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Contents

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INDUSTRIAL PROMOTIONAL AGENCIES AND ENTREPRENEURSHIP DEVELOPMENT: A CASE STUDY OF TWO BACKWARD DISTRICTS IN TAMIL NADU

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Abstract

Healthy growth of an economy depends upon its industrial growth, which in turn depends on the entrepreneurial skills available in a society. Governments of India and Tamil Nadu have made many efforts for promoting entrepreneurship development. Many agencies came in and promoted entrepreneurship development. These agencies are collectively called as Industrial Promotional Agencies. They provide many supports for establishing and also running industrial units. In order to evaluate the effectiveness of the IPAs programmes, the required information from sample enterprises in Dharmapuri and Pudukottai were collected and analyzed. These two originally industrially backward Districts have certainly benefitted from the programmes of IPAs.

Keywords: *Entrepreneurship development, Industrial Promotional Agencies, Socio-economic profile, First Generation Entrepreneurs, Performance indicators*

Introduction

The importance of industrialisation in economic development of a region cannot be over emphasized. Almost all the developed countries are found to have achieved economic development mainly through advancement in the industrial sector. Basically all societies at earlier stages of their development have viewed industrialisation as the main vehicle for improving living standard. The pace of industrialisation predominantly depends, among other factors, on the policy backing of Government to promote industrialisation. Besides the Government policy, the socio-economic factors condition the emergence of entrepreneurship which is the most vital force in the process of industrialisation.

A few studies on the entrepreneurship development have identified the capital as the predominant determinant of the emergence of entrepreneurship. The availability of and access to capital, to a large extent, are found to be the decisive factors of the entry of entrepreneurs. This is probably one of the reasons why the industrial map of India is dominated by entrepreneurs belonging to resource-rich social strata from the resource-rich regions. Having recognized these facts, the Central and State Governments in India have

initiated several steps to attract the entrepreneurs to the backward districts and encourage potential entrepreneurs from backward region. One such step is establishment of Industrial Promotional Agencies (IPAs), which train potential entrepreneurs, provide capital and infrastructural facilities, supply raw-materials, extend incentives and concessions, and also assist in marketing finished products and thereby encourage the new entrepreneurs. In this regard, the Pande and Wanchoo working groups, which took initiatives in 1968 are worth recalling. The former group identified backward areas while the latter recommended specific fiscal and financial incentives for starting industries in backward areas.

Besides capital, appropriate training also plays a vital role for development of entrepreneurship. The importance of training has been emphasized by some studies on entrepreneurship. For instance, John A. Harris (quoted in Peter Kilby, 1971), based on his study of Nigerian experience, observes that the deficiencies in developing entrepreneurship are superficial and they can be 'remedied' over a relatively short period by providing proper education and training. Bhalla (1989) has also stressed the importance of training for potential entrepreneurs in some developing countries including India. Similar view is held by one of the famous sociologists David C. McCelland (1961) who has done considerable research on entrepreneurship development. He is of strong view that "business and government in under-developed countries can immediately promote economic development by fostering achievement oriented ways of thinking. Such ways of thinking about problems can be 'taught' in training courses. This kind of course can provide an individual with the means that will allow him to change his own motivation if he wants to do so."

Having realized the significance of training programmes in promoting entrepreneurs, the Government at the Centre and the State embarked upon various Entrepreneurship Development Programmes (EDP). The encouragements extended by the IPAs to the entrepreneurs in Tamil Nadu are of two kinds. The first one consists of training programmes, identification of viable projects, and extension of term loan facilities to entrepreneurs for acquiring fixed assets, setting up of industries in the backward areas and providing all required facilities under one roof (which, in short, may be grouped as Entrepreneurship Initiation Programme - EIP). The second category includes capital subsidies, interest free short term loans, supply of raw-materials, power subsidy, marketing support and other concessions which are provided for the successful running of the enterprises (which may be categorized as Entrepreneurship Enhancement Programmes - EEP). These two categories of programmes - EIP and EEP - can be collectively called Entrepreneurship Development Programme - EDP, as they aim at both attracting the prospective entrepreneurs to manufacturing and also supporting them to succeed in their endeavors.

For instance in Tamil Nadu, a host of Industrial Promotional Agencies has been sponsored to channelize the above mentioned facilities. Tamil Nadu Industrial Investment Corporation (TIIC), District Industries Centre (DIC), Small Industries Development Corporation (SIDCO), State Industries Promotion Corporation of Tamil Nadu (SIPCOT), Small Industries Servicing Institute (SISI) and Industrial and Technical Consultancy

Organisation of Tamil Nadu (ITCOT) are some of those agencies directly engaged in promoting industrial development. Besides, the nationalised banks and Industrial Credit and Investment Corporation of India (ICICI) also extend supports to the units.

The policies and programmes adopted by these institutions would have had some welcome effect on the pace of emergence of entrepreneurship. As the availability of funds in the capital market is made relatively easier and also cheaper (thanks to capital subsidy), it would attract resource poor section of the society and areas of the economy to make use of the new opportunities. Consequently, there may be a favourable shift in the socio-economic profile of entrepreneurship which could broaden the entrepreneurial base in a society. In other words, emergence of First Generation Entrepreneurs (FGE), who actually establish the units and whose parents or known fore-fathers were not in manufacturing (which in the strict sense of the term entrepreneurship), might be facilitated, thanks to these promotional agencies. Bharathan (1981) has observed that the concessions offered by the Government have attracted blue and white collar employees to start units with their small savings at Hosur (an erstwhile backward area). Similarly a case study of Aurangabad indicates that a good number of FGE have come up in the District especially due to the financial incentives rendered by All India State Financial Institutions. Another study at Tiruchirappalli Taluk (Thangamuthu & Iyyampillai, 1983) pinpoints the fact that when improved industrial plots are provided and market for the finished products is assured, a higher proportion of FGEs are likely to enter into manufacturing. As Sharma and Singh (1980) have pointed out, the self-employment programme for the prospective entrepreneurs undertaken by SISI has also contributed to entrepreneurship development.

Gangadhara Rao and Vasundhara Gangad (1986) have examined the social background of entrepreneurs in the industrial estates of Andhra Pradesh and found out that the entrepreneurs have come from varied origins. The above studies have discussed the positive effects of the Government efforts. However, it may be noted that the Governmental efforts have not had uniformly positive impact. For instance studies by Kashyap (1966), Kalyani Bandopadyaya (1969) and Somasekhara (1975) have brought out not-so-successful experiences of Government programmes in entrepreneurship development. Little (1987) has also observed that in many countries the measures targeted to favour small scale entrepreneurs have had only negligible positive impact. It is in this context, analysis on the role of IPAs on entrepreneurship development at various stages of enterprises is found to be very much significant and relevant.

The major objectives of the present study are: (a) to examine as to what extent the efforts of the IPAs have succeeded in the development of new entrepreneurs (FGES) and to understand the socio-economic profile of the emerging entrepreneurs; (b) to study the type of interaction between the new entrepreneurs and the IPAs and to assess the effects of such interaction; and, (c) to evaluate the entrepreneurial performance of these new entrepreneurs in terms of select indicators such as capacity utilization, market expansion, sales maximization, profit earnings and diversification and to relate these performances with the extent of facilities availed from the IPAs.

Methodology

Selection of Study Area

It is logical to look for and assess the effects of IPAs measures in a region which has received a special thrust of assistance from IPAs. In Tamil Nadu, Dharmapuri and Pudukottai have been declared as industrially backward districts and are given a special thrust by the IPAs since mid-seventies. Though these two districts are still industrially backward in comparison with other major districts in Tamil Nadu, some discernible quantitative and qualitative improvements, which could be attributed to the Government measures, are observed from the available data. These districts which had very low proportion of number of factories, fixed capital, working capital and total value added in 1975, experienced significant increase in all respects between 1975 and 1982. This shows that the development of these districts has outweighed that of other districts. Hence, these two Districts have been chosen as the study area. The reference period is 1988-1989.

Industrial Promotional Agencies

The list of IPAs considered for major part of the analysis includes DIC, ITCOT, TIIC, SIDCO, SIPCOT, SISI and the Lead Banks of those two Districts. These organizations have made special efforts to industrialize the regions. Other small organizations and voluntary agencies which also undertake some marginal steps for entrepreneurship development have not been considered.

Selection of Sample Units

The study covers only the privately owned units established by the FGEs after 1974. Joint stock companies, public and co-operative sectors have been omitted from the purview of the study. This is so because of the problems in identifying the real entrepreneurs. Secondly, the cut-off year 1974 was chosen because, (i) the efforts of the IPAs have become significant in the study districts only after 1974 and (ii) one of two study Districts viz. Pudukottai has come into existence only in 1974. Thirdly, the analysis of the emergence of FGEs is felt to be more meaningful to assess the role of IPAs on entrepreneurship development. Fourthly, the units registered with Inspector of Factories alone have been considered, for they contribute more than 60 per cent of total industrial production. Hence, first, the publicly and co-operatively owned industrial units (24 in Dharmapuri and 12 in Pudukottai Districts) were excluded from the list of units obtained from the Inspectors of Factories of respective districts. There are 241 and 177 privately owned units in Dharmapuri and Pudukottai Districts. Of the 241 units in Dharmapuri, three are run by non-first generation entrepreneurs, six are found to have been established before 1974 and 16 are found to have been closed down. Of the 177 units in Pudukottai, six are run by non-first generation entrepreneurs, three are found to have been established before 1974 and 21 are found to have been closed down. Therefore, excluding 25 and 30 units from the above respective totals, the actual size of the universe is only 216 and 147 in

those districts respectively. Out of these, a random sample of 75 and 60 units were chosen by lottery method in Dharmapuri and Pudukottai Districts respectively. However, one unit in each District furnished partial and unsatisfactory information. Hence, the analysis is confined only to 74 units in Dharmapuri and 59 units in Pudukottai Districts.

Classification of Units

For the sake of analytical convenience, the units have been grouped into 10 industrial groups. They are:

1. Food processing industries, including rice mills, oil mills, sago and starch factories, flour mills, biscuit producing units, beverages, etc.
2. Mining, quarrying and tile works
3. Textile units
4. Leather and rubber based industries
5. Wood-based industries including match works and fibre units
6. Engineering units, including structurals, fabrications and other metal based industries
7. Chemical industries
8. Paper and paper board industries, poly-text industries and printing presses
9. Electrical goods units
10. Auto repairing units

Among the industrial groups, the engineering and food processing units are more in number both in census as well as in sample.

Data Collection

In order to attain the objectives of the study, a well-structured questionnaire was prepared to collect the primary data. It contains 52 major questions and related sub-questions. These questions are given under three major heads.

1. Entrepreneurs' profile
2. Parental background of the entrepreneurs
3. Information about the industrial units

The first section of the questionnaire sought some general information about the industrial units, social, economic and educational status of the entrepreneurs, family particulars, level of technical knowledge, source of knowledge about IPAs, major facilities availed from IPAs etc.. This helps to understand socio-economic profile of the select entrepreneurs in both Districts.

