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# Environmental Impact Assessment Of River Sand Mining Using Rapid Impact Assessment Matrix(Riam) From Bharathapuzha River, Central Kerala, India

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***Abstract:*** *Rivers play a major role in shaping the geographic, biological and cultural diversity of a region through which it drains. During the past 4-5 decades, anthropogenic activities like mining, damming, pollution, etc. have degraded these fragile ecosystems disrupting their natural dynamic equilibrium that is essential to maintain its stability as well as vitality. With the rapid development in the economy and growth in population, mining of rivers widely for river bed materials, especially sand and gravel, began to continue to meet the demand in the construction sector and gradually flourished as an industry. Sand and gravel are non-renewable resources, possibly in the human life scale. Further, indiscriminate sand mining from rivers can cause serious environmental problems, if the river being mined is erosional. So the present study is an attempt to unravel the environmental effects of sand mining from Bharathapuzha river which is located in the central Kerala*

***Key words:*** *Environmental impacts, River sand, Mining, Bharathapuzha river*

**INTRODUCTION:** Rivers have always been an integral part of human lives as a source of various resources including water and a mean of civilization of so many cities, towns and villages. However, in developing nations most of the rivers are faced with a large number of environmental problems giving rise to a wide range of health issues productivity loses, social upheavals, etc. Large quantities of sand and gravel are mined in the past few decades for building/construction purposes. Sand and gravel are predominant in the alluvial deposits - both from the floodplain / over bank areas. Mining sand and gravel from the active channel is referred to as instream mining whereas mining sand from the floodplains or old terraces adjoining the river channel is referred to as floodplain mining. Studies reveal that river sand mining is taking place several folds, higher than the natural replenishments. This in turn leads to severe damages to the natural and man- made assets associated with the rivers. In Kerala, rivers and the adjoining wetland ecosystems are fast degrading consequent to indiscriminate sand mining over the years. Many studies, stressed the imminent need for stringent efforts for regulating sand mining on an environment-friendly basis as the activity threatens the very existence of the river ecosystem. Taking a serious note on the adverse impact of river sand mining, Government of Kerala enacted the legislation 'The Kerala Protection of River Banks and Regulation of Removal of Sand Act, 2001' to protect river banks and river beds from large scale dredging of sand and protect their biophysical environment and regulate the removal of river sand. River basin has long been exploited as sources of building aggregates like sand and gravel (UNEP, 1990; Kondolf, 1997; Sunilkumar, 2002; Padmalal et al, 2003). Kitetu and Rowen (1997) classified the impacts of river sand mining broadly into two categories 1) off-site impacts and 2) on-site impacts. The off-site impacts are primarily transport related whereas the on-site impacts are generally channel related.

**GEOLOGIC SETTINGS OF THE STUDY AREA:** Bharathapuzha river, popularly known as '*Nila*', is the life line of about 110 local bodies of Palakkad, Thrissur and Malappuram districts of Kerala (Fig.1). The river has a length of about 209 km and a catchment area of about 6186 $km^2$. Out of the total catchment, about 28% of the area (i.e., 1786 $km^2$) lies in Tamil Nadu State and the remaining in Kerala. The river originates from the Anamalai Hills at an elevation of about 1964m above msl and drains through highly varied geological and geomorphological features of Tamil Nadu and Kerala States. The drainage network of the Bharathapuzha river is formed by the union of four major tributaries, namely, Chitturpuzha (also known as Kannadipuzha), Gayathripuzha, Kalpathipuzha and Thuthapuzha. The point of confluence of Chitturpuzha and Kalpathipuzha is at Parali and from there onwards the river is called the Bharathapuzha (proper). The river, in general,

exhibits a dendritic drainage pattern. Bharathapuzha river hosts many reservoirs – two of them are in Tamil Nadu (Thirumoorthy and Aliyar reservoirs) and nine in Kerala (Kanhirapuzha, Thunakadavu, Malampuzha, Walayar, Meenkara, Chulliyar, Pothundy, Parambikulam and Mangalam reservoirs). Apart from these, two major diversion schemes, (viz., Moolathara and Cheerakuzhi diversion schemes), many check dams, subsurface dykes, etc., are also built up in the river. The origin of Bharathapuzha river is closely related to the origin of Palaghat gap. Bharathapuzha river drains through highly varied geological formations composed of Archean crystallines, laterites and coastal sands and alluvium. The Archean are represented by charnockites, garnet-sillimanite-gneisses (khondalite), calc granulite and associated crystalline limestones, hornblende-biotite gneisses, granites and quartzo-feldspathic gneisses. The basic metamorphic bodies and acid intrusive are represented by pyroximite, amphibolite, dolerite, pegmatite and quartz vein. The Archean crystallines cover almost the entire basin except the linear stretch along the master channel of the Bharathapuzha river and also the region close to the river mouth .The crystallines are capped at many places by laterites. Recent to sub recent sediments include coastal sands and alluvium. These deposits near the river mouth areas are underlain by semi consolidated / friable, variegated Tertiary sandstones and claystones (Fig. 2).

**MATERIAL AND METHODS:** This study covers a spectrum of subject components falling under diverse field of environmental and socio environmental aspects of Bharathapuzha river. The required information for EIA studies has been collected using a questionnaire survey. A systematic fieldwork was carried out in the entire Bharathapuzha river basin for mapping mining locations, degraded river reaches, quantity of sand extraction and other relevant information regarding various subcomponents for applying in the EIA procedure. Standard format of Gilpin (1995) was used for the preparation of questionnaire used for field surveys. The Rapid Impact Assessment Matrix (RIAM) is based on a standard definition of the important assessment criteria, as well as the means by which semi quantitative values for each of these criteria can be collected to provide an accurate and independent score for each condition. The impact of the project activities is evaluated against the environmental components/subcomponents; and for each individual component a score is assigned, which provides a measure of the impact expected for the component (Pastakia 1998). The important assessment criteria fall in two groups: 1) Group A - criteria that are important to conditions and, 2) Group B - criteria that are of value to the situation. The values allotted to each of these groups of criteria are determined following Pastakia (1998). Rivers of Kerala are under immense pressure due to various kinds of human interventions among which indiscriminate extraction of sand and gravel is the most disastrous as this activity threatens the very existence of the river ecosystems (Kitetu and Rowan, 1997, Kondolf, 2002). The semi-quantitative Rapid Impact Assessment Matrix (RIAM) is used for assessing the environmental impacts caused by mining. The scoping components included in the RIAM were, physical or chemical, biological or ecological, social or cultural and economic or operational components.

**RESULTS AND DISCUSSIONS:**

River sand mining- Indiscriminate sand mining activities of the past few decades as well as reduction in the flow of water have imposed drastic changes in the environmental scenario of Bharathapuzha river. About 21 local bodies including the shornur And Ottapalmm municipalities of Palakkad district, 6 local bodies of Thrissur district and 11 local bodies including the Ponnani Municipality of the Malappuram District are involved in sand mining from Bharthapuzha and its tributaries (Fig.3). In addition to this, illicit sand mining activities are also recorded at many stretches of the river system. It is estimated that the 21 local bodies of the Palakkad district together extract an amount of about 734490$m^3$ of sand annually from the Bharhtapuzha river. The quantity of river sand quarried by Thrissur and Malappuram districts are 210400$m^3$ / year and 457600 $m^3$ / year respectively.

The sediment discharge data of Bharthapuzha River obtained from the river gauging stations of Central Water Commission (CWC) located at Kumbidi and Pulamanthole have been used for estimating the sand replenishment of the river (Table 1). The average annual discharge of sand moving past these gauging stations as suspension amounts to 52608 metric tones (MT) in Kumbidi and 6440 MT in Pulamanthole The daily dividend worked out as per 200 working days a year comes to about 264 MT in the downstream reaches of

Kumbidi. This means that, if one is very strict in sustainable mining an amount of 2164 MT of sand can only be mined from the river stretch downstream of Kumbidi gauging stations amounts to 2712 MT, which is several folds higher than the natural replenishments .

**ENVIRONMENTAL PROBLEMS OF SAND MINING** - Bharathapuzha river, the lifeline of Palakkad, Thrissur and Malappuram districts of Kerala is under severe stress due to various kinds of human interventions including indiscriminate sand mining The various environmental issues noticed during the field survey are salt water ingression during summer season, disposal of waste materials including those of slaughtered animals into the river channel, occurrence of vegetated or partially vegetated sand islands within river channel, extensive sand mining and wet pit mining, ponding of water due to differential scooping of sand, agricultural activities on river beds, disposal of waste materials in to the river, ponding of water due to differential scooping of sands, agricultural activities of river beds and extensive sand mining, reclamation of river bed, water scarcity in discriminate pumping / lifting of water and extensive sand mining, reclamation of river bed, collapse of river bank, water scarcity, collapse of engineering structure, slumping of riverbanks, indiscriminate pumping / lifting of water for various activities, check dam within river bed, encroachment of river bed, etc. are the major problems. Bharathapuzha river is the homeland for a rich stock of flora and fauna with a high diversity index. The study found that the biotic environment of Bharathapuzha river system decline considerably due to extensive sand mining. The fishes such *as Awaous gutam, Gara muliya* and *Glossogobius giuris* occurring in the river prefer to live in sandy substratum. Removal of excessive quantity of sand and exposure of intervening clay layers may adversely affects the breeding and spawning grounds of several aquatic animals including these important fish species. In Bharathapuzha, out of 47 fresh water species, 26 species are enlisted under threatened fresh water fishes as per the norms of IUCN (1990). The major causative factor responsible for the threat is habitat loss due to extensive sand mining, encroachment and other type of human interventions (Bijukumar, 2001). The flow regulation by means of check dams, pollution, destruction of natural pools and riverine vegetation and unscientific fishing methods are the major threat to fish fauna in the river.

Sand mining provides direct employment opportunities top about 6000 laborers in the Bharathapuzha river basin. Besides thousands of employees in the construction industry also depend indirectly on river sands. A preliminary socio economic survey in some local bodies which are involved in sand mining from the rivers of Kerala revealed that over 60% of the laborers engaged are solely dependent on sand mining and are above 35 years old. Out of the total labour force in the basin about 35% is working in the 11 local bodies of Malappuram district. The 21 local bodies of Palakkad accounts for about 45% of the labour force and the remaining are distributed in the 96 local bodies of Thrissur District.

The method of the RIAM makes it possible to carry out an analysis of the results based on individual environmental scores (ES) for each environmental component/subcomponents that are classified in ranges so that the effects can be compared to each other. The description of the components and the impact categories in the assessment process are depicted in Table 2. Table 3 summarizes the final results of the RIAM process. From the tables, it is evident that most of the impacts are in the negative end and the benefits from the activity are very limited and are mainly short-term economic gains. Considering the magnitude of the negative impacts strict measures are required to rescue the Bharathapuzha river from the uncontrolled sand mining operations that is being wide spread all along the river channel. Table 4 depicts the major observations on various environmental issues which are noticed during the field work in the entire Bharathapuzha river stretch.

**SUMMARY AND CONCLUSIONS:** Bharathapuzha river, one of the major perennial rivers of Kerala falls within 11°45'-11°55'N latitudes and 75°50'-76°15'E longitudes. The river drains through the highland, midland and lowland physiographic provinces of Kerala. The soil types encountered in the study area are lateritic soil, red sandy soil, and forest loam and reverine alluvium. Major landuse classes in the study region are agricultural land, wasteland, grassland, forest plantations and water bodies.

The study reveals that, about 21 local bodies of Palakkad district, 6 local bodies of Thrissur district and 11 local bodies including the Ponnani Municipality of the Malappuram district are involved in sand mining from Bharathapuzha and its tributaries. In addition to this, illicit sand mining activities are also recorded at many stretches of the river system. It is estimated that, the local bodies of the Palakkad district extract an amount of about 734490$m^3$ of sand annually from the Bharathapuzha river. The quantity of river sand quarried by Thrissur and Malappuram districts are 210400$m^3$ / year and 457600 $m^3$ / year respectively.

The degradation of the river is well reflected in the biotic environment of the Bahrathapuzha river. The indiscriminate mining of construction grade sand, tile and brick clays from the floodplains and limestone from the upper catchments not only disturbing the food web and natural nutrient cycles at significant levels, but drastically changing the fluvial geomorphology and scenic beauty of the unique fluvial system. Mining from upstream areas can reduce water quality for downstream users and damage aquatic life. It is a fact that sand mining poses grave environmental as well as socio-economic problems. The threat to the livelihoods of local communities from this mindless commercial activity seems to be more real now than ever before. They include the depletion of groundwater, lesser availability of water for industrial, agricultural and drinking purposes, destruction of agricultural land, loss of employment to traditional farmers, threat to livelihoods, human rights violations, and damage to infrastructure and many more. It has affected the stability of riverbanks leading to loss of productive land. From the EIA study, it is well understood that river sand mining changes the physical characteristics of the river basin, disturbs the closely linked flora and fauna, alters the local hydrology, soil structure as well as the socio-economic condition of the basin, in general.

Potential impacts, both positives and negatives, of sand mining from Bharathapuzha river were identified and evaluated by using Rapid Impact Assessment Matrix. It allows data from different sectors to be analyzed against a set of common important criteria within a common matrix, thus providing a clear evaluation of the potential impacts. The negative impacts of the activity are many folds higher (i.e. around 86%) than the marginal economic gains (14%), which in turn is of short-term nature.

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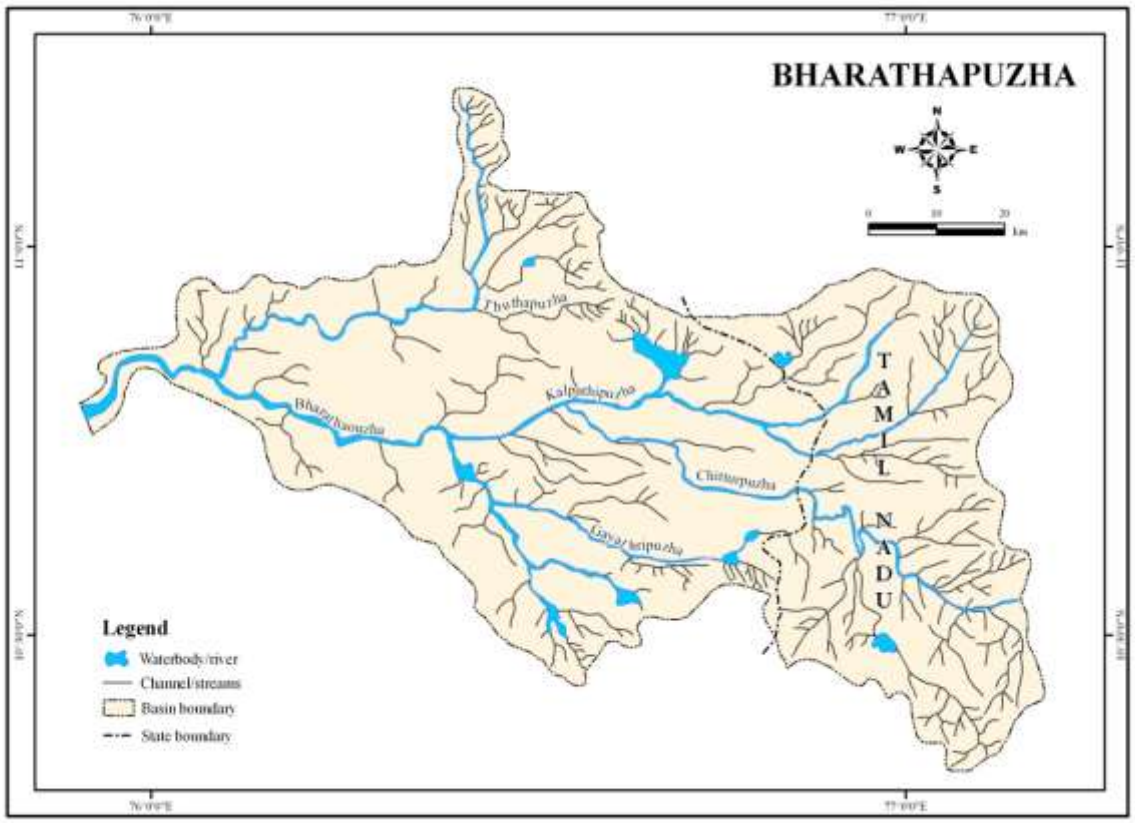

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**Fig.1 Location map of the study area**

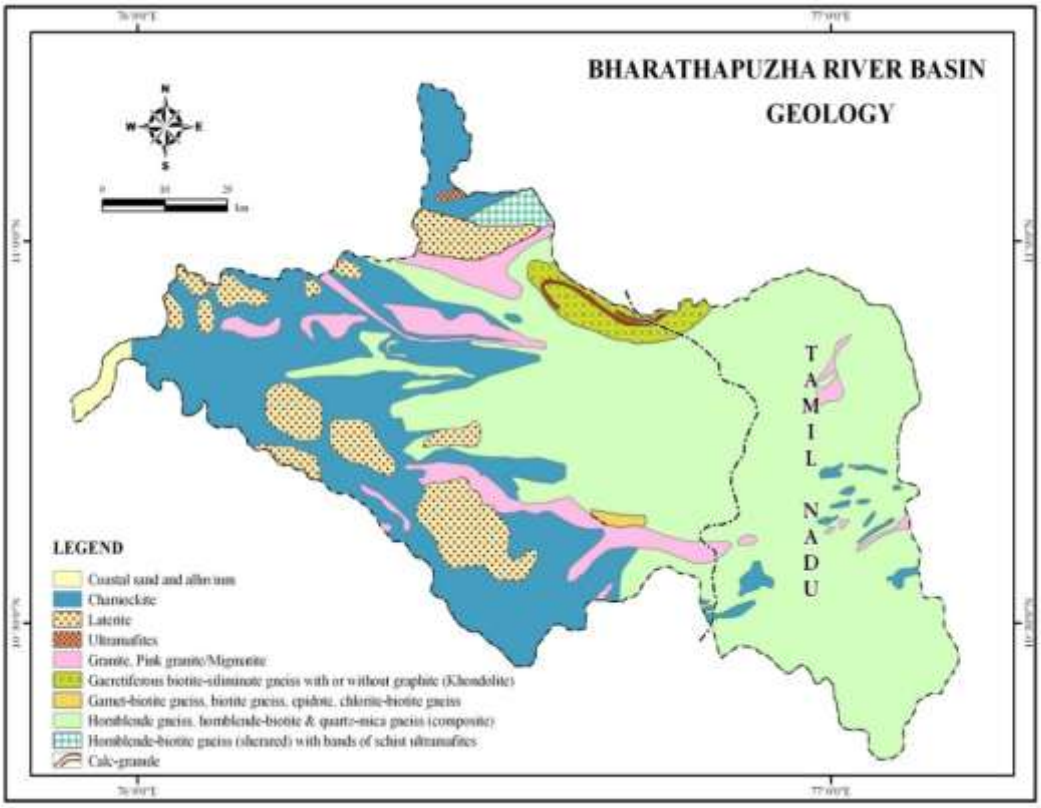


**Fig.2 Geology map of the study area**

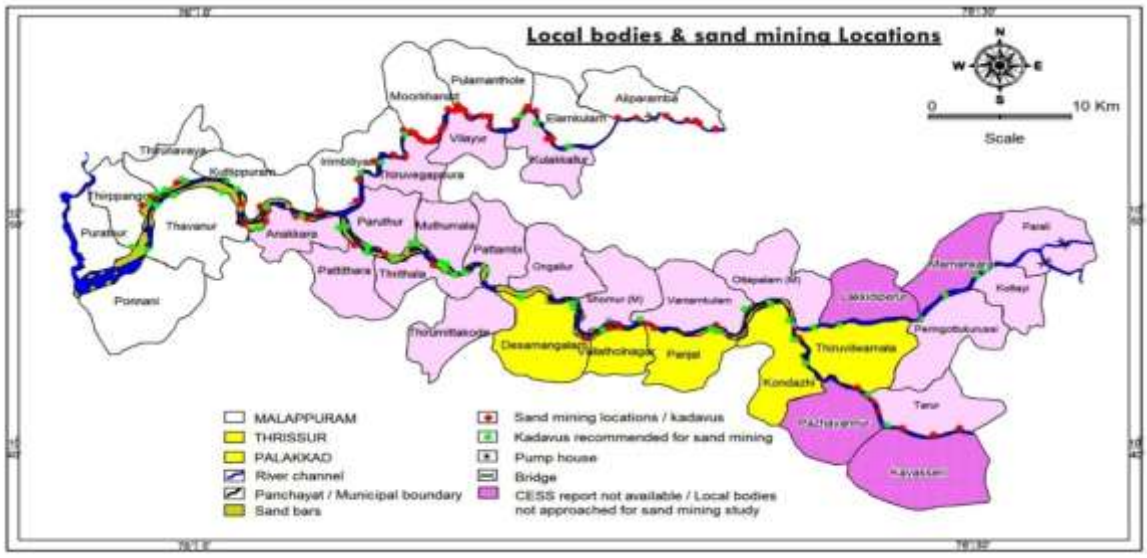


**Fig.3 Local bodies engaged in sand mining and sand mining locations**

**Table1 Discharge of sand and total sediment through Bharathapuzha**

| Year | Sand (MT) | | Total sediment | |
|---|---|---|---|---|
| | Kumbidi | Pulamanthole | Kumbidi | Pulamanthole |
| 1989/90 | 23559 | 4197 | 301431 | 108598 |
| 1990/91 | 44925 | 4709 | 272597 | 138242 |

| | | | | |
|---|---|---|---|---|
| 1991/92 | 81355 | 7462 | 575945 | 119298 |
| 1992/93 | 47198 | 6741 | 539389 | 154859 |
| 1993/94 | 39087 | 5655 | 353707 | 66693 |
| 1994/95 | 63594 | 11932 | 769037 | 194727 |
| 1995/96 | 65894 | 6866 | 370751 | 94795 |
| 1996/97 | 55253 | 3955 | 240799 | 85292 |
| Average | 52608 | 6440 | 427957 | 120313 |

**Table 2 Environmental components/subcomponents and impact categories of sand mining from Bharathapuzha river (after Pastakia, 1998)**

| Components of environment | | | Assessment criteria | | | | | ES | RV |
|---|---|---|---|---|---|---|---|---|---|
| Environmental conditions/Parameters | | Subcomponents | Group A | | Group B | | | | |
| | | | A1 | A2 | B1 | B2 | B3 | | |
| Physical & Chemical | Land/River channel | Land stability | 1 | -2 | 3 | 3 | 3 | -18 | -B |
| | | Landuse / Land cover | 1 | -2 | 2 | 2 | 3 | -14 | -B |
| | | Soil | 1 | -2 | 2 | 2 | 3 | -14 | -B |
| | | Landform | 1 | -3 | 3 | 3 | 3 | -27 | -C |
| | | River bed | 1 | -3 | 3 | 3 | 3 | -27 | -C |
| | Air | Air quality | 1 | -1 | 1 | 1 | 1 | -3 | -A |
| | | Noise level | 1 | -1 | 1 | 1 | 1 | -3 | -A |
| | Water | Ground water | 1 | -3 | 3 | 3 | 3 | -27 | -C |
| | | Surface water | 1 | -2 | 2 | 2 | 3 | -14 | -B |
| Biological & ecological | Flora | Instream flora | 1 | -2 | 2 | 2 | 3 | -14 | -B |
| | | Riparian flora | 1 | -2 | 2 | 2 | 2 | -12 | -B |
| | Fauna | Instream fauna | 1 | -2 | 2 | 2 | 2 | -12 | -B |
| | | Riparian fauna | 1 | -2 | 2 | 2 | 2 | -12 | -B |
| | Habitat | Habitat loss | 1 | -2 | 2 | 2 | 3 | -14 | -B |
| Social & cultural compo-nents | Social - health | Accidents | 1 | -1 | 1 | 1 | 1 | -3 | -A |
| | | Health impairment | 1 | -1 | 1 | 1 | 1 | -3 | -A |
| | Social - cultural | Heritage / Historical areas | 1 | -3 | 3 | 3 | 2 | -24 | -C |
| | Socio-livelihood | Sustainable livelihoods (Fishing, farming etc.) | 1 | -2 | 2 | 2 | 2 | -12 | -B |
| Economic & operational environment | Economic | Employment | 1 | 2 | 2 | 2 | 2 | 12 | B |
| | | Economic base | 1 | 2 | 2 | 2 | 2 | 12 | B |
| | | Agriculture | 1 | -2 | 3 | 3 | 3 | -18 | -B |
| | | Aesthetics | 1 | -2 | 2 | 2 | 2 | -12 | -B |
| | Operational | Approach road | 1 | -2 | 3 | 3 | 3 | -18 | -B |
| | | Engineering structure | 2 | -3 | 3 | 2 | 3 | -48 | -D |
| | | Infrastructure | 2 | 3 | 3 | 3 | 3 | 54 | D |
| | | Transportation | 2 | -3 | 3 | 3 | 3 | -54 | -D |

*ES Environmental score, RV Range value*

**Table 3 Summary of assessment of RIAM of sand mining from Bharathapuzha river after Yousefi et al, 2008**

| Sl No. | ES | Range Value | | Description | Environmental components | | | | | Final(1) | Impact total (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Alphabetic | Numeric | | PC | BE | SC | EO | Total | | |
| 1 | 72 to 108 | E | 5 | Major positive change | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 36 to 71 | D | 4 | Significant positive change | 0 | 0 | 0 | 1 | 1 | 4 | 7 |
| 3 | 19 to 35 | C | 3 | Moderate positive change | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 10 to 18 | B | 2 | Positive change | 0 | 0 | 0 | 2 | 2 | 4 | 7 |
| 5 | 1 to 9 | A | 1 | Slight positive change | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 0 | N | 0 | No change/status quo | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | -1 to –9 | -A | -1 | Slight negative change | 2 | 0 | 2 | 0 | 4 | -4 | 7 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | -10 to -18 | -B | -2 | Negative change | 4 | 5 | 1 | 3 | 13 | -26 | 45 |
| 9 | -19 to -35 | -C | -3 | Moderate negative change | 3 | 0 | 1 | 0 | 4 | -12 | 20 |
| 10 | -36 to -71 | -D | -4 | Significant negative change | 0 | 0 | 0 | 2 | 2 | -8 | 14 |
| 11 | -72 to 108 | -E | -5 | Major negative change | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

ES Environmental score, PC Physical and chemical, BE Biological and Ecological, SC Social and Cultural, EO Economic and operational. (1) Product of range values (numerical) and environmental component's total.

**Table 4 Major observations on various environmental issues of the Bharathapuzha river**

| River sector | Major observations |
|---|---|
| Ponnani- Chamravattom sector | Salt water ingression during summer season, disposal of waste materials including those of slaughtered animals into the river channel, occurrence of vegetated or partially vegetated sand islands within river channel, extensive sand mining and wet pit mining |
| Chamravattom –Thirunavaya | Ponding of water due to differential scooping of sand, occurrence of vegetated or partially vegetated sand islands within river channel, agricultural activities on river beds and extensive sand mining |
| Thirunavaya–Thuthapuzha confluence | Occurrence of vegetated or partially vegetated sand islands within river channel, disposal of waste materials in to the river, ponding of water due to differential; scooping of sands, agricultural activities of river beds and extensive sand mining |
| Thuthapuzha confluence –Thrithala | Occurrence of vegetated or partially vegetated sand islands within river channel, reclamation of river bed, water scarcity in discriminate pumping / lifting of water and extensive sand mining |
| Thrithala- Pattambi | Reclamation of river bed, collapse of river bank, water scarcity, collapse of engineering structure, agricultural activities on river beds and extensive sand mining |
| Pattambi- Karakkad | Ponding of water due to differential scooping of sands and water pollution, collapse of side walls, and other engineering structure, water scarcity in regions adjacent sand mining areas, agricultural activities on river beds disposal of waste materials including those of slaughtered animals into the river, extensive sand mining etc. are noticed |
| Karakkad –Shornur | Slumping of riverbanks, indiscriminate pumping / lifting of water for various activities and extensive sand mining |
| Shornur- Chorottur | Acute water scarcity in the adjacent areas, slumping of river banks, indiscriminate pumping of water, occurrence of vegetated or partially vegetated sand islands within river channel, extensive sand mining |
| Chorrotur- Kuthampilli | Extensive sand mining, indiscriminate pumping of water for various activities and encroachment |
| Kuthampilli – Peringottukurissi | Check dam within river bed, encroachment of river bed, pumping of water for various activities and indiscriminate sand mining |
| Peringottukurissi- Parali | Rocky riverbed, indiscriminate sand mining, vegetated sand islands within river channel and presence of check dam |