpura granite. The dolomitic limestone and marble also follows the same trend. Further north, granites and Asbestos deposits of Devgarhetc were found in the same trend. Whereas on the eastern side of Aravallisthe minerals dolomite, soapstone are found following the same trend of Aravallis. The multi basemetal deposits of Khetri, deri, Ambaji are also following the same trend of Aravallis. From this it could be inferred that basemetal deposits may extend beyond basantgarh towards south side which needs to be proved by exploratory borehole drilling. Further, it is seen from the map that on the west of Aravallis copper deposits and on the eastern part about 100km away in the same trend lead, zinc deposits are found to occur. The lead zinc deposits of Zawar group of mines, Sindeswar Khurd, Rampura-Agucha, Kayar mines are positioned in a semi circular manner on the eastern side of Aravallis following the trend of Aravallis.The shape might have changed from vertical to arcuate could be due to minor tectonic disturbances subsequent to the upliftment of Aravallis. Thus at the foot hills of Aravallis on both eastern and western sides needs to be explored for these minerals as it may occur.

Though most of the minerals are following the vertical trend at few places it is tilting upto 45 degrees. The surficial deposits of siliceous earth and different types of clays are also following the same trend. The clay deposits are occurring along the saraswati river in the north south direction while the limestone deposits of Sojat, Bhilwara, Gotan, Boranda, Mundwe are also following the same vertical trend. Further, it is noticed that the shape of the Aravallimountains in the central part is bulging and on the sides it is pinching . the pegmatitic intrusions with in the Aravallis have given rise many minerals. However, it is noticed that the quality/ grade of the minerals in the central part of Aravallis is high and in the sides it is low quality with siliceous mix.

CONCLUSIONS

The mineral deposits of Rajasthan are following the same trend of Aravallis. However, in few places it is observed minor disturbances upto 45 degrees from the vertical.hence, search for new mineral deposits should be parallel to Aravallis in the same strike direction from the established deposits.the exploration front continues to be in slow pace particularly in the small mines. It has been further observed that in many of the mining lease areas the exploration work that still remains to be done by the lease holders. Since the continuity of occurrence of these deposits have not been proved at many places it requires exploration at district level and to be correlated.

So, the gaps in exploration for search of new areas of mineral deposits may be parallel to the strike direction of Aravallisonly.the trend is being confirmed with the strike and dip directions observed in the working mines.In this direction Govt of India has issued directives to gear up the exploration activities in the country. Acknowledgement: The author is thankful to the Vice-chancellor, SRM University, Registrar and Pro-vice chancellor of SRM University, Andhra Pradesh for their guidance and encouragement in publishing this paper.

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Climate and Hydrological Variability Trends in the Mahakali River Basin

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ABSTRACT

The Mahakali River basin is a transboundary river between India and Nepal that exhibits complex fluvial geomorphology and climatic variability. This study applies theoretical concepts to analyze river behaviour and its response to climate, tectonics, human interventions, and mining practices. The study finds that the river runoff is mainly driven by the monsoon, but is also influenced by snowmelt during winter. The basin has witnessed anomalous trends in temperature, precipitation, and runoff, indicating a higher frequency of extreme events. The study also assesses the morphometric indices of the basin, which reveal the susceptibility of different sub-basins to erosion and slope failures. The study identifies the Lower Kali Basin as the most vulnerable to tectonic and anthropogenic impacts, especially due to the proposed multipurpose dam and the ongoing road development projects. The study also evaluates the environmental and social impacts of mining in the basin, which can cause soil erosion, sinkholes, biodiversity loss, water contamination, carbon emissions, social conflicts, and cultural degradation. The study also highlights the challenges of developing hydrological models in the Himalayan region due to the lack of in-situ data and the uncertainty of satellite-based products. The study provides a holistic view of the landscape morphology and the processes involved in sculpting it, and also a window to be alert during the monsoon season along this Lesser Himalayan valley. The study recommends environmentally sustainable and socially responsible mining practices that respect the rights and interests of the local communities and the transboundary cooperation between India and Nepal.

***Key words:* Mahakali River basin, morphometric controls, climate inconsistency, hydrological variabilities**

INTRODUCTION

Climate variability and hydrological trends are important topics for understanding the impacts of climate change on water resources and ecosystems. Understanding the causes and consequences of these phenomena is essential for developing adaptation and mitigation strategies to cope with the current and future challenges of water security and sustainability. However, there are many uncertainties and complexities involved in studying the interactions between climate variability, hydrological trends, and human activities, especially at the regional and local scales. This paper aims to provide a general introduction to the topic of climate variability and hydrological trends, with a focus on the Mahakali river basin. the river is also known as the Sarda or Kali River, which is a transboundary river that originates from the high Himalayas and flows through Nepal and India. It is a mountain-fed catchment of the Ghagra sub-basin in the Ganga Flow System. The river merges with the Ghaghra River near Gaurahee (Lakhimpur Kheri district of Uttar Pradesh) after flowing through the *Terai plains* originating from the Trans Himalayan region. The river demarcates the international administrative boundary of Nepal (far Western regions) and India (Uttarakhand Kumaon division).

The aim of this research paper is to analyze the long-term (1981-2020) changes in the climate of the Mahakali River basin, which is located in a region that has experienced anomalous patterns of heavy rainfall and rising near surface temperature (up to 0.6°C in the last century). These changes have created a climatic crisis in recent decades (IPCC, 2001) that is evident in both global and basin-scale climate data. The paper also seeks to understand the relationship between the morphological and climatic features of the basin in the same period, with a special focus on the higher altitude regions that are more vulnerable to climatic variations.

STUDY AREA

The Mahakali river basin covers an area of more than 15,000

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km^2, of which almost 65% lies in India and the rest in Nepal (Pandey et al. 2019). The climate of the Mahakali River basin is influenced by the monsoon system, which brings about 70% of the annual precipitation from the south-western monsoonal precipitation (Panda et al. 2013). The complex and dynamic system of the Mahakali River basin marks it as a hotspot of transboundary cooperation and conflict, as the river is shared by two countries, which have different interests and perspectives on its management and development. The basin faces multiple challenges and opportunities, such as climate change, water scarcity, hydropower generation, biodiversity conservation, disaster risk reduction, and socio-economic development, which require scientific evidence and policy dialogue to address them effectively. The basin covers four districts of far Western Nepal (Baitadi, Dadheldhura, Kanchanpur and Darchula districts) and six districts of Indian Kumaun Himalayas (Pitthoragarh, Champawat, Bageshwar, Almora and Udham Singh Nagar). The Lipulekh and Limpayadhura pass also lies in the Mahakali River Basin and marks an important border with Tibet (Trust, 2017). The river originates near Kalapani (at an altitude of 3,600 m), Pithoragarh district from the Uttarakhand Himalayas and flows through narrow gorges passing through Garbyang, Tawaghat and Dharchula in the upper reaches, which becomes wider after Brahmadev Mandi near Tanakpur at the entry point of Terai Plains (Midha and Mathur 2013). The Darma, Gauri Ganga, Chimilia, Sarju, Lodhiya and Ramgun rivers join the trunk river at Tawaghat, Jaulgibi, Gurans Himal, Jhulaghat and Jogbudha Valley respectively.

The basin can be divided into four physiographic divisions, Higher Himalayan Zone, Lesser Himalayan Zone, Shivalik and Terai plains. The basin also experiences considerable spatial and temporal variability in rainfall and temperature, due to the complex topography and elevation gradient. The basin has a range of climatic zones, from alpine to subtropical, and hosts various types of ecosystems, such as forests, grasslands, wetlands, and agricultural lands. The climate of the basin is also projected to change in the future, with possible impacts on the water resources, biodiversity, and livelihoods of the people. The Higher Himalayan region of the basin is mostly snow-covered with steep barren slopes, while the Lesser Himalayan gentle slopes have dense vegetation cover over, which is more or less continuous in the Siwalik region. The *Tarai Plains* are composed of Himalayan sediments and are known for their dense Sal Forests and grassland around seasonal swamps. The dendritic drainage pattern at the upper reaches of the basin mark deep eroded Tethys Sedimentary Sequence (TSS) and the Higher Himalayan Crystallines (HHC). Linear drainage patterns at places along the Lesser Himalayan metasedimentary (LHS), the Siwaliks, and the alluvial plains show erosional incompetence along the region. The molassic sediments derived from the erosion of the Himalayas are known as the Muree and Siwalik formations. These formations are internally folded and imbricated. The sub-Himalaya is thrust along the Main Frontal thrust (MFT) over the Quaternary alluvium deposit which signifies its active movement of Himalaya. This area has stream bed deposits and alluvium of Holocene age. Siwalik group consists of sandstone, shale and claystone of Pliocene and Pleistocene age. Murree formations have sandstone, shale and claystone (Manandhar et al., 2012).

Gori Ganga and Dhauli Ganga valleys show a variety of rocks like gneisses, migmatites, psammitic, quartzite, marble, mica schist and amphibolite exists. A north-north easterly dipping major tectonic plane in Kumaon region termed as Main Central Thrust is the northern tectonic limit of sedimentation of the Garhwal group with the Central Crystalline (Trust, 2017). Saryu and Ladhiya valley have sequence of Garhwal group comprises Shale, Slate, Phyllite, quartzite, dolomite, limestone, magnesite, occasional calc slate and metavolcanics (Trust, 2017). The trunk river crosses through the Trans Himadri Fault (THF; likeness to the South Tibet Separation System; STDS), which isolates the limit between TSS and schistose rocks of Buddi Formation, among Garbayang and Buddi. The stream also cut across the Main Central Thrust (MCT) close Pangla and moves through the synclinal collapsed Chhiplakot nappe among Pangla and Dharchula, which speaks to a subsequent enormous (after Almora nappe) thrust sheet, which is presently disengaged from its root zone (Talukdar et al., 2020).

The northern and southern limit of Chhiplakot nappe is set apart by North Chhiplakot Thrust (NCT) and South Chhiplakot Thrust (SCT), individually. Between Dharchula and Joljibi, the Kali River courses through the metasedimentary of the Inner Lesser Himalaya (Valdiya, 1980) and streams over the Berinag Thrust (BT) zone. In the focal part, the waterway streams through the synclinally collapsed, low to medium grade transformative rocks of the Almora Nappe (AN), laying on the Lesser Himalayan metasedimentary succession. The northern limit of AN is characterized as North AlmoraThrust (NAT), and the southern limit is known as South Almora Thrust (SAT; Valdiya, 1980). The nappe zone includes the Saryu

Formation of the Almora Group, record and quartzite of the Rautgara Formation, quartzite with meta basics of the Berinag Formation, and Deoban limestone (Valdiya, 1980). Towards the lower comes to, the waterway streams over the 2 km wide zone of Ramgarh Thrust that comprises of Paleoproterozoic rocks of the Lesser Himalaya groupings. Further downstream, the Kali Waterway streams over the Fundamental Limit Thrust (MBT) zone. The steeply inclined thrust plane has brought Lesser Himalayan rocks upon the Cenozoic sedimentary territory of the External Himalaya. Nonetheless, towards the Himalayan front, the waterway streams over the Himalayan Frontal Thrust (HFT), which characterizes the southern limit of the Himalaya against the Indo Gangetic Fields of Quaternary age. The alluvial fans (Bastiya Fan) at the mouths of settled in streams getting through the raised slope front are elevated and disfigured into pressure edges and dejections adjoining the Himalayan Frontal Fault (HFF) (Valdiya, 1982)

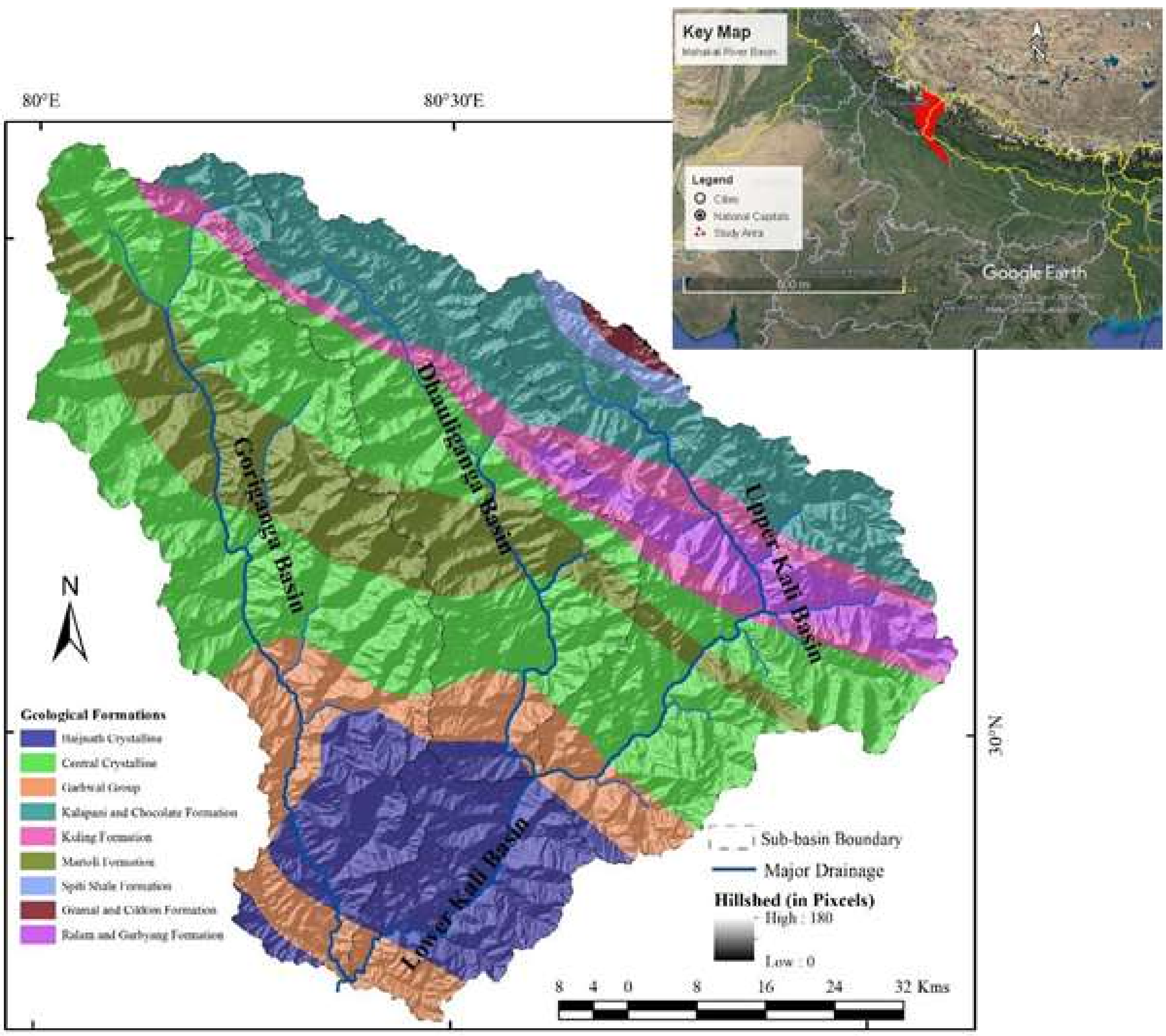


Figure 1: Geology of the the Upper Mahakali Basin

There are several contrasts can be observed in terms of geology and climate and thus in geomorphology in plane, Terai and Himalayan region. In hill ranges, Synclinal valleys play an important role, it forms due to linear stream erosion. Valley floors contain fluvioglacial outwash materials and often form erosional terraces due to entrenchment of longitudinal streams. By drainage system, the mountain ranges show a deep dissection which shows a dendritic pattern. (Trust, 2017). The silt consists of Sharda River flows downward from the Himalaya and Siwaliks into the flat Gangetic plain of Uttar Pradesh which creates a landscape known as Terai. The region is known for dense

Sal Forest, wet tall grasslands and shallow seasonal swamps. Geological structure consists of old and new alluvium. The new alluvium gets renewed every year by fresh deposits brought down by active streams. Old alluvium is found away from river courses on uplands of the plain.

Plain zone is the place where deposition process forms multiple paths with shallow beds, enabling massive floods as monsoon-swollen rivers overflow their low banks and shift channels. Many areas show erosion in the form of gullies which is highly fertile soil i.e., red, Terai and alluvial soil.

In a major part of the mountainous region which is known as Terai region, subtropical climate prevails and average temperature of this zone is 25 degrees. Rainfall varies from 1200mm to 3000mm per annum with rare cloudbursts. In monsoonal months, from June to September runoff increases which causes flooding in the area. Rivers coming from mountainous regions provide water for the settlement near the Shivalik hills and Churia hills. This region is also termed as the granary of the nation in the Nepal region. In the plain region, the weather is very hot in summer and very cold in winter having high precipitation by making this area suitable for farming with highly fertile soil. In the month from mid-April to the end of May, hot wind known as Loo prevails. The basin also experiences frequent cloudburst events too, as 90% of rainfall occurs in the monsoonal period where rainfall intensity of 350mm for consecutive 48 hours is considered as high intensity rainfall. Rainfall exceeding 70mm/hour is considered as cloudburst rainfall and it can disrupt slope and channel equilibrium at local and regional levels. (Adhikari, 2013)

METHODOLOGY

The research work incorporates the data from climate and other data available in public domain. The major resource used for the study is ECMWF (European Community for Medium-Reach Climate Estimates). The ECMWF teamed up with a few organizations to foster ERA5, a re-investigation of meteorological perceptions from January 1981 to December 2020. This dataset incorporates the environment data of a very long while related with land influencing factors. Reanalysis joins mathematical model data alongside perceptions from across the world into a total and unsurprising environment dataset. The perceptions got then can straightforwardly be utilized for future investigation of environment patterns.

The research work is mainly discussed with the topographic and the climatic datasets. The ***Topographical Data*** provides information about the surface elevation and its distribution to analyze the basin and/or drainage parameters, like drainage pattern, basin morphology, drainage control over the basin, etc. Whereas, the ***Climatic Data*** has vast directory to deliberate but only three major controlling parameters, precipitation, runoff and temperature, have been opted considering the time frame and scope of the research work.

The JAXAs Global ALOS digital elevation model (ALOS DEM) collected from the NASA Earth Data available at the public domain. The ALOS DEM is a high-resolution SAR (Synthetic Aperture Radar) data, with 32-bit pixel value are and 12.5m resolution. The basin and other basin parameters have been developed with the help of *Hydrology Tool* of Arc GIS by marking the pour point. The drainage network has been extracting from was used to calculate linear, areal and relief basin morphometric parameters. The stream network of the basin was extracted with geo-processing tool as per Strahler (1964) and Mahala (2020), i.e., where segments with no tributaries identified as a 1st order stream and when at least the two 1st order stream joins form a 2nd order stream and so on. The trunk river, Mahakali, is computed as 8th order river in the basin after merging of Gauriganga river at Jauljibi.

The climatic elements considered for the research work are ***2m Temperature, Runoff** and **Precipitation***. The datasets of these climatic elements downloaded from the Copernicus Environment Information Store under the ERA5-Land hourly information from 1981 to present accessed on ***www.cds.climate.copernicus.eu.*** The data collected in ***'netCDF format'*** among available two format options with a global coverage of January 1981 to December 2020 temporal spread. The downloaded data have hourly temporal resolution, and the information acquired in 5 years interval time frames, e.g., from 1981 to 1985 and 1986 to 1990 and so on. The following climatic elements download from Copernicus (2020):

2m Temperature: Temperature of air at 2m over the surface of land, ocean or in-land waters. The data are stored in the kelvin (K). The temperature assessed in kelvin can be changed over to degrees Celsius (°C) by subtracting it from 273.15. This parameter is calculated by interpolating between the lowest model level and the earth's surface, taking account of the atmospheric conditions.

Total Precipitation: It is collected fluid and frozen water, including precipitation and snow, that received by the earth surface. It does exclude mist, dew and precipitation that didn't landed on the surface. It is estimated in m. Accumulated liquid and frozen water, including rain and snow that falls to the Earth's surface. It is the sum of large-scale precipitation and convective precipitation. Precipitation variables do not include fog, dew or the precipitation that evaporates in the atmosphere before it lands at the surface of the Earth. This variable is accumulated from the beginning of the forecast time to the end of the forecast step. The units of precipitation are depth in meters. It is the depth the water would have if it were spread evenly over the grid box.

Total Runoff: Some water from rainfall, melting snow, or deep in the soil, stays stored in the soil. Otherwise, the water drains away, either over the surface (surface runoff), or under the ground (sub-surface runoff) and the sum of these two is simply called 'runoff'. The units of runoff are depth in meters. This variable is the total amount of water accumulated from the beginning of the forecast time to the end of the forecast step. The units of runoff are depth in meters. Runoff is a measure of the availability of water in the soil, and can be used as an indicator of drought or flood.

All the mentioned climate datasets, i.e., collected is of 40 years from 1981 to 2020 and are of 24 hours of each day in NET.CDF (Experimental Format) and thereafter of form is submitted to download and access these data.

Table 1:A brief about the properties of the data used for the research work (downloaded from ECMWF and Earth Data Search NASA)

Variables	Datasets	Availability	Resolution	
			Temporal	Spatial
Total Precipitation (in m)	ERA5 Land hourly data	1981 to 2020	Hourly	0.1°×0.1°
2M Temperature (in K)		1981 to 2020	Hourly	0.1°×0.1°
Total Runoff (in m)		1981 to 2020	Hourly	0.1°×0.1°
Elevation (in m)	SAR data	Recent	-	12.5m

DATA PROCESSING

The data collected from the source mentioned above has been processed on GIS and other platforms for analyses in order to come up with some sensible result or correlation. The fluvial geomorphology provides a holistic view of the landscapes morphology and the processes involved in sculpturing them. So, it serves as tool and effective approach for reading a landscape in a diversified river setting with variable roles of climate and tectonics and also the role of human interventions affecting them. It involves the application of theoretical concepts with the field-based investigations to interpret and analyze the river behavior. In this study Remote sensing and GIS analysis techniques are used to determine geological and morphometric properties of kali river basin that marks the eastern international border between the India and Nepal. A drainage basin reflects its geology with subsurface lithology and geomorphic processes that have operated over time and slope as indicated by various morphometric studies. Drainage morphometry was first initiated by Horton (1932). Several software packages available for analyzing drainage basin parameters in raster grids of satellite images and digital elevation models (DEMs). These extensions and algorithms are used for extraction of drainage networks Morphometric analysis used to identify specific features, process zones, and component parts of 'riverscapes' from continuous data (Wheaton et.al. 2015). Also used to understand the process and organization shaping river. The relationship between drainage morphometric parameters to its underlain geology, geomorphology and hydrological characteristics is established through the work of different geologist and geomorphologist (Strahler 1952; Chorley et al. 1985). Drainage morphometric parameters are important indicator to understand the hydrological and morphological characteristics of any region. The different morphometric characteristics like linear parameters (stream order, stream number, bifurcation ratio, strength length, mean stream length), areal or basin parameters (circularity ratio, elongation ratio, drainage density, drainage frequency) and relief parameters (dissection index, ruggedness index) are important for any river basin management (Adhikari, 2020). Drainage morphometric parameters are important indicator to understand the hydrological and morphological characteristics of any region (Burbank & Anderson, 2001; Delcaillau, Carozza, & Laville, 2006). Increasing availability of Digital Elevation Models (DEM) and geographic information system (GIS) software has helped in identifying the large-scale characterization of landscapes in response to tectonic activity (Reshmi et.al.2017). To understand the river's form, their patterns in their organization, fluvial geomorphologists have mapped the rivers and made inferences and interpretations about the processes producing and shaping of those form. These maps of the river work as row data to describing and quantifying the rivers. The morphometric analyses and field mapping present a critical template for a range of toolkits for integrative river science (Wheaton et al., 2015). This morphometric analysis ultimately used to understand the process and organization shaping river. Geomorphic maps provide a platform to interpret and quantify process relationships and their controls, to evaluate river change and adjustment potential, and to assess evolutionary trajectories (Wheaton et al., 2015). In recent decades, recurrent periods of intense flooding in the Sharda River and unpredictable changes in its channel morphology have caused huge losses to the valuable biodiversity of the forest–wetland–grass-land complex and to human property (Midha et.al. 2013).

The research work incorporates results of the basic morphometric parameters for the tectonic assessment of the area, i.e., basin perimeter, basin area, minimum height, maximum height, basin length, number of stream order, length of stream order, mean stream length, stream length ratio, bifurcation ratio, mean bifurcation ratio, drainage density, stream frequency, ruggedness number, length of overland flow, basin relief, relief ratio, relative relief, texture ratio, form factor, circulatory ratio, elongation ratio, time of concentration has been calculated to study the morphology and to check the susceptibility of Mahakali basin as per methods suggested by Horton (1932 and 1945), Schumm (1956 and 1963), Strahler (1964), Ozdemir and Bird (2009) and Hardely and Schumm (1961).

Climatic data sets downloaded in the NETCDF format processed to bring it in Text format. This led to Grid analysis and Display System. Climate Data Operator used command for the processing of climate data using a set of commands. Finally, the output file of yearmean and ymonmean file is converted into graphical form by using GrADS software. After taking the data into excel, we add this XY data of climatic parameters on ArcGIS software and then exporting it as a layer file and thereafter interpolating the data with the shape file of our basin using IDW tool, we get all the three climatic parameters in map form to analyze the variation within a year and within a month of all 40 years.

RESULTS

The study revel that remotely sensed data (ASTER-DEM) and GIS based approaches in evaluation of drainage morphometric parameters and their influences on landforms. The drainage pattern of the study area is demarcated by., trellis, dendritic, and radial to dendritic patterns, the highest order is seventh order. The drainage (<1) density reveals that the soil of the area is having moderate to coarse texture with permeable in nature. The bifurcation ratio indicates that some region drainage patterns are structurally and lithological controlled and some areas are not. The relative ratio and basin relief indicates high basin relief, high gravity of water flow, and erosion rate. The overall shape of basin is elongated to semicircular in shape interpreted on the basis of form factor, elongation ratio and circulatory ratio.

The area is studied with the help of linear, areal and relief morphometric parameters. The parameters discussed in the methodology have been calculated for each of four sub-basins. The area has streams up to 8^{th} order with moderate stream frequency (0.3 meter). The results show low drainage density in the western (Upper and Lower Kali River) catchments to moderately high drainage density in the eastern region. The relief parameters have low values for eastern catchments and high in the western catchments. The elongation ration is highest for the lower Kali River Basin. Low form factor of the basin (0.30 to 0.45) indicating high susceptibility to erosion. Very low values of time of concentration indicating controls of relief paraments over the region. The Gauriganga catchment is covering largest area while lower Kali River catchment is smallest. Upper Kali catchment is covering lesser area than Dhauliganga catchment but higher in length.

The plotted climate element data of 40 years (1981 to 2020) with five-year intervals represents the dominant factor governing the basin provides us the prevailing condition over the basins for prolonged period of time. The analysis is made on the basis of average annual spatial pattern and average monthly spatial pattern of a parameter along the basin. The anomaly maps also have been prepared to check the recent changes in the spatial pattern as compare to the oldest available data.

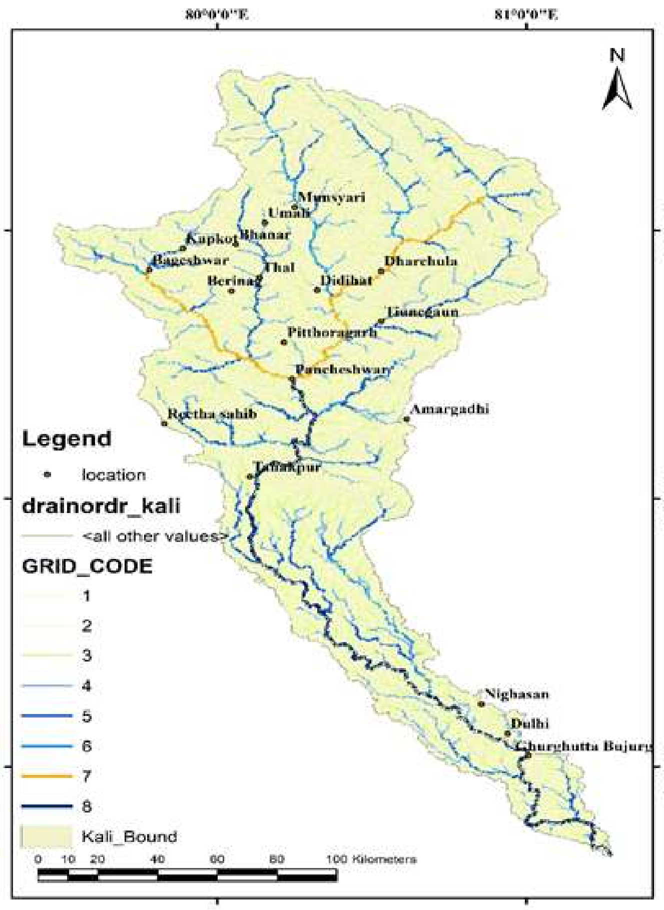
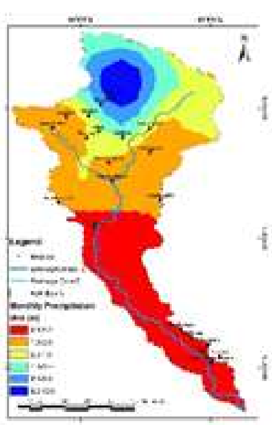


Figure 2: Drainage map of the basin

The precipitation over the basin has a usual pattern with less rainfall in the southern planes (i.e., *Tarai* area after Tanakpur) and less snow fall in the northern most mountains (i.e., north of Higher Himalayas). The Panchewar and Darma valleys are receiving high rainfall in the basin (Figure 3). The anomaly map (Figure 6c and 7c) of the area shows a declining pattern of precipitation along Darma valley and the Nepal Lesser Himalayan region around Darchula district. Whereas, the Higher Himalayan mountains and the Pancheswar valley shows an increase in the precipitation during 40 years.

The monthly average rainfall of the basin shows high precipitation along Darma valley during pre-monsoon and winter monsoon but along Pancheswar valley during monsoonal precipitation. The situation led to high risk of flooding during monsoon at the lower elevations. The situation can be worsened during August, when the both the Darma and Panchewar valley gets high precipitation. The runoff along the basin has trends similar to precipitation, i.e., higher runoff values around Pancheswar valley and in the vicinity of Lesser Himalayan mountains. The runoff values are decreasing southward and become almost constant after foothills. The runoff anomaly map of the basin shows an increase in the runoff values north of Lesser Himalayas and decrease along the Darma valley, but interestingly the value of runoff become high near the confluence with Ghaghra river.

The scenario depicts a lesser contribution of water from the Mahalkali river as compare to the major river in the recent years. Constantly increasing trend of temperature from north to south is depicted by the near surface air temperature along the basin.



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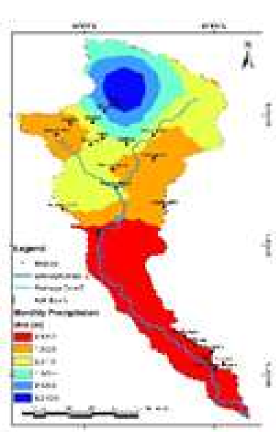

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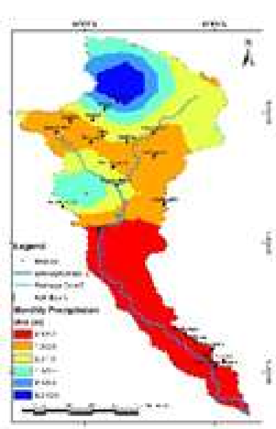

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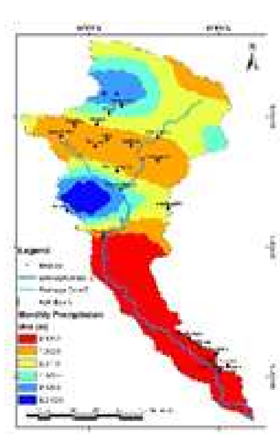

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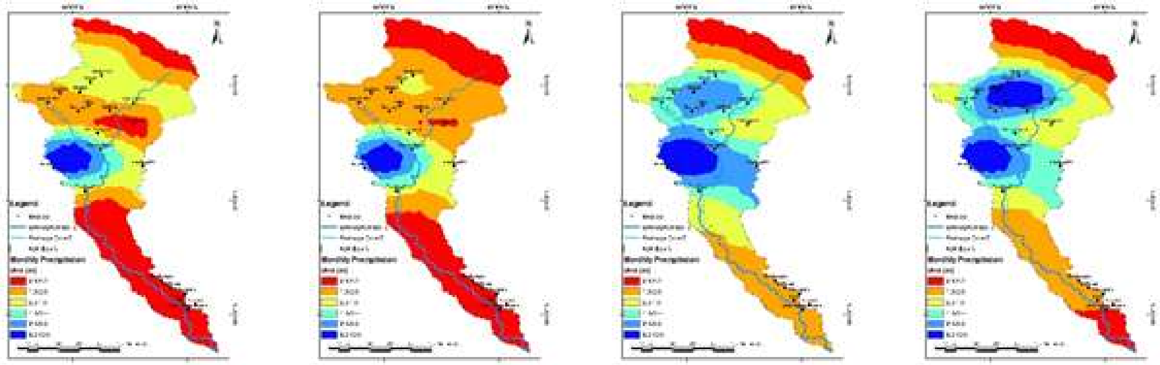

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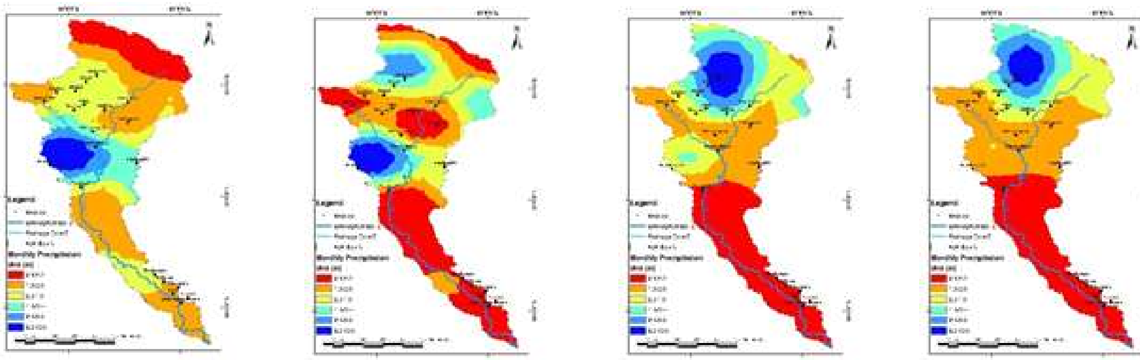
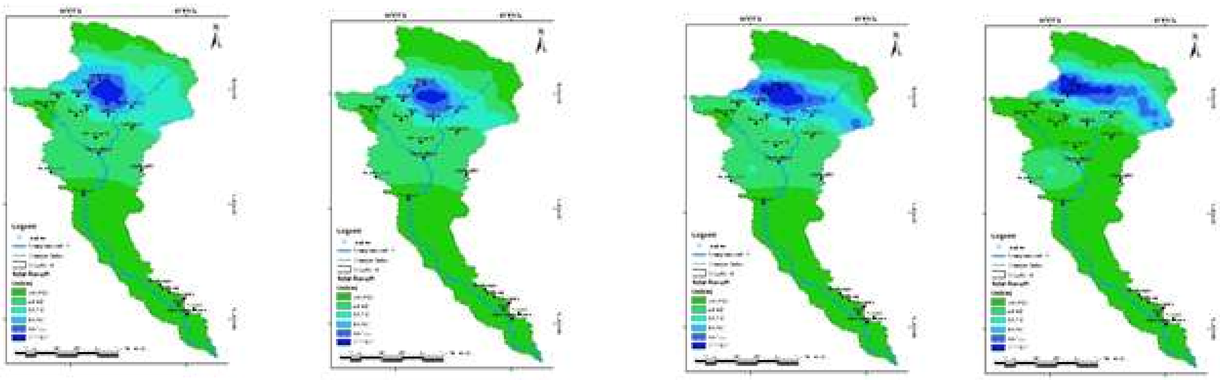


September October November December

Figure 3: Average Monthly Precipitation Pattern



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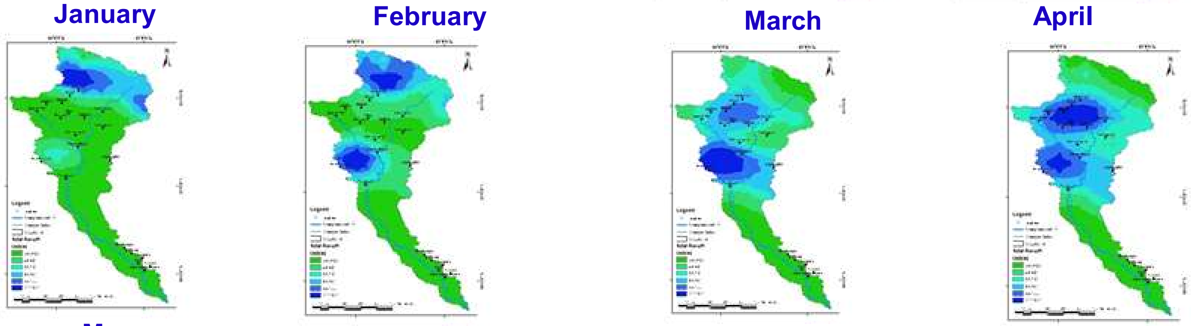

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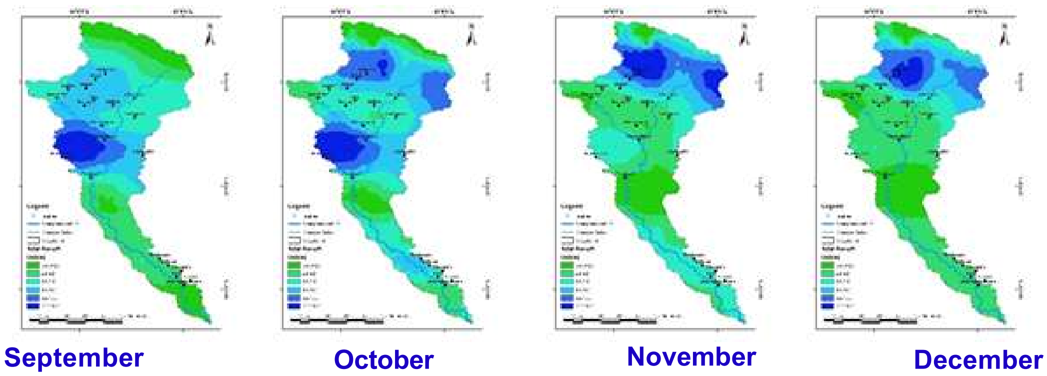


Figure 4: Average Monthly Runoff Pattern

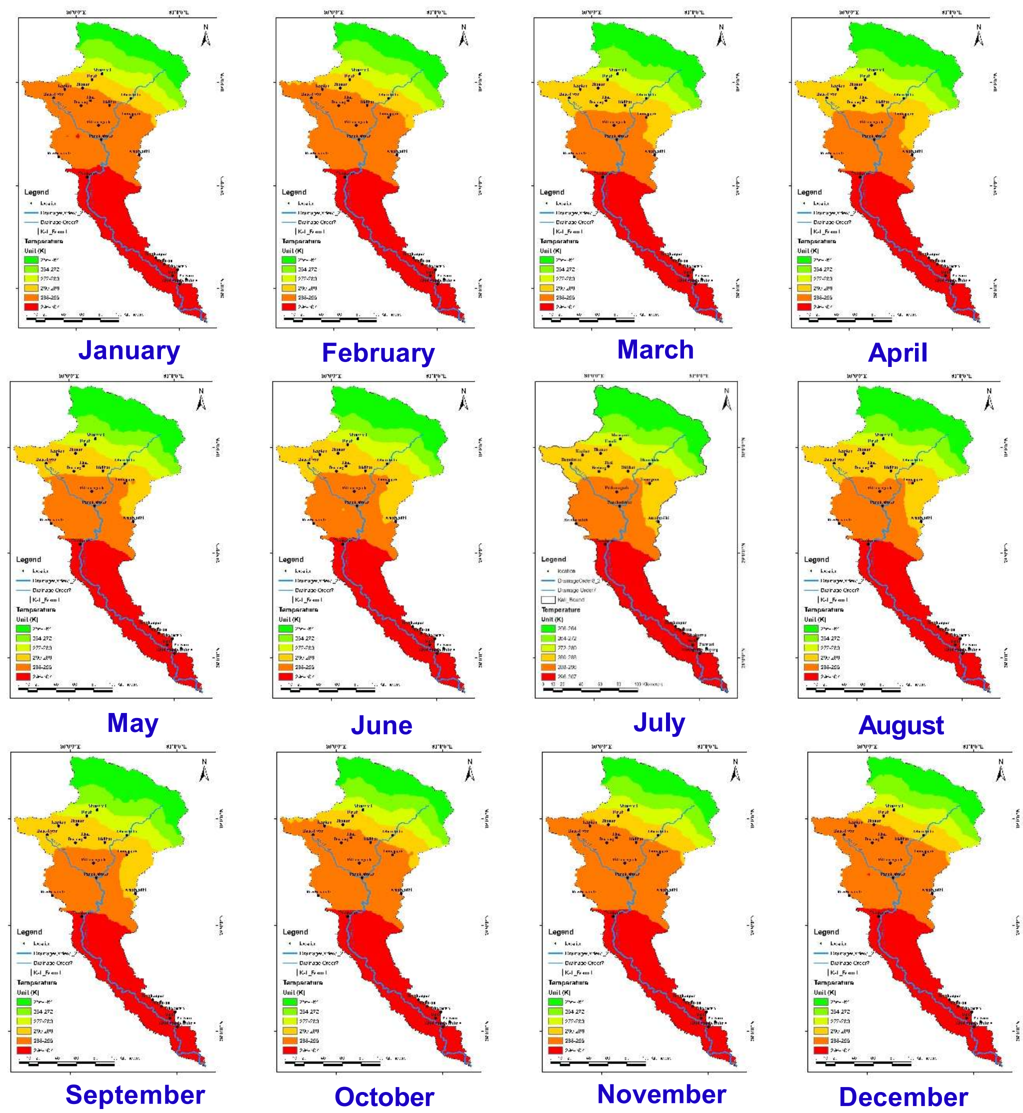


Figure 5: Average Monthly Temprature Pattern

RESULTS AND ANALYSIS

The analysis of precipitation anomalies within the basin provides valuable insights into the changing rainfall patterns over the past four decades, particularly with regard to the influence of anthropogenic activities such as tourism development and their subsequent impact on regional climate dynamics. The identification of spatial distribution patterns of precipitation anomalies across the basin serves as a fundamental aspect of climate research. By employing grid-wise analysis techniques, researchers can discern localized variations in precipitation trends, which are crucial for understanding regional climate shifts and their implications.

The mention of the middle part of the basin, where significant land use changes have occurred due to tourism development in towns like Pithoragarh, Dharchula, and Munsiari, underscores the role of human activities in shaping local climate conditions. Research in this area may delve deeper into the specific mechanisms through which land use changes, such as urbanization and deforestation associated with tourism, contribute to altering temperature and precipitation patterns. The observed moderate temperature anomaly in the middle part of the basin implies potential impacts on atmospheric moisture dynamics, a key determinant of precipitation. Research exploring the complex interactions between temperature, atmospheric moisture content, and rainfall patterns in tourism-affected regions can provide valuable insights into the mechanisms driving changes in precipitation regimes.

The finding of increased rainfall intensity in the lower and upper reaches of the basin, juxtaposed with the stability in precipitation levels in the central part, highlights the spatial heterogeneity of climate change impacts within the basin. This underscores the importance of localized climate studies in accurately assessing regional climate vulnerabilities and formulating targeted adaptation strategies. Moreover, the implications of these findings extend beyond academic research to practical considerations such as water resource management and climate change adaptation. Understanding how precipitation patterns are evolving within the basin is essential for devising effective strategies to mitigate water-related risks and adapt to changing hydrological conditions, particularly in areas experiencing positive trends in rainfall. The runoff pattern map of the basin reveals a remarkable correspondence with the rainfall pattern in the last four decades. However, a striking anomaly is detected in the middle of the basin, where the runoff remains normal despite the evident change in the landuse pattern near Pithoragarh and Dharchula. On the other hand, the runoff has increased slightly in the lower reaches of the basin, i.e., near the confluence of the river, in the last 40 years. This could be attributed to the enhanced rainfall in this region, as well as the increased surface runoff due to urbanization and deforestation. The most significant change in runoff is observed in the higher altitudes, which are predominantly glaciated or snow-covered areas. This indicates a higher degree of anthropogenic influence in the region, such as greenhouse gas emissions, black carbon deposition, and tourism activities. These factors could have accelerated the melting of glaciers and snow, resulting in increased runoff in the high-altitude streams. Interestingly, the anomaly is very low in the center of the basin, which typically receives the highest precipitation in the basin. This suggests that the natural factors, such as topography, soil, and vegetation, have a dominant role in regulating the runoff in this region. In conclusion, it can be inferred that the areas of low precipitation have experienced higher runoff in the last 40 years, while the areas of high precipitation have maintained their runoff pattern. This could be a sign of higher melting rates along the higher altitudes, which could have serious implications for the water resources and the ecosystem of the basin.

The runoff pattern map of the basin shows a strong correlation with the rainfall pattern over the past four decades. However, an anomaly is observed in the middle of the basin, where the runoff is unaffected by the apparent landuse change near Pithoragarh and Dharchula. Conversely, the runoff has slightly increased in the lower basin, near the river confluence, in the same period. This may be due to the higher rainfall in this area, as well as the enhanced surface runoff caused by urbanization and deforestation. The most notable change in runoff occurs in the higher altitudes, which are mainly glaciated or snow-covered areas. This implies a greater impact of human activities in the region, such as greenhouse gas emissions, black carbon deposition, and tourism activities. These factors may have hastened the melting of glaciers and snow, leading to increased runoff in the high-altitude streams. Interestingly, the anomaly is minimal in the center of the basin, which usually receives the highest precipitation in the basin. This indicates that the natural factors, such as topography, soil, and vegetation, play a major role in controlling the runoff in this region. Therefore, it can be concluded that the low-precipitation areas have witnessed higher runoff in the past 40 years, while the high-precipitation areas have preserved their runoff pattern. This could be a sign of higher melting rates along the higher altitudes, which could have severe consequences for the water resources and the ecosystem of the basin.

A significant change in the temperature is detected after the foothills or Tarai region compared to the nearby Shiwalik mountains. The average monthly temperature follows the same trend as the annual average temperature, except for the variation in values during winters. This consistent pattern of the temperature along the basin suggests that the atmospheric changes are driven by the monsoonal wind pattern along the Himalayas, rather than the surface temperature.

CONCLUSIONS

In the intricate tapestry of the country's hydrological systems, the Mahakali River basin emerges as a crucial thread, weaving together the destinies of two burgeoning nations, India and Nepal. However, this lifeline is currently navigating the turbulent waters of frequent hydrological variations, a phenomenon that has become increasingly pronounced in recent decades. Through a meticulous analysis employing various methodologies, the study has illuminated the intricate interactions among climatic, hydrological, tectonic, and geomorphic factors shaping the basin's characteristics. The study embarked on a journey to explore the ebb and flow of major climatic elements within this hydrologically sensitive river basin. The findings paint a picture of a river whose lifeblood is the monsoon, yet it also receives a generous bounty of water during the winter monsoonal period.

The observed alterations in temperature, precipitation, and runoff patterns underscore the heightened variability and uncertainty experienced within the basin. However, the winter monsoon, with its primary offering of snowfall, contributes minimally to the river's runoff, serving instead as a reservoir for the dry seasons. A closer examination of the climatic elements reveals a pattern of anomalies during the periods of 1986-90, 2001-05, and 2016-20. These irregularities signal an increase in the frequency of extreme events in the region, casting a shadow of uncertainty over the future.

This study examines the precipitation anomalies in the basin and their implications for regional climate change over the last 40 years. It analyzes the spatial distribution of precipitation anomalies using grid-wise techniques and reveals the influence of tourism development on rainfall patterns. The study also identifies the towns in the middle part of the basin that have undergone significant land use changes due to tourism and discusses how these changes may affect temperature and precipitation. It suggests further research on the causal mechanisms linking tourism-related land use changes, such as urbanization and deforestation, with climate variability.

The study also investigates the temperature anomaly in the middle part of the basin and its possible effects on atmospheric moisture, a critical factor for precipitation. It explores the complex interplay between temperature, moisture, and rainfall in the tourism-affected areas and elucidates the processes that shape the precipitation regimes. The study compares the rainfall intensity in the lower and upper parts of the basin with the stable precipitation levels in the central part and illustrates the spatial heterogeneity of climate change impacts within the basin.

The study emphasizes the importance of localized climate studies for assessing regional climate vulnerabilities and developing tailored adaptation strategies. It also highlights the practical relevance of the findings for water resource management and climate change adaptation, as understanding the changing precipitation patterns is essential for designing effective measures to cope with water-related challenges and adapt to the altered hydrological conditions, especially in the areas with positive rainfall trends.

Furthermore, the morphometric analysis with delineation of various morphometric indices, such as basin perimeter, area, relief ratio, and drainage density, has revealed the basin's structural control and erosion potential. In light of these findings, the study proposes several recommendations to enhance the resilience and sustainability of the Mahakali River basin. Integrated flood management systems, sediment management plans, and river restoration initiatives are identified as crucial measures to mitigate hydrological risks and improve ecosystem health within the basin. The study also acknowledges the presence of limitations and gaps in the existing knowledge and data, emphasizing the need for further research to address these shortcomings. Moving forward, it is imperative for stakeholders to adopt a holistic and interdisciplinary approach in managing the Mahakali River basin. Transboundary cooperation and coordination among relevant actors are essential to ensure the effective implementation of management strategies and the equitable distribution of resources.

The study concluded that the Mahakali River basin is a complex and dynamic system that requires a holistic and interdisciplinary approach to understand and manage its resources and challenges.

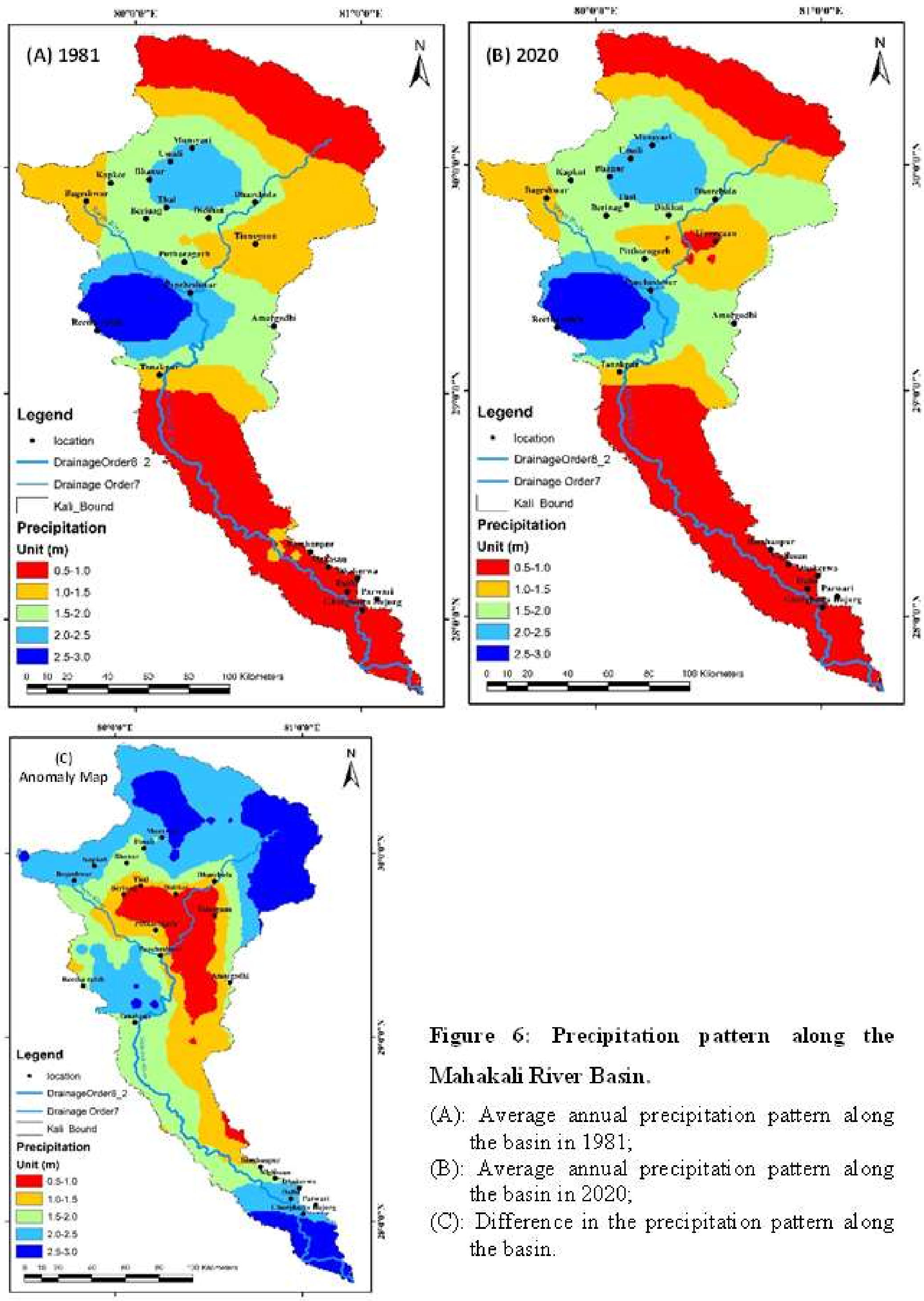
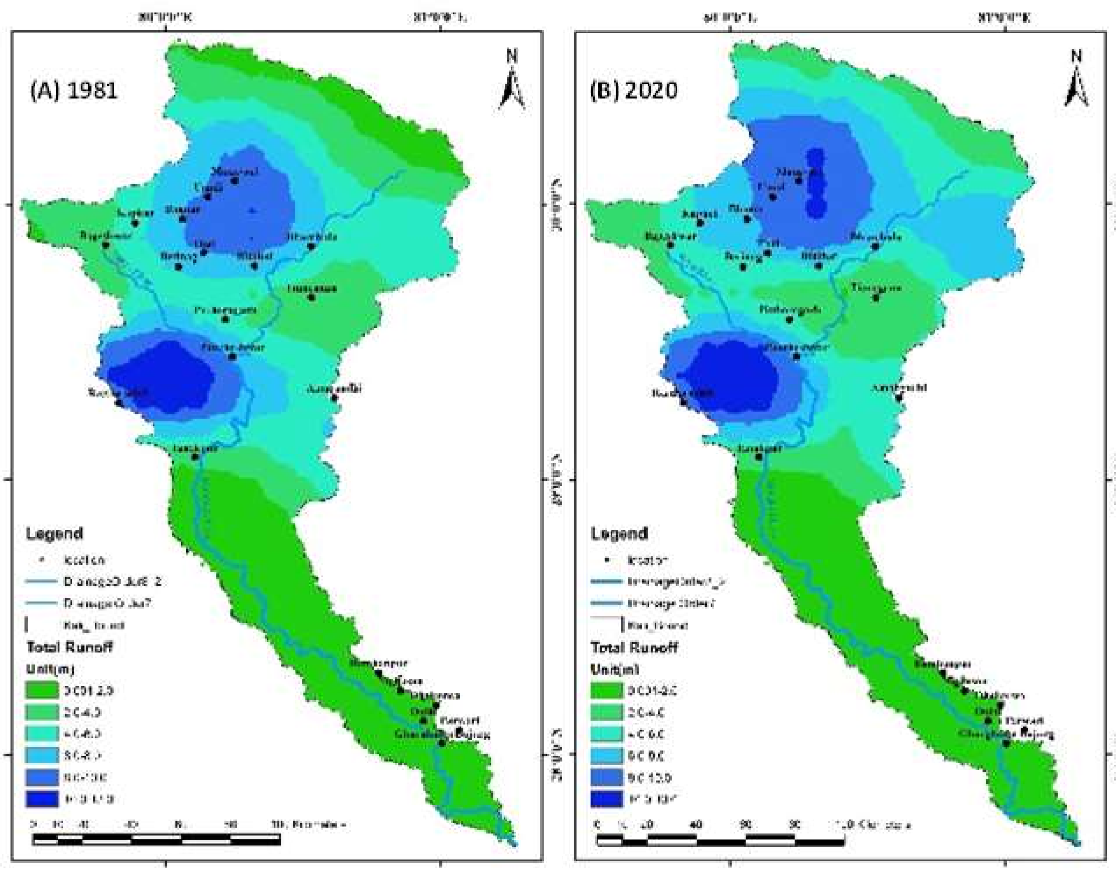


Figure 6: Precipitation pattern along the Mahakali River Basin.

(A): Average annual precipitation pattern along the basin in 1981;

(B): Average annual precipitation pattern along the basin in 2020;

(C): Difference in the precipitation pattern along the basin.



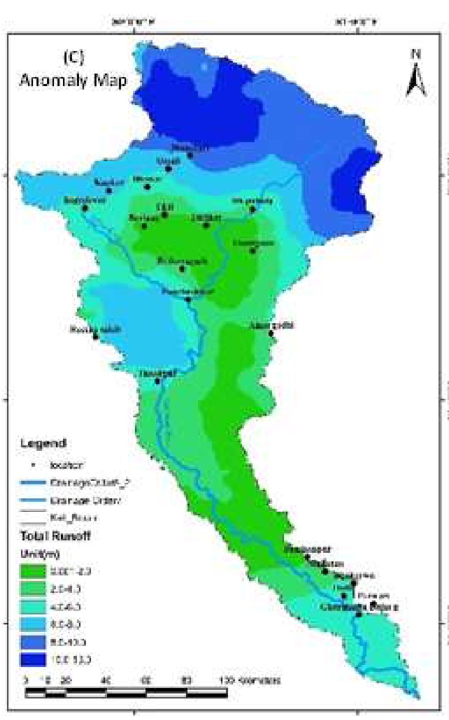


Figure 7: Spatial distribution of Runoff over the Mahakali River Basin.

(A): Average annual runoff along the basin in 1981;
(B): Average annual runoff along the basin in 2020;
(C): Difference in the runoff distribution along the basin.

The runoff pattern map of the basin reveals a remarkable correspondence with the rainfall pattern in the last four decades. However, a striking anomaly is detected in the middle of the basin, where the runoff remains normal despite the evident change in the landuse pattern near Pithoragarh and Dharchula. On the other hand, the runoff has increased slightly in the lower reaches of the basin, i.e., near the confluence of the river, in the last 40 years. This could be attributed to the enhanced rainfall in this region, as well as the increased surface runoff due to urbanization and deforestation. The most significant change in runoff is observed in the higher altitudes, which are predominantly glaciated or snow-covered areas. This indicates a higher degree of anthropogenic influence in the region, such as greenhouse gas emissions, black carbon deposition, and tourism activities. These factors could have accelerated the melting of glaciers and snow, resulting in increased runoff in the high-altitude streams. Interestingly, the anomaly is very low in the center of the basin, which typically receives the highest precipitation in the basin. This suggests that the natural factors, such as topography, soil, and vegetation, have a dominant role in regulating the runoff in this region. In conclusion, it can be inferred that the areas of low precipitation have experienced higher runoff in the last 40 years, while the areas of high precipitation have maintained their runoff pattern. This could be a sign of higher melting rates along the higher altitudes, which could have serious implications for the water resources and the ecosystem of the basin.

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