The second part of the questionnaire includes parental background of the entrepreneurs, father's socio-economic conditions, political dependency, nature of employment at the time of starting the unit, socio-economic background of relatives and friends who do business in the same line both before and after establishment of the unit. This helps to know how far the parents, relatives and friends are instrumental to the entrepreneurs in different ways.

Part three seeks to bring out information on the reasons for starting the unit, capital structure, employment pattern, partnership particulars in the case of partnership organizations, source of finance, source of raw-material, channel of marketing, concessions and subsidies from IPAs etc. Further, it collects information about annual stock of the produce, net profit before and after tax, retained earnings, risk and insurance, lay-off, strikes and lockout, problems faced by the firm, plan for future expansion, future plan of the entrepreneurs for their family members.

Statistical Tools

To find out the impact of nativity of the entrepreneurs (X_1), entrepreneur's membership in political party (X_2), entrepreneur's education (X_3), entrepreneur's experience (X_4), asset position of entrepreneur's at the time of industrial establishment (X_5), frequency of contact with IPAs before industrial establishment (X_6), parental occupation (X_7), relatives in Government service (X_8), relatives in industrial / business fields (X_9) and volume of fixed capital at the end of the first year of production (X_{10}) on percentage of loan to fixed capital (Y), ordinary least square (OLS) method was used. This would show as to what extent the above independent variables have influenced the dependent variable namely, percentage of loan to fixed capital.

Comparison of the differences in the different categories of units in the study area could be useful to find out how far they are statistically different. Hence, 't' statistics have been worked out in the following manner.

1. The variables used for the comparison of the units in Dharmapuri and Pudukottai Districts are:

(i) Percentage of loan to fixed capital
(ii) Nativity of the entrepreneurs
(iii) Entrepreneurs' membership in political party
(iv) Entrepreneurs' education
(v) Entrepreneurs' experience
(vi) Asset position of entrepreneurs at the time of industrial establishment
(vii) Frequency of contact with IPAs before industrial establishment
(viii) Parental occupation
(ix) Relatives in government services
(x) Relatives in industrial / business fields
(xi) Volume of fixed capital at the end of the first year of production.

2. The variables used for the comparison of the IPA supported units in Dharmapuri and Pudukottai Districts are:

(i) Simple growth rate in fixed capital
(ii) Amount of loan from IPAs
(iii) Amount of retained earnings

(iv) Capacity utilization in percentage
(v) Ratio of sales to production in percentage

3. The variables used for the comparison of the IPA supported units and non-supported units in Dharmapuri District and in Pudukottai District separately are:

(i) Simple growth rate in fixed capital
(ii) Amount of retained earnings
(iii) Capacity utilization in percentage
(iv) Ratio of sales to production in percentage

Limitations

This study is not free from limitations. The information on production at the end of the first year of the establishment of some of the industrial units was mostly recalled from the memories of the entrepreneurs and not from any proper records. In a few cases, entrepreneurs of the industrial units were not available at the time of interview. Unavoidably, in such cases information related to the units were gathered from managers of the respective units. It is difficult to identify the entrepreneurs in some cases where investment is undertaken in the name of family members. So the definition of entrepreneur in the above two cases becomes very difficult. Lastly, it is also observed that some of the entrepreneurs gave inconsistent figures at various stages of the questionnaire. The exact figure of profit or loss could not be ascertained in some of the units.

Findings

The present study has aimed at understanding the role of IPAs on entrepreneurship development. This has been done from the perspectives of IPAs and the entrepreneurs. The measures undertaken by IPAs are analyzed and an appraisal of their performance and policy implications are also given. Secondly, randomly selected FGEs from the two select backward Districts viz. Dharmapuri and Pudukottai have been studied for understanding their perception of IPAs and also for assessing the impact of the IPAs. The following are the observations emerging from the analysis of the information collected from the entrepreneurs.

Mobility

The entrepreneurs had evinced a strong tendency to migrate to the study districts to make use of the facilities extended by the IPAs. This particular motivation to move is relatively more among the entrepreneurs of engineering units in both the districts. There is no much mobility among the entrepreneurs in agro-based industries. These industrial units are normally established by the local entrepreneurs utilizing the local resources. Thus the environment conducive to industrial promotion supported by well-developed infra-structure and favourable externalities seem to be the most important factor to attract the entrepreneurs towards the nodal points (industrial estates) developed by the IPAs.

Social Profile

Classification of entrepreneurs into different caste groups has shown that entrepreneurs have emerged from wide cross-section of caste categories. But SC / ST entrepreneurs are virtually non-existent in both Districts. The same fact has been observed in other districts of Tamil Nadu (Thangamuthu & Iyyampillai, 1983). Agro-based industries are dominated by backward caste entrepreneurs with farming background. The SIDCO and SIPCOT industrial estates (promoted by IPAs) are found to be dominated by the entrepreneurs from socially forward communities. The backward communities, perhaps, could have failed to compete with the forward communities in getting sites in the industrial estates. Most of the entrepreneurs have not received loan from IPAs. Relatively larger number of backward caste entrepreneurs have availed loan facility from IPAs in both districts; the upper caste entrepreneurs, thanks to their better economic endowment, did not avail loan from IPAs.

Education

It is obvious that education is an important factor to initiate any industrial activity. But the level and the nature of educational requirement of entrepreneurs are industry specific. It is observed from our analysis that entrepreneurs with higher professional education are concentrated in engineering units in both the districts. The relationship between the level and type of educational qualifications of entrepreneurs and the type of industries is quite evident from the data both in Dharmapuri and Pudukottai Districts. Nature of education is closely associated with the type of firms. This particular aspect of the socio-economic characteristics of entrepreneurs indicates that reasonably a good number of entrepreneurs have emerged from poor socio-economic environment, because of their educational attainments. The data relating to the relationship between loan groups and educational status of entrepreneurs do not bring out any consistent trend. The level and nature of entrepreneurs' education do not seem to have any uniform association with the volume of loan in both districts.

Parental Education

Fathers' educational status does not seem to be an important factor in determining entrepreneurial ability. In fact, both in terms of number of enterprises owned and the loan amount borrowed from IPAs, there is no positive relationship between fathers' and sons' education. In other words, fathers' educational status of a significant number of entrepreneurs is low and these entrepreneurs have borrowed heavily from IPAs.

Parental Occupation

It is also clear from the data that there is no association between the entrepreneurial activity and parental occupations. In fact, entrepreneurs come from a wide cross-section, wherein fathers' occupation varies significantly. Fathers' occupational and educational status does not significantly influence the number of

entrepreneurs in general, nor the number of entrepreneurs in any particular type of industry.

Social Connections

Most of the entrepreneurs have not associated themselves with any socio-cultural or industrial or political organizations in order to make use of such associations to get things done with the IPAs.

Experience

Apart from formal education, experience gained in the family-based units and firms elsewhere have mostly influenced the entrepreneurs in the choice of their line of industrial venture. The entrepreneurs of agro-based industries inherited little technical expertise. Experience gained in their parent units helped them either to carry on their enterprises or to launch new units. As far the engineering units, experience derived elsewhere in similar units seems to have induced a significant number of entrepreneurs to start their own units in both the study districts. The length of experience of the entrepreneurs is positively associated with loan amount obtained.

Choice of Industry and Location

Given the fact that the entrepreneurs have emerged from a cross-section of different socio-economic profiles, economic independence seems to be the dominant motivation for most of the entrepreneurs in various types of industries to start industrial activity in both districts. Besides this motivation, the decision to choose a particular line of production has depended on the success of other entrepreneurs in similar line (demonstration effect). Incentives and concessions offered by IPAs and easy availability of raw-material and labour are the two important factors that determined the location of industrial units.

Performance Appraisal

Growth of Investment

Only agro-based and engineering industrial units have registered a considerable increase in the quantum of fixed capital both in the study districts; other industries have made only marginal improvement in their fixed capital investment over the period. The impact of IPAs has not been thus reflected in any perceptible expansion of capacity in these industrial units. Significant changes also took place in working capital. Number of industrial units with working capital up to Rs. 2,00,000 has come down over the period. On the other hand, units with working capital more than Rs. 2,00,000 have gone up. As in fixed capital, it is the engineering group which has made considerable improvement in terms of working capital since their establishment. Despite the marginal improvement in fixed capital investment, the working capital, on an average has gone up.

Units which have borrowed from IPAs are distributed across all types of industries. In other words, there does not seem to be positive relationship between quantum of IPAs loan and the quantum of initial fixed investments (in different industries). The picture relating to asset formation across different categories of industries indicates that most of the industrial units which did not receive loan from IPAs have also acquired assets. The number of different types of labourers employed over a period of time does not show much relationship with amount of loan from IPAs in Dharmapuri District. But the number of labourers with technical skill (by experience) has increased with the size of loan and the percentage of growth is higher for the units in which the proportion of loan to the volume of fixed capital is higher. The recruitment of different types of labour has increased in almost all the units in Pudukottai District.

Performance Indicators

In terms of certain performance indicators such as changes in production capacity, actual production, changes in capacity utilization and actual sales, success rate is different across different loan groups (defined on the basis of the proportion of loan to the volume of fixed capital) in both districts. And, the data do not show higher growth rate for higher loan groups. In Dharmapuri District, performance of group 2 (20 % of fixed capital is loan) in terms of these indicators was negative. Although group 5 (100 % of fixed capital is loan) made positive changes in terms of these indicators, the change was very negligible.

Loan Repayment

The amount borrowed by the majority of the units from IPAs consistently increased for different loan groups. Only a few units in Dharmapuri District did not pay back their dues to IPAs. Most of the units under all loan groups either fully or partially repaid their loan arrears. In Pudukottai District, there is not even a single unit which has not repaid loan arrears. In both districts, most of these units have repaid more than one-third of the loan amount. The entrepreneurs, who are able to get finance from one source, could also have been capable of getting loan from other sources. Almost all units which received financial assistance from IPAs have been benefited by financial help extended by the nationalised banks as well. There is, however, no consistent variation in the volume bank loans among different loan groups in both districts. Most of these units which borrowed from nationalised banks either fully or partially repaid their dues in Dharmapuri District. Most of the units under higher loan groups (where loan is more than 80% of the fixed capital) are yet to repay their dues in Pudukottai District.

Almost all units under various loan groups have been established with some amount of entrepreneurs' own savings in both districts. However, the higher loan groups have invested only a small amount from their savings. Obviously, subsidy increases in the same proportion as the loan amount. Most of the industrial units which did not receive loan assistance from IPAs, however, have availed the subsidies under various heads. Only one unit in both the study districts has received raw-material from IPAs. Loan, building and

subsidy seem to be the most important facilities availed by the majority of the industrial units in both the study districts.

Awareness of IPAs

Most of the entrepreneurs in Dharmapuri District came to know about the facilities offered by IPAs through news agency. This particular mode of dissemination of knowledge seems to be the most efficient in both districts. Besides this, a sizeable number of entrepreneurs have received the information about IPAs in Pudukottai District through friends.

Frequency of Contacts

The frequency of contact with IPAs to avail facilities is more for all loan groups both before and after the establishment of industrial units in both districts. The entrepreneurs under higher loan groups have visited IPAs more than the entrepreneurs belonging to lower loan groups in both the study districts.

Specific Services

It is clear from the analysis that the role of IPAs towards running the industrial units is not as effective as in the encouragement of IPAs towards promoting prospective entrepreneurs to start the units. IPA's role in disseminating information about the prospective product to be developed and effective market potential for the product is hardly felt by the entrepreneurs. Friends seem to be more effective source of information about the product, market prospects and technology. Majority of the industrial units, which utilized services like loan, arrangement for license, feel that encouragement towards obtaining these services from IPAs was good.

Difficulties

Many industrial units both in Dharmapuri and Pudukottai Districts suffered in the initial stage due to several reasons such as inadequate supply of raw-materials and working capital, higher interest charge on working capital and lack of technical personnel. The number of industrial units affected by these problems has increased over the period. More particularly, inadequate supply of technical personnel was severely felt by the majority of units in Dharmapuri District. Similarly, competition among rival industrial units caused much hardship to these industries in Pudukottai District. Most of the industrial units in both districts have experienced inadequate and untimely supply of raw-materials.

Policy Implications

From the discussion of the problems faced by the entrepreneurs in availing the facilities being extended by IPAs and the problems faced by the IPAs in assisting the entrepreneurs, a few policy implications emerge. The entrepreneurs always expect a lot from the IPAs and the IPAs also seem to have their own expectation about the response of

entrepreneurs. Hence, one should be neither carried away by the entrepreneurs' complaints about the IPAs nor by the IPAs' impressions on the entrepreneurs. Sometimes, the undue expectation on either side leads to "subjectively unimpressive" performance. Also one must consider other closely related aspects of the policies to be suggested. However, the scope of the present work has not covered all the aspects that are related to the entrepreneurship development. The potential costs as well the benefits of the programmes expected by the entrepreneurs have not been analyzed. Keeping this as a major constraint, the following suggestions have been made so that a congenial environment, within the given system, could be created for both the IPAs and the targets.

1. The supply of raw-materials is considered as additional burden by SIDCO on the one hand and it is least utilized by the entrepreneurs. The problems in this respect are found to be built-in and quite complicated. To improve the condition: i) Efforts must be made to widely publicize the availability of raw-materials in SIDCO and also the terms and conditions relating to the supply of raw-materials. Every entrepreneur must be made known of this facility. ii) SIDCO must take steps to arrange for timely supply of the raw-material, particularly when open market prices are high and highly fluctuating. iii) SIDCO must try to supply just the required quantity and item of raw-materials. It should not dump on the entrepreneurs, to purchase more than the required quantity.

2. The marketing facility of SIDCO is still not known to a vast majority of the entrepreneurs. The facility and the terms and condition must be properly publicized in the media familiar to the entrepreneurs. It is understood that a very high proportion of the beneficiaries of the scheme come from Madras; the entrepreneurs in other districts should also be made aware of this facility. It is also said that some entrepreneurs, who try to avail of this facility, are unable meet the quality requirement. The entrepreneurs on their part must also try to fulfill this requirement.

3. Regarding the TIIC, there are two suggestions:

i) It is good that TIIC tries to assess the credit worthiness and the genuineness of the entrepreneurs before extending finance. However, it is felt in many cases that the potential entrepreneurs, in the process, get disheartened and lose the very hope of establishing a unit. Many a time, the TIIC is said to try to assess the accounting viability of the unit and not the performance feasibility. The exact production performance and marketing possibilities are said to have been not properly explored by TIIC. Indeed, there are no suitable experts in the regional and branch offices of the TIIC. Hence, mostly some Charted Accounts are depended upon to produce viability report and the loans are sanctioned. TIIC must, with an open mind, judge the real performance viability. Also, TIIC should not have pre-conceived notion about the potentialities of an entrepreneur on the basis of his/her caste or creed; also TIIC should not be influenced by any politically or otherwise influential persons who cannot give any assurance of repayment.

ii) It is good that the TIIC tries in principle, to collect both principal as well as interest in the regular / alternative time. It is understood that the officials in charge of collection are not very prompt. Unless the top officials press them, they do not approach the units, it is reported. Hence, the entrepreneurs are sometimes forced to pay a huge amount of accumulated arrears.

4. The ITCOT takes efforts to train the potential entrepreneurs and to prepare and scrutinize the project proposals. Pertaining to these facilities, two suggestions could be useful: i) The trainees feel that ITCOT takes unduly long time to process the project reports. An association of trainees says that in many cases, ITCOT takes more than six months to process the project proposals. It would be better if ITCOT could reduce this time-lag. ii) In organizing the training programmes, the coordinator often faces problems in selecting the trainees. As the local politicians meddle with the selection, he is unable to select right persons for training. Also, due to the problem of delay and influence, the coordinator is of the opinion that the percentage of successful entrepreneurs among the trainees becomes low.

5. Regarding the Central and State subsidies, many entrepreneurs feel that the cost in terms of time and money for fulfilling the formalities for establishing a unit in and the cost of overcoming further problems after establishing the unit in a backward region outweigh the subsidy amount. The innocent entrepreneurs, who are lured by the subsidies, mostly prove to be unsuccessful in establishing or running the units. Hence, at the initial stage of industrial development in the backward region, a higher percentage of subsidies could be sanctioned. Also, different levels of subsidies, based on the level of industrial development, type of units, level of employment generation could be thought of side by side. Steps should also be taken to clarify and publicize these details in order to avoid unnecessary confusions and favoritism.

6. The respondent entrepreneurs have stated three major and reasonable problems. They are:

i) Lower quality of the labour available
ii) Non-availability of sufficient quantity of raw-material in time
iii) Competition from the similar units.

While the first problem is common in both the districts, the second one is mostly found to exist in Dharmapuri District and the third one is faced by Pudukottai entrepreneurs. The reason for the difference between the two Districts is the nature of their dependence for raw-materials and for marketing. In Dharmapuri, as the units demand a wide range of raw-materials, this could be solved by SIDCO, if it could take some serious measures to procure raw materials. In Pudukottai, most of the units are serving the needs of Bharat Heavy Electricals Limited (BHEL), Tiruchirappalli. Hence, they feel that if the number of units in the similar line of production is less, each one could get larger share of orders from the parental unit.

However, the number of this kind of ancillary units has been constantly increasing ever since the BHEL was established. The non-availability of skilled labour is something to be tackled as long-term measures. One suggestion in this regard could be establishing more training institutions in this area. The lower wage paid by the private entrepreneurs, taking advantage of existing unemployment problem, makes the experienced and skilled workers to move out of the units, either taking up own job or Government job. Hence, the entrepreneurs are unable to keep their experienced labourers with them and unable to maintain / increase the quality of their products / services. A majority of the entrepreneurs have also stated that the rail transport, communication, hospital and banking facilities are inadequate in industrial estates. Providing just a canteen and road transport, though important, alone could not improve the situation/location. The lack of coordination between IPAs and other government agencies such as electricity board, tax department etc., makes the entrepreneurs to run from pillar to post, wasting money and time. This was admitted some of the IPAs' officials too. They say the certificates and assurances from the IPAs normally have little significance to the lending institutions. Unless the IPAs follow them up with judicious efforts, no tangible results could be realized. The 'single window' system, which is much talked about, may have to be launched in effective manner in order to encourage and promote entrepreneurship.

Conclusions

To conclude, in an evaluation / assessment such as this, no conclusions can emerge in precise quantitative terms. The subjective perception of the entrepreneurs about the performance of IPAs and that of the latter about the entrepreneurial performance cannot be gauged using quantitative units. To the extent possible, an attempt has been made to indirectly assess the success of the linkage between the entrepreneurs and the IPAs. This study, by and large, observes that the role of IPAs in provision of industrial infrastructure and overhead facilities has been fairly satisfactory and that has effectively induced many potential entrepreneurs (most of the first generation) into the field. The other facilities have either not been effectively provided by the IPAs or not been adequately availed by these FGEs. The performance of these units has been a mixed one; some with outstanding success and some with poor performance; on an average, many units have realized reasonable levels of performance. The entrepreneurial performance as observed in this study has to be understood in the over-all perspective of the constraints generally encountered by new entrepreneurs in traditionally backward districts.

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EVALUATION OF LANDSLIDE VULNERABILITY ZONATION USING GEOSPATIAL TECHNOLOGY: A CASE STUDY OF COONOOR TALUK, THE NILGIRI DISTRICT, TAMIL NADU

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Abstract

Disaster is a natural or man-made event that negatively affects life property, livelihood or industries often resulting in permanent changes to human societies, ecosystems and environment. Landslide is the major disaster event frequently occurs in hilly areas. Though landslide occurs periodically in different part of Coonoor Taluk, The Nilgiri District of Tamil Nadu, they were affected very severe; during the 1824 to recent years, inflicting loss of life and damage to property. This stressed the need for probing the geospatial aspect of the phenomenon to unravel of the landslide. The aim of the study is to find the landslide vulnerability zones of Coonoor taluk to find out the LVZ, following physical factors were selected i.e. slope, Geology, Geomorphology, Soil, Soil depth, land use and drainage. Thematic maps were derived from satellite images and toposheets. The themes were weighted and ranked according to the major nature of the landslide vulnerability. The weighted and ranked themes were overlaid in GIS and cumulative map is prepared and classified into ones based on mean, standard deviation, and sum. The study area classified into five vulnerable zones namely Zone I, II, III, IV and V. The zone V has very highly vulnerable zone (7.8%), zone IV highly vulnerable zone (37.3%), zone III moderately vulnerable zone (30.9%), zone II low vulnerable zone (11.0%), and zone I very low vulnerable zone (12.8%).

Keywords: *Landslide, Vulnerability, Multi criteria evaluation*

Introduction

Landslide is the major disaster event frequently occurs in hilly areas. Outward and downward movement of mass consisting of rocks and soils due to natural or manmade causes is termed as landslides. These events are associated with pre and post of earthquake, soil erosion, rainfall and anthropogenic activities. Outward and downward movement of mass consisting of rocks and soils due to natural or manmade causes is termed as landslides. These events are associated with pre and post of earthquake, soil erosion, rainfall and anthropogenic activities. The landslides are classified into slides, fall, flows, spreads, slump and creeps and mudflow or mudslides.

There are lot of studies on natural disaster and their causes and effects. Most of the studies were carried out on regional basis of the occurrence of various Natural disaster studies on landslides and their causes are many but a micro level study are limited. The Geologic and geomorphic factors are the causes for landslide in Himalayan region Chansarkar 1975. Landslide and soil erosion in Darjeeling and landslips in hill slopes in the eastern Himalayas was carried by Dutt (1966) and Hazara (1966) stated the stability and landslides on the hill slopes. Kalroda (1972) analysed the causes and the occurrences of landslide an associated phenomenon with reference to Himalaya. Nautiyal (1966) analysed the stability of hill side and prone to landslides. A report on land slides in Nilgiris Kodaikanal and Yercaud were appeared in daily magazines and Newspapers. Study on the occurrence of landslides and their impact on environment in Nilgris hills of Tamil Nadu is attempted here to bring out the nature of landslides.

Landslides have occurred in Nilgiri ranges since time immemorial but they have been recorded particularly during expeditions only from the beginning of the last three century before. A huge landslide near the spot where the Sispara Ghat road passes over Kundah hills, sliced part of KudiKadu hill in 1824, after heavy rains lashed the area for eight days. Harness, Baike and Benza have recorded this land slide popularly known as Avalanche landslide. The Scar was well known land mark which was later concealed by forest growth. It was visible from as far as Ootacamund. The Kotagiri - Mettupalayam road was damaged by a heavy rain storm in 1881, in the same year land slips smothered the Coonoor Ghat road at many places. Ten years later on November 1891, a record rainfall of 74 cm, within a few days, at Kotagiri brought traffic to a stand still for three weeks due to many landslips on the Kotagiri - Mettupalayam road. In December 1902, 53 cm of rain in Kotagiri including 22 cm, on a single day, brought havoc., 21 inches of rain fell in that month in Coonoor was received, of which 8.45 inches fell in a single night. The old and new Coonoor railway was blocked for a month and the new Coonoor Ghat roads for nearly as long; and all the traffic of the eastern side of the plateau was thrown upon the Kotagiri Ghat, which was itself in a pellous condition. Slips have occurred throughout and being serious in six places.

On November 1979, Heavy rainfall started from 12th November and highest rainfall was 114.5 mm at Kodanad (table 1). On 13th it was 149.4 mm at Coonoor and 169.9 mm at Kodanad. On the 15th night heavy landslide had occurred at Doddacombai. On 16th night there was heavy rain at Coonoor resulting in washing away of one woman and two children. On 19th there was heavy landslide of 100 yards in width and about 1.00 km in length in selas of Ketti village of Coonoor taluk resulting in filling up of valley of 30° -50°.

The North East monsoon was heavy and there was a ‘cloud burst’ on 25th October 1990. More than 35 families were buried in a place called Geddai. On November 1993, there was another cloud burst' in the upper reach of Marappalam of Coonoor Taluk, about 18 huts situated below the road and washing Coonoor - Mettupalayam Ghat road for about 1 1/2 km. The road traffic was suspended for more than a for night 12 persons lost their live and 15 persons missing.

It is laid that 21 passengers were washed away with two buses. On 11th December 1998 due to continuous rainfall one big boulder weighing about 20 m tones fell at the Coonoor - Mettupalayam main road and the road was closed for traffic, the rock was blasted and earth slips were removed and traffic was resumed from 14-12-1998. On December 2001 due to continuous rainfall, massive landslides occurred near Pudukadu on the Coonoor - Mettupalyam highway damaging two bridges resulting in continuous closure of traffic. In addition a closer damage was also caused to the railway track between Coonoor - Mettupalayam. Bridge No- 55 near Hill grove railway station was completely damaged and bridge No- 56 was also damaged. On 14th November 2006 Burliar landslide occurred killing one person and three were hospitalized. The main cause for the damage is heavy rain fall inshore span of time.

The aim of the study is to assess the Landslide vulnerability area for the Coonoor Taluk, Nilgiri District using Remote Sensing data and GIS techniques. The aim requires the following objectives: determination of various themes or parameters for the vulnerability prone mapping and preparation of necessary thematic maps and determination of ranks and weights for the different themes in the analysis. Integration of different themes using GIS to prepare landslide vulnerability zonations.

Study Area

The study area Coonoor Taluk is situated in the Eastern slope of Western Ghats stretching from west to east and it comes under the part of the Nilgiri District. The taluk consist of 9 villages they are Coonoor, Ketti, Jakathala, Yedapalli, Adigaratti, Ubatala, Hulikal, Melur and Barliar. Coonoor is the head quarter of this taluk. It is located between 11° 15' N and 11° 25' N latitude and 76° 40' E and 76° 53' E Longitudes. It covers an area of 248.08 km^2. The climate of the study area is temperate and salubrious for more than half of the year. The average day temperature of the taluk is 16.15° C and the average rainfall is about 901.65mm and winter is relatively cool. The taluk receives rain both from Southwest and Northeast monsoons contributing the major share to the total rainfall, followed by summer showers and a little contribution by winter showers. The maximum rainfall received during the month of October and November. The average maximum temperature is 20.27°C and the average minimum temperature is 12.02°C.

Soils of the study area are classified into family level (Soil Taxonomy, USDA, 1975). Five soil families and their associations were identified such as 1) Fine loamy, Lithic Troporthents - Hallimoyar 2) Fine loamy, Typic Dystropepts - Attavalai 3) Fine, Typic Dystropepts – Millithenu 4) Fine loamy, Fluventic Dystropepts – Terremia 5) Fine, Ultic Tropudalfs – Karumpalam. The dominant soil of this region is Karumpalam and Terremia it covers major part about an area of 102 km^2; followed by Millithenu and Karumpalam at the southern part covered 40.3 km^2. Attavali and Terremia soils found on the middle part occupied 6.1 km^2 and Hallimoyar soil found as minimum category (Figure 2.3). The soil map further classified into based on depth such as 50 cm, 125 cm and 150 cm.

Physiographically the Nilgiri District can be divided into the four regions (1) The Nilgiris plateau, (2) The Nilgiris Wynad plateau, (3) The Sigur plateau and (4) The outer slope facing the plains. Coonoor taluk falls mostly under the last categories of the above four regions and to certain extent under the first category. The outer slopes are less precipitation and present an altitudinal zonation of different types of vegetation. The Nilgiris plateau has a series of hills and valleys upheaved at the junction of Eastern and Western ghats of the Penninsula. The elevation of the taluk ranges from 500m to 2520m and the slope from in the valleys and hills. The general trend is towards east. The taluk is drained by a number of streams and rivers. The important ones are part of Moyar river, Coonoor river, Adathore halla, Yerkada halla, Halada hala and minor streams.

There are two categories of vegetation a) Shola grassland vegetation of the Niligiri plateau: It is evergreen vegetation called locally as shoals. The proportion of the sola trees to the grass land areas is roughly by 1:4 ration. b) The forests of the outer slopes: The eastern part shows marked altitudinal zonation in the vegetation. Below 450m the vegetation is thorny and from 450m to 1070m, the vegetation is marked by the presence of sandals and bamboos. Agriculture and Land use concern the total geographical area the forests consist of about 20% and the net area sown is about 60%. Being an hilly tract the cultivation is done on bench terraces.

This involves in high capital investment as compared to that of the plain areas. Among the net area sown, tea occupies the major area, followed by coffee, millets and vegetables. Tea is raised in an area of about 107 km^2 considerable areas of fruit crop cultivation have also been cultivated in the taluk. Vegetable crop cultivation is concentrated in the Keathy valley. Among vegetables, potato occupies the major area. The cultivation is mainly depending on (Monsoon) rainfed. The irrigated area is very limited, in Coonoor taluk, there are only 65 wells that irrigating 26 ha.

Most of the villages and towns are well connected by road way system. The taluk has no national highway. Two state highways which connect, Uthagamandala and Kothagri to Mettupalayam via Coonoor. There is link between Uthagamandalam and Madras. The taluk is linked by a Metergauge railway line between Metupalayam and Uthagamandalam with a total length of 46 km. The quick transport of vegetables is being done by rail to far off places like Trichy, Chennai, Mumbai etc., and by lorries to the nearby places like Coimbatore, Mysore etc., The taluk has all communication facilities like postal, telegraphic and telephone services.

The taluk is highly populated, the total population being 1, 89,744 of which 94,532 are males and 95,212 females as per 2001 census. The Coonoor is well developed in industrially and economically. The cordite factory at Aravankadu is located in Coonoor sector besides the Needle industries at Ketthi. In view of the extensive plantation crops in the region, there are a number of small ancillary industries located in and around Coonoor

for the manufacture of tea chests, card board boxes etc. The tea factories both in co-operative and private sectors number 102 in this region. This area has got a large number of beauty spots such as Kattery water falls, Log falls, Catherine falls, Lamb's rock, Dolphin nose view point, Sim's park in Coonoor is a well-known tourist attraction.

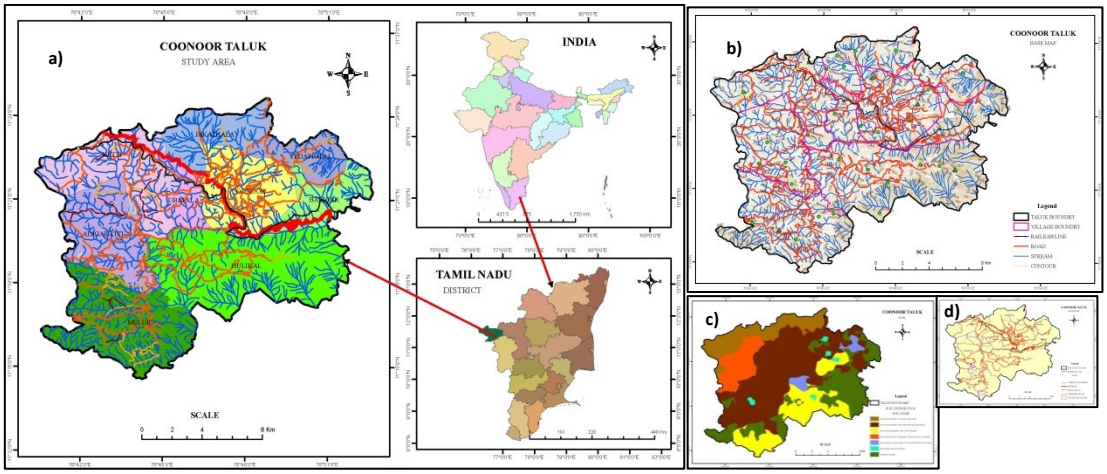

Fig.1. a) Study Area, b) Contour, c) Soil, d) Transport

Database and Methodology

The landslide is an important hazard in this area. So many landslides occurred in this area as per the historic records. The incident varies in different scale. This area holding nearly 2 lakes of population. This type of problem mostly solved through the strategic plans and by adapting multi criteria analysis. This can be achieved by identifying the criteria closely related to the problem. Such a voluminous data can be properly managed and analysed with use of a Geographical Information System. Present study utilized Survey of India Toposheets 58 A/11, 58 A/15 on 1:50,000 scale to demarcate the physical and cultural features like drainage, road, reserve forest etc. Satellite Imagery IRS –IC LISS III year 2000 and 2009, with 23.5m resolution used to prepare land use and geomorphology. Geology map published by Geological Survey of India. Soil map from Soil Survey Land use Organisation. Arc GIS 9.1 and Erdas 8.7 software were used to generate thematic map and prepare layout.

GIS is the best platform for analyse the spatial and non-spatial data. Before the integration phase weightage and ranks were assigned based on the suitability nature. In of each theme, the analysis weightage and ranks were multiplied for each theme; which are integrated by Union operation by using equation 1. The landslide vulnerability is the addition of the sum of the weight * ranks of the individual theme. Mean and standard deviation is calculated for the landslide field in the table of cumulative map. Based on the mean and standard deviation the landslide zonation's are classified into five zones.

$$LSVI = \sum W * R$$

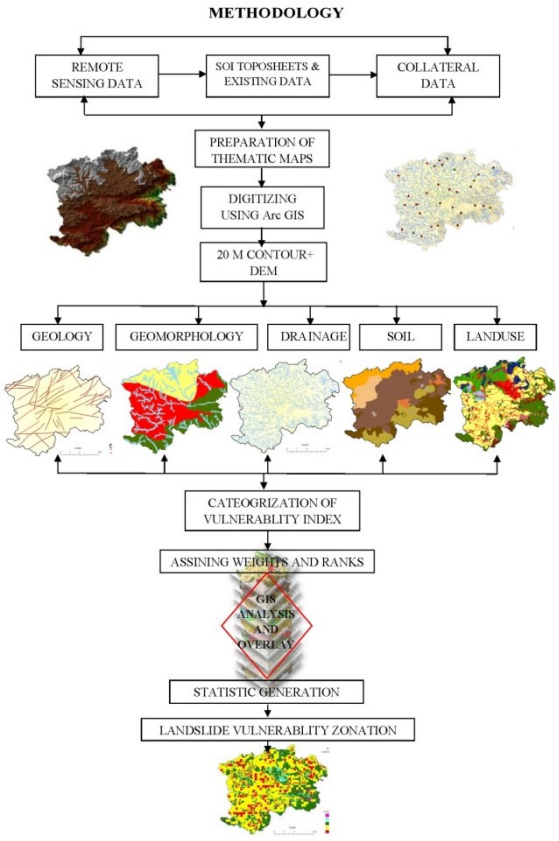

Fig. 2. Methodological Workflow

Table 1. Major Landslide Locations

Name of the Slide	Location	Remarks
Runneymede Slide	11° 19' 30'': 76° 47' 50"	The main scarp and across the stream section, a group of four parallel arcuate fractures of 1 to 1.5 metres in depth, 1979
Glenmore Slide	11° 19' 30'': 76° 46'40"	This area is ideally a potential zone for further activity with the triggering mechanism of rains; this is hazardous, endangering not only the tea estate but also the lives of hundreds of people living at the higher elevations, October, 1980
Coonoor Slide	11° 20' 30'': 76° 47' 30"	The area is located about a kilometre north of Coonoor railway station. The area had been affected by the landslide activity earlier. This is evidenced by a prominent fracture line above the road connecting the two landslide scars.
Karadipallam Slide	11° 21' 00'': 76° 46' 30"	The main scarp trends east-west over a length of 140m bucking in the middle towards south. Above the eastern portion of the main scarp a 0.5m wide crack is observed above the crown. This is a new feature which has developed after the main sliding event in December 1979.
Katteri Road Slides	11° 20' 00'': 76° 47' 10"	It is a well-known landslide prone area. A number of landslides devastated this area periodically and the first slide happened in 1927.
Culvert 413/5 and 414/1 on Mettupalayam to Ootacamund Road		This slide has occurred with talus debris. The slide is 100m long, with a maximum width of 40m. The thickness is 6 to 7m. The slide is 80 m long and 17 m in wide. The height of the main scarp is11m.
Aravankadu Slide	11° 22' 30'': 76° 46' 30"	The length of the slide is 150m, width 60m and height 12 to 15m. This is due to reactivation of a paleoscar. It was active last in 1947
Doddakombai Slides	11° 16'00'': 76°39' 00"	The main scarp is 10m wide and 6m high. The Doddacombai slides can be classified as debris slides. November 1979
Allada Slides	11° 17' 30'': 76° 44' 10"	The first slide has a length of 60 m and a width of 15 m. the main scarp is 3 to 8 m deep. The Allada slides are classified as debris slides, caused by pore pressure.
Selas Slide	11° 19' 50'': 76° 44' 55"	The selas slide is about 700m long, 65 m wide and 8 to 21 m thick Tea gardens over an area of about 50,000 Sq. m were destroyed and a further 10,000 to 12,000 sq.km of tea garden was threatened November, 1979.
Mallikorai Slide	11° 23' 00'': 76° 47' 00"	The slide has a length of over 500m and width of 150m.
Yellanalli Church Slides	11° 22' 30'': 76° 44' 30"	The main scarp is 7 to 8m. This slide is due to the removal of the toe during road construction & steep and high slope has moved is in a valley which will have copious runoff monsoon.
Annikorai Slide	11° 27' 30'': 76° 43' 50"	It has a length of 150m, width 100m, & a thickness of 8 to 10m. It's a planar failure.
Burliar Slide		Unprecedented rains triggered about a thirty landslides with in an area of 6.67 Sq. Kilometers in the Burliar area. November 2006

Results and Discussion

Landslide Vulnerability Analysis

The main aim of the study is to find the landslide vulnerable zones of Coonoor taluk. As we know the landslide in the function of multiple phenomena. For this study relevant thematic maps prepared from various sources the toposheets and satellite images. GIS based multi criteria analysis is selected to achieve the aim of the study. Multi criteria analysis needs various themes, weights and Ranks. The selected themes were weighted their close contribution to landslide. The selected themes are geology, geomorphology, land use, slope and soil. The weights for the above themes are shown in table 2.

Amongst all natural hazards landslides are most difficult to predict as the causes inherent in the terrain, vary from place. But, forecasting of the danger prone areas is rendered possible through application of zonation. Zonation, in a broad sense, implies division of land surface into zones of existing or potential hazard from landslides with different degrees of susceptibility. Landslide-hazard zonation has been attempted only in

the past fifteen years in different parts of the world and is still in an infant stage. Slope failures are likely to occur in landslides when optimum combinations of geological, geomorphological and hydrological conditions that led to the past failure recur.

Conditions, that caused the landslides, such inclination of the slope, position of groundwater level and property of the soil are identified and their cumulative effect weighted for evaluating the possible future behaviour of the slope. An attempt has been made, assigning qualitative and semi-quantitative values to the conditions and processes involved, not only to identify potential hazard zones but also assess their susceptibility to induce severe damage.As part of the investigation of the landslide it was felt that area would help in a better understanding of macro-geological and regional features which in turn would aid in evaluating and formulating plans talking geological aspects into consideration.

Slope

The slope is generated from the 20M contours create from DEM and based on elevations of the study area. There are 5 slope categories this area such as 0 - 5°, 5° - 15°, 15° - 25°, 25° - 35°, >35°. Weightage for the slope is 4 and the slope classes are ranked according to landslide suitability, 15°- 25° as the most vulnerable slope followed by 25° - 35° ranked with the value of 19 and 8 respectively.

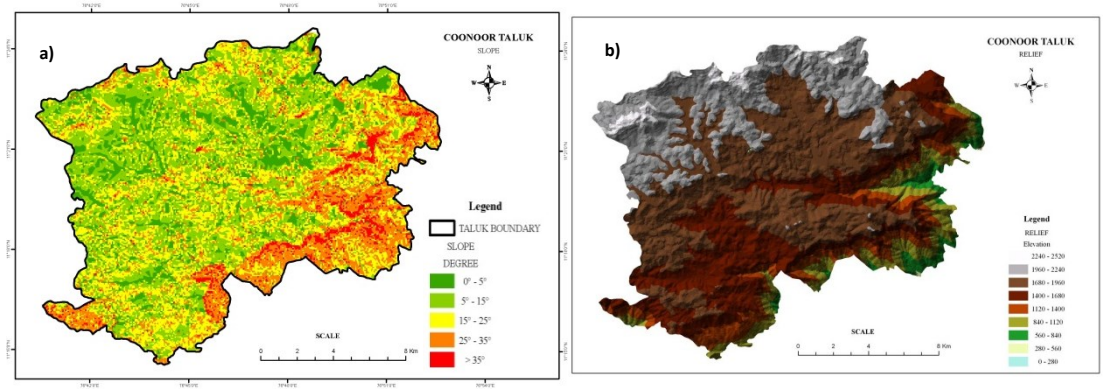

Fig. 3. a) Slope b) Relief

Geomorphology

Satellite images and existing geomorphic maps were utilized for demarcating escarpment slopes, plateau landforms, alluvial and colluvial fills and trends of ridges are identified in this study area. There are four major types of Geomorphological units were found in this region they are Highly Dissected Plateau (HDP), Moderately Dissected Plateau (MDP), Low Dissected Plateau (LDP) and Infield Valleys (IFV). The Geomorphic landforms are assigned weight and ranked according to the nature related to landslide.

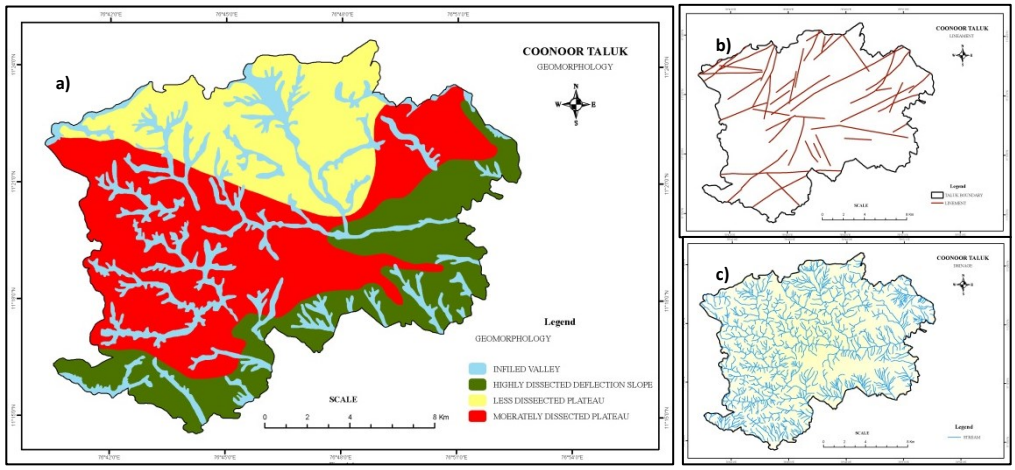

Fig. 4. a) Geomorphology b) Lineament c) Drainage

Lineament Density and Drainage Density

The lineament of the area analysed in two methods such as frequency and Density. Lineament frequency calculated by 0.5cm * 0.5cm grid of the study area which covers 0.25 sq.km. After identifying the lineament frequency and density. The high density got high rank value. Those areas doesn't have lineaments "0" were allotted. The drainage network of the Coonoor Taluk, Nilgiri Hills digitized from SOI toposheet. Drainage density calculated for each 0.5cm grids. The higher ranks were given for higher density. The minimum density is 0.004 and maximum is 8.83. The drainage density calculated for every 0.25 sq.km. of the study area. This is calculated by setting up grid in GIS. The density of the study area is classified in to four categories.

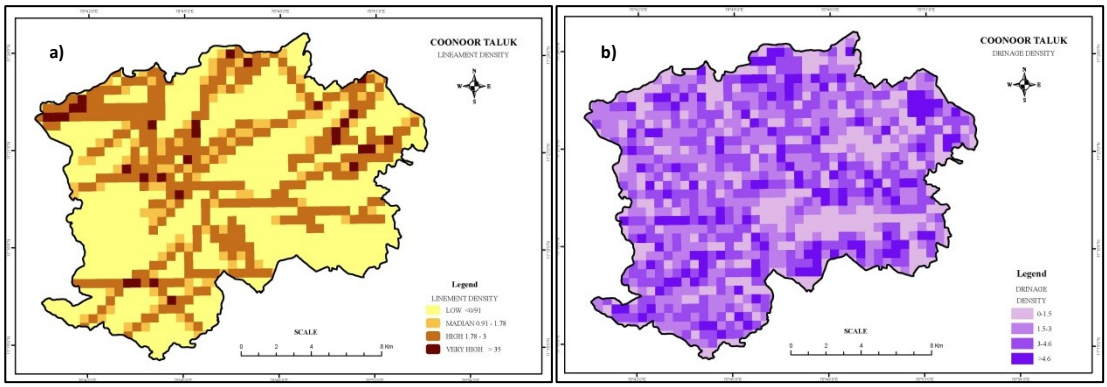

Fig. 5. a) Lineament Density b) Drainage Density

Soil and Landuse

The soil and soil depth layers were prepared from the Coonoor taluk soil report published by Soil Survey and Landuse Organisation, Government of Tamil Nadu. The soil composition and soil depth is considered for this analysis, ranks and weight are given in

table (4.1). The landuse/ land cover map derived from the hybrid method of SOI toposheets and IRS – IC- LISS III image 2005. The landuse classes digitized single feature and the area is classified into the following landuse / land cover categories. They are water body, settlements, vegetables, tea & coffee, forest plantation, dense forest, range land and open forest. By understanding the land use class and landslide suitability ranks were given in table. This map shows the status of urban and rural development, varieties of agricultural crops, position of forest plantations etc. Land use/ Land cover considered as are the most important theme for this analysis.

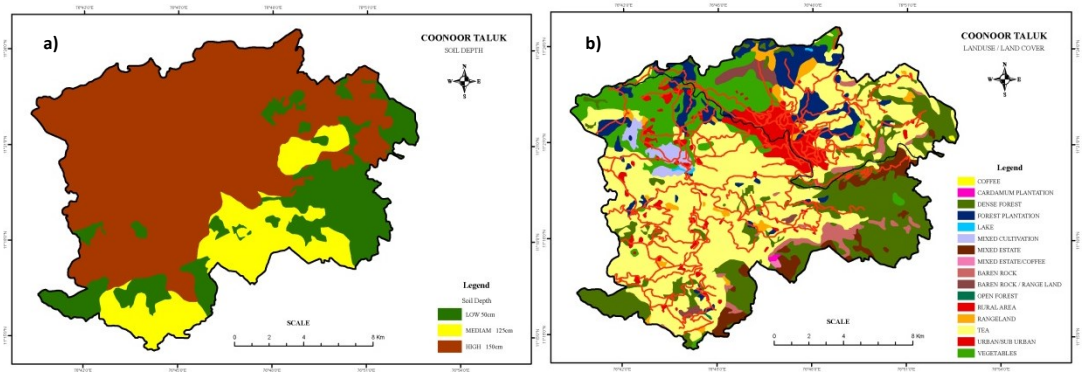

Fig. 6. a) Soil Depth b) Landuse

Landslide Susceptibility Values (LSV)

Apart from the cartographic approach mentioned in the foregoing it was felt that a numerical method to evaluate the relative slope stability would be essential. To achieve this end the different factors considered were grouped according to their relative importance and landslide susceptibility values were (LSV) assigned to them. Landslides being essentially gravity-types of movement the degree of the slope was accorded the prime importance. Taking all the factors into consideration and with an intimate knowledge of the Nilgiri landslides, a LSV of 25 was assigned to this factor. Drainage plays and important part in the promotion of landslides. If the density is less infiltration takes place; on steep slopes flows occur and river erosion removes the toe support. A LSV of 15 was assigned to drainage. Under similar topographic conditions with similar thickness of soil and type drainage, the susceptibility to landslides is accelerated by human environment. Hence the land use practices adopted was also considered and a LSV of 10 was assigned.

Landslide Vulnerability Index and Zones (LVI and LVZ)

The LVI of each area was calculated and the areas are graded according to the aggregate LVI values. The study area has divided into vulnerability zones into five grades I to V with increasing susceptibility to zone V the most susceptible. The aggregate LVI values for the various zones are as follows: Zone I - 1 to 9, Zone II - 10 to 19, Zone III - 20 to 29, Zone IV - 30 to 35 and Zone V - > 35. It was found, by trial and error methods, that LSV and

LSI were the best fits on the zonation maps. By using the statistics the LVI in classified in to 5 zones namely, Zone V is the high vulnerable zone occupied an area of about 27.1 sq.km. (7.8%), followed by Zone IV found in 128.6 sq.km. (37.3 %) Zone III found in an area of 106.8 sq.km. (30.9 %), Zone II found in an area of 38.5 sq.km. (11.0 %), Zone I found in an area of 44.1 sq.km. (12.8%). Further, the resultant LSV map has been overlaid with existing landslide events around five locations are fall on the zone V that is high vulnerable are, followed by other zones. Same result also cross check with present land use and identified the changes, it is clearly shows that most of the tea plantation area are high possibilities of landslide.

Table 2. Factors Weight and Rank

Thematic Layers	Map Weight	Individual features	Class	Ranks
Slope	4	0° - 5°	Very Low	1
		5° - 15°	Low	7
		15° - 25°	Medium	19
		25° - 35°	High	8
		>35°	Very High	3
Soil	1	<50cm	Low	2.50
		125cm	Medium	13.50
		150cm	High	18.50
		Reserve Forest		0
Drainage Density	1	0 - 1.5	Low	3.30
		1.5 - 3	Medium	7
		3 - 4.6	High	0.20
		>4.6	Very High	0.50
Lineament Density	1.5	0 - 9.1	Low	0.5
		9.1 - 1.78	Medium	0.8
		1.78 - 3	High	1.20
		>3	Very High	1.50
Geomorphology	0.5	HDP	Very High	1.7
		MDP	High	0.8
		LDP	Medium	0.5
		Infield Valleys	Low	0.1
Landuse/ land cover	2	Settlements		0
		Vegetable		3.60
		Dense Forest		0.50
		Tea plantation		3.50
		Mixed cultivation		0.20
		Open forest		1
		Range land		0.2
		Barren rock/ rangelands		0.3
		Mixed estate		0.3

Source : Compiled by Authors

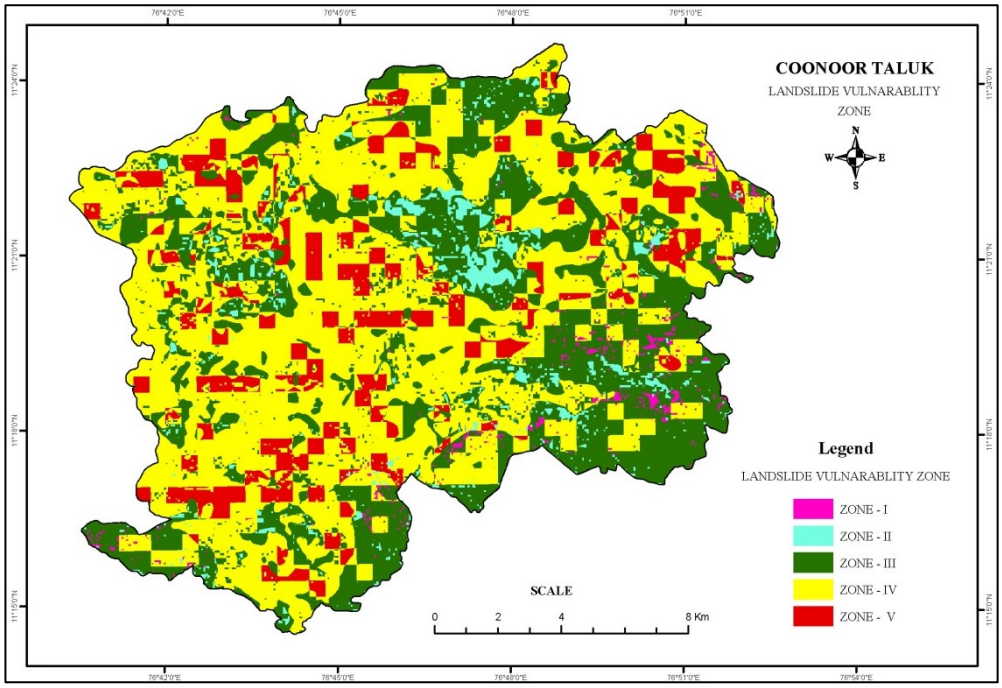

Fig. 7. Landslide Vulnerability Index and Zones

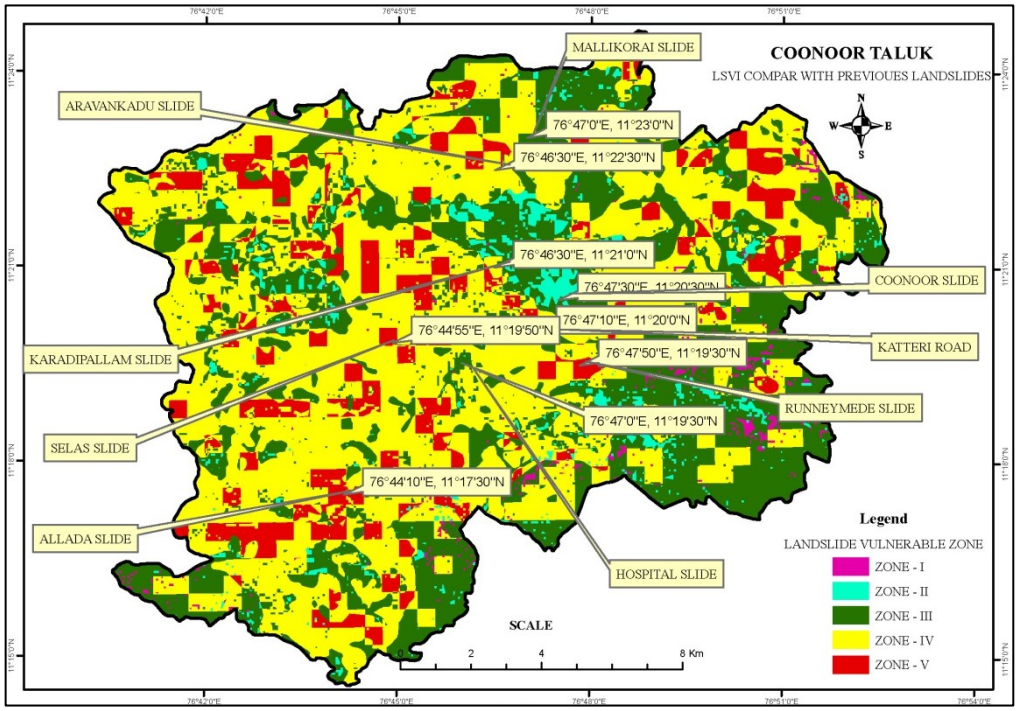

Fig. 8. LSVI Compare with Previous Landslide Locations

Recommendations

Many factors undermine the stability of slopes. Man has got little control over the invariant factors such as geological, geomorphological factors, rain and seismic vibrations. But the contribution by main for the introduction of instability of slope can be minimized or eliminated by concerned effort and well-conceived plans. Two factors over which we can exert partial control are soil, movement, amount and pressure of water in the sub-surface. Water, surfacial and underground, and the mantle of soil with varying thickness, plays a vital role in initiating landslides in the study area. The landuse practices in Niligiris district have considerably changed over the years. The frequency of landslides in the last few years may be partially attributed to the interference of man with the geoenvironmental factors. They were replaced by forest plantation and tea garden. This drastically alters the hydrological conditions of the slopes. The conversion of grass lands to vegetable plots alters the sub surface water conditions in addition to promoting landslides, erosion and sliting at lower levels. Excessive grazing leads to denudations of the vegetative cover.

1. Maintaining slope stability
2. The forest intercepts and protects the mass action of heat, wind and rain.
3. Vegetable debris on the forest floor immobilizes water and cuts down erosion.
4. Frequent changes in agricultural practices should be avoided.

The cuts made for the roads for rural development should be based on shear properties of the respective slopes and natural angle of repose. This has to be adhered to strictly, when new roads are built. In the urban areas of the study area there is lack of regular drainage system. In most of the places, residential development goes with septic sewerage system. In hill town, it generally considered that the drainage problems are minimum, as existing natural slopes and the mantle of soil over them dissipate the drainage water.

The hills which make up the Coonoor town especially the ones straggling the Coonoor river on its northern bank are piled to the top with buildings, shops and others. The town seems to have grown of its own accord without any control over the years. In addition to the weight of the manmade structures, the influence of the septic sewerage water and toe cutting by number of streams steep cuts of the roads and embankments, contribute for the instability of the town. Tamil Nadu Housing Board considers the weight of the buildings has definitely increased the stress in the slop. The slope cuts behind the houses are steep and impose threat to the buildings. The drainage system leaves much to be desired. Better planning in designing the cuts in the slope and reduction of weight of buildings are needed. As a general suggestion for new buildings especially in the urban areas in the study area, light weight building material may be used in preference to heavy construction materials.

Conclusions

It is well known that Nilgris is distributed by landslide. In this study Coonoor taluk is selected as the study area. It is one of the populated and upcoming urban centres in Nilgris

District. The aim of the study is find the landslides vulnerability zones in Coonoor taluk to find out the zones six physical factors were used, its weight and ranks are assigned through multi criteria evaluation approach based weighted linear combination. Classified landslide vulnerability zones are clearly depict the nature of particular area in terms of vulnerability to landslide.

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INNOVATIONS, PATENTS, SPILL OVERS AND DEVELOPMENT: A PANEL DATA ANALYSIS OF R&D EXPENDITURE AND ECONOMIC GROWTH IN INDIA

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Abstract

Research and development expenditure and the consequent innovations and R&D spill overs are crucial for modern economic growth. This paper has estimated the effects of R&D expenditure and patents, as measures innovations and R&D spill overs on per capita income of India and NSDP of 17 states using a panel data for the period 1998-2008 and applying OLS and panel fixed effects and random effects methods. The OLS estimates of all India data show that R&D expenditure has negative impact on per capita income in India. The panel estimates also show that R&D expenditure has no impact on per capita income of the states in India. The random effects results show a positive and significant effect of R&D expenditure on per capita income of developed states, while the same is insignificant in less developed states. With regard to the effect of patents, the estimated panel results suggest that the effect of R&D spill overs on per capita income of states is positive and significant. The patent effect on state income is positive and significant in developed states, but insignificantly negative in less developed states of India. The R&D spill overs effects are more dominant that the R&D expenditure effects on per capita income.

***Keywords*:** R&D expenditure, innovations, spill overs, patents, growth and development, panel data analysis.

Introduction

Since independence, the continuing emphasis on science and technology under the larger development agenda has been increasing significant budgetary allocations to research and development. The growing government expenditure is largely seen as necessary for both infrastructure development and keeping up with global trends. No doubt, such R&D expenditure and the associated development contribute to economic growth and development. Initially, the government encouraged focused R&D in agriculture, like developing high yielding varieties of food crops and later on in the industrial sectors like manufacturing and services. After the 1990, the focus shifted to service and infrastructure sectors, especially in the information and telecommunications technology (ICT) sector. With the development of intellectual property rights and the structural and market reforms,

private investments in R&D has increased resulting in improved product quality, productivity of workers, and efficiency of organisations. All these positive developments due to increasing R&D expenditure are to foster economic growth and improve standard of living, promote better income distribution and reduce poverty. The R&D expenditure and the associated developments in science and technology also contribute positively to social sector development, improving educational standards and attainments, health and family welfare, quality of life, women empowerment and child development. More importantly, R&D expenditure builds human capital as well as social capital which have the greater potential for spill overs and externalities, leading to the pool of talents and knowledge that serve as catalyst for fostering science and technology development.

The R&D constitutes the search for new technology and therefore new goods. Total R&D activity includes besides government and business sector, higher education, government and private non-profit institutions also undertake R&D activities. More investment in education is likely to enhance the country's absorptive capacity whilst they learn more quickly from the foreign technological base.

Patents, as they contain technological knowledge particularly the outcome of innovation processes, are generally assumed as new knowledge that reflect the extent to which a country is ready to gain or adopt new knowledge. The total number of patent applications represents knowledge spill overs and reflects its relative strength in technology. Particularly, it indicates a country's ability to turn new knowledge locked up in applications into economic growth. The patents require some protection and intellectual property rights. Patent protection is important for economic growth because it may invite foreign investment, foreign trade, and flow of new technology. A common argument for patent protection is that, under protection the expected rate of return for devaluation of time, energy, and money towards innovate will increase. In the absence of intellectual property right, fear of losses from piracy and imitation may adversely affect private sector devaluation to R&D. Intellectual property rights will aid developing countries to achieve higher rate of economic growth through technological advancement. The IPRs influence economic growth through the channels of international trade, foreign direct investment (FDI), licensing, and R&D innovation (Janjua and Samad, 2008; Sattar and Mahmood, 2011). The IPRs affect international trade flows when knowledge intensive goods move across national boundaries.

For absorption of such science and technology knowledge by an enterprise the output of research and development activities need to be innovative and reduce costs of adoption and use. Innovation activities are not restricted to new products (goods and services), they also include innovations in processes (production on the shop floor, design, marketing and distribution, financing) as well as innovations in business and organisational practices. Research and development resulting in new goods, new process, and new knowledge is a major source of technological change. Opening to trade and FDI would allow enterprises to gain more from global technological development and knowledge flows.

Among the clearest of these benefits are the productivity increases and jobs created in information technology (IT) and IT enabled services and business process outsourcing.

Indicators of India's capacity for innovation highlight its promising innovation potential. Generally, innovation measures focus on the inputs and immediate outputs of formal R&D, as there is more such data on them. Evidence on where India stands comes from quantitative data on formal R&D such as the stock of scientists and engineers engaged in R&D and R&D spending on the input side, scientific and technical publications and patents on the output side. India's innovation potential on the input side, its stock of scientists and engineers engaged in R&D is among the largest in the world. India's sizable investments in higher education historically focused on science and engineering. Its concentrated stock of high-caliber human capital is a top reason it is potentially very good at innovation.

India's emergence as a major economic and R&D power is anticipated to have wide-ranging implications for the people of India and globally. In 2005, India had more than 12million science and engineering graduates of which 2 million are postgraduates and100,000 are Ph.Ds. Estimates of India's number of scientists and engineers that are researchers in R&D suggest that there are 117528 personnel, compared with 810525 for China and 487477 for Russia. Though there is no doubt that India has an impressive stock of skilled talent based on past investments in higher education, the more pressing question is the availability of qualified talent, measured by both quantity and quality. The national investment on R&D which was Rs.4.68 crores in 1950-51, Rs.18000.16 crores in 2002-03, Rs. 19726.99 crores in 2003-04, Rs. 21639.58 crores in 2004-, and Rs. 37,777.90 crores in 2007-2008. Still, it is only 0.85 percent of GDP in 2007-2008. In this, the share of the central government has been 57.5 percent, state government 7.7 percent, public sector industries 4.5 percent and private sector industries 25.9 percent. Thus, the domestic R&D spending is dominated by the public sector. Though the R&D expenditure in India has been increasing over time, India's R&D expenditure is still low compared to major industrial economies. In PPP terms, India's R&D expenditure has been $26.9 billion in 2004 was the ninth largest spending. The largest R&D spending has been the US at almost $340 billion, followed by China at about $136 billion.

India is still at a typical early innovation stage with regard to the distribution of domestic R&D efforts. About 75 to 80 percent of domestic R&D is conducted by the public sector, 20 to 25 percent by private enterprises, and just 3 percent by universities. In contrast, average R&D expenditures in OECD countries are 69 percent by enterprises, 18 percent by universities, 10 percent by government R&D labs, and 3 percent by private non-profit institutions. In China, more than 65 percent of expenditures are undertaken by enterprises. With the significant increase in R&D by multinational corporations (MNCs) in India since 2002, total private R&D investment is estimated to have risen from $0.8 billion in 2002 to $4.1 billion in 2005. This led to a corresponding increase in total R&D spending from $4 billion in 2002 (where total private spending was only 20 percent) to $8.5 billion in 2005, the total private spending, including MNCs, is estimated to have risen to 48 percent.

Generally, the innovative output of the R&D activities is measured by indicators like internationally refereed scientific and technical publications. In 2003, the number of Indian scientific and technical articles published in internationally recognised journals tracked by the U.S. National Science Foundation has been 12,774, compared with 8,684 from Brazil, 13,746 from Korea, and 3,747 from Mexico. But, India is lagging behind China (27,816) and Russia (15,782). Within India, the largest share of India's scientific publishing is done by the Council of Scientific and Industrial Research (CSIR), followed by the seven Indian Institutes of Technology and the Atomic Energy Research Institute. Another indicator of R&D innovation, the number and frequency of citations of Indian publications has also been rising, indicating improved output and quality.

More precise output of innovative R&D products is patent rights granted. There has been a significant increase in patent applications filed in India. Between 1975 and 1995, patent applications in India totalled roughly 1,000 Indian filings and 2,000-2,500 foreign filings a year. By fiscal year 2004-05, there has been more than 3,600 Indian applications, more than 3,100 foreign applications, and more than 10,000 PCT filings directed at India. Further, the share of Indian patent applications in the United States though small is rising significantly in recent years. The share of Indian patent applications in the United States rose from 0.04percent of the worldwide total in 1995 to 0.37 percent in 2004.A ranking of patents granted in the United States between 1995 and 2004 showed India in 24th place. India appears better at producing basic knowledge (scientific and technical journal articles) than commercialisable (patents) knowledge.

Trade and FDI openness are positively associated with innovation. Export orientation and foreign ownership are strongly and positively correlated with developing new products as the output proxy for innovation. Export orientation is also positively associated with absorption of knowledge. Reforms since the mid-1980s, and particularly since 1991, have liberalised India's FDI regime, with most FDI going to electrical equipment (electronics and information technology), telecommunications, transport (automobiles and automotive components), chemicals and pharmaceuticals, and the service sector (financial, information technology, and business process outsourcing services), with most recently a focus on the R&D side of these sectors.

Developments in endogenous growth models draw attention to endogenous technological change to explain the growth, shifting the focus from accumulation of wealth as maintained by the neoclassical growth models. Romer (1986) has put forward the first step that research and development enhance economic growth by incorporating technological progress as an important source of growth factor. Evidences also show that modem economic growth rapidly increases by upgradation of technology and scientific knowledge. Further, it is estimated that from one third to one half of the growth experienced by the industrially advanced countries have come up from the technological progress. Thus, technology has emerged as the principal driving force for long-run economic growth.

The different R&D based growth models of economics growth like Romer (1986; 1990), Lucas (1988), Barro (1990; 1991), Grossman and Helpman (1990; 1991b), and Aghion and Howitt (1998) share a prediction of 'scale effect' (Jones, 1999; 2002). The positive spill overs or externalities stem from knowledge capital (Romer), public services (Barro), human capital (Lucas) or product and process innovations (Grossman and Helpman). For example, if the level of resources devoted to R&D-measured, say, by the number of scientist engaged in R&D – is doubled, then the per capita growth rate of output also doubles, at least in the steady state. Ulku (2007b) observes that in R&D based growth models innovation is created in the R&D sector and it enables sustainable economic growth, provided that there are constant returns to innovation in terms of R&D.

Coe and Helpman (1995) find that among OCED countries the domestic R&D capital stock has significant effect on the total factor productivity. Rodriguez-Pose (2001) and Rodriguez-Pose and Crescenzi (2008) explain that higher research and development expenditure has a strong effect on GDP per capita output growth and lower research and development activities tend to have a lower GDP per capita output growth. Bebczuk (2002) finds that research and development on education has a positive impact on GDP per capita growth. Lederman and Maloney (2003), tracing the evolution of research and development (R&D) expenditure along the development process using new global panel data, show that R&D effort measure as a share of GDP rise with development at an increasing rate and that protection of intellectual property right, ability of mobilise government resources, and research institution quality are the main reasons why R&D effort rise with level of development. Ulku (2007a), employing panel data techniques on patent and R&D data for 20 OECD and 10 Non-OECD countries for the period 1981-97, finds that innovation has a positive effect on per capita output of both developed and developing countries. Philip (2006) analyses research and development expenditure and per capita GDP growth in India using sectoral data for the period 1950-2006.The empirical results show that there exists a long run positive relation between the R&D expenditure and GDP per capita growth in India. Yaman and Tiken (2008) argue that economic growth can only be sustained through improvements in technology. This technology is implemented through R&D expenditure by information society. The study observes that the returns to R&D are higher for developing countries compared to the development countries.

The recent growth models emphasise that technological innovation lead to increase the GDP per capita growth of the developed and developing countries. This study tries to understand the effect of technological innovation, especially R&D expenditure, on economic growth and the channel of such influence. The main objectives of this paper are to identify and estimate the effect of research and development expenditure on per capita GDP growth, and to examine the R&D spill overs effect on GDP per capita growth.

A Brief Review of Literature

The wide and growing literature on endogenous growth theory suggests that research and development expenditure and R&D spill over have positive and significant

impact on GDP and per capita income growth. Also, a consensus has emerged following a vast array of research on the effect of innovation, whether measured by R&D spending, patenting, or innovation counts, on productivity that innovation has a significant effect on productivity at the levels of firm, industry and country. The elasticity of output with respect to R&D is usually between 0.05 and 0.1, and that the social rate of return to R&D is between 20 and 50 percent.

Cameron (1996) examines the effect of R&D, innovation, patents and technological spill overs at the industry and national level. Focusing on theoretical and empirical part of research and patent activity on economic growth, it is shown that technology has significant impact on economic growth. The study also finds that the spill overs that occur in the innovation process are large and significant. The study suggests that technological spill overs are important especially spill overs in higher education play an important role in economics growth.

Devarajan and Swaroop (1996) study the link between various components of government expenditure and economic growth of developing countries during the period 1970-1990. The focus of the study is on how the government productive and unproductive expenditure influence long run per capita GDP growth. The study uses pooled data of total government expenditure on defense, education, health, transport and communication. The paper also attempts to examine the endogeneity and reverse causality problems associated with public expenditure and economic growth. The empirical results show that the government total expenditure has a positive impact on the GDP per capita growth. A unit increase in total government expenditure leads to an increase of 0.05 percent per capita output growth. The expenditure on defence and infrastructure are negatively related with per capita GDP growth. The expenditure on education and health also have negative effects on growth. The negative coefficients need not necessarily mean that such expenditures are unproductive, instead they mean that in slow growing economies they are inadequate to impact positive growth and they need to spend more on the social and infrastructure sectors to grow faster. The implication of the findings of the study are that governments of developing countries are misallocating the public expenditure in favour of capital expenditure at the expenses of current expenditure and therefore the development countries have to focus on budget policy reforms.

Bertucci (1999) focus on one aspect of government's role in technological change, public policies towards research and development using data from 25 OECD countries during the period 1960-1990. The study describes recent trends in public expenditures on R&D, economic role of R&D and the rationale for a substantial government involvement in the R&D process. Although, the OECD countries spend a larger R&D expenditure on general science, health, transportation and other fields, few countries provide more R&D expenditure on agricultural sector. The study finds that that R&D spending grew rapidly in the OECD economies from the 1960s through the 1980s, as a result gross domestic product (GDP) increased 2 percent to 2.4 percent. The study concludes that although R&D makes an important contribution to economic growth, unresolved issues remain regarding

the role of government, the relative importance of basic and applied R&D, and the mechanisms by which R&D is most effectively transmitted to economic growth.

Freire-Seren (2001) conducts a theoretical and empirical analysis on R&D expenditure and per capita GDP growth using cross country data during the period 1970-1990. The estimated result for the effect of R&D expenditure growth on growth of GDP per capita is 0.08; 10 percent increase in R&D expenditure will lead to increase 0.8percent of per capita GDP growth rate. The study also finds that human capital, measured by year of schooling, has a positive and significant impact on GDP per capita growth; ten percent increase in human capital increase per capita GDP growth by 1.9 percent.

Rensman and Kuper (1999) examine the role of R&D and patent activity in economic growth using the cross country panel data, from Germany, France, the United Kingdom and the United States of America, over the period 1957-1991.Data on patents is taken as new knowledge that a country is ready to gain or adopt new knowledge. The study finds that R&D expenditure and patent activity have positive effect on growth. The results show that in USA technology plays important role in economic growth, the coefficient is 0.63 and significant. However, the patent and R&D effect in France are negative. The study concludes that patent and R&D play significant role for economic growth, but that R&D expenditures and patenting activity do not capture all forms of knowledge.

Thompson and Rushing (1996) analyse the link between patent protection and economics growth using 112 cross country data for the period 1970-1985. The study focuses on economic stagnation or slow growth issue between some developing and underdeveloped countries that arise due to lack of strong intellectual property rights. The study observes a positive and significant relationship between patent protection and economic growth in developing countries with per capita income more than $3,400, whereas in less developed countries with per capita incomes less than $3,400patent protection has no impact on economic growth. The study concludes that fewer developing countries would not benefit from strong protection, until achieving a significant level of development.

Bassanini and Scarpetta (2001) study the long-term links between policy settings, institutions and economic growth in OECD countries controlling for underlying differences in technological progress. The focus is on the possible influences of human capital, R&D activity, macroeconomic and structural policy settings, trade policy and financial market conditions on economic efficiency and the effects of many of the same factors on the accumulation of physical capital. The panel fixed effects model estimates identify that accumulation of physical as well as human capital are the main drivers of economic growth. In addition, R&D activity, a sound macroeconomic environment, trade openness and well-developed financial markets contribute to raise living standard in OECD countries. The R&D investment has a positive impact on GDP per capita output. The coefficient of R&D investment implies that 1 percent increase in R&D intensity would have a long-run effect of about 1.2 per cent higher GDP per capita output in OECD countries.

Van Pottelsberge and Guellec (2004) focus on the contribution of technological change to multifactor productivity growth in 16 major OECD countries over the period 1980-98. The study employing the error correction model and 3SLS finds that domestic R&D expenditure has significant and positive impact on multifactor productivity. In the long run government university research increased productivity around 0.17 percent. This is much higher than the ratio of public performance business GDP which show that overall public R&D is very valuable to the economy.

Szarowska (2001) try to identify basic activities which can stimulate cooperation of the public and the private sector R&D expenditure and economic growth of the Czech Republic during the period 2000-2005The study finds that a serious problem of the Czech knowledge economy is the lack of research workers and qualified professionals in the business sector, which limits the research and innovation activities. One of the causes of this situation is the lack of mobility of research workers between academic sites and entrepreneurial entities. The study suggests that to develop economic activity it is necessary to increase cooperation of research and educational institutions with the business sphere, improve the connection between the public research and the private sector, and support transfer of knowledge.

Lederman and Maloney (2003) trace the evolution of R&D expenditure along the development process to understanding the link between innovation and development using global panel data. The study shows that R&D effort measure as a share of GDP rises with development at an increasing rate. Their striking finding is that some countries like Finland, Israel, Korea and China have displayed impressive R&D take-offs, not because of over-investment in R&D but due to the high social rate of return for R&D expenditure. In an attempt to explain why rich countries invest more in R&D than poor countries, the study finds that financial depth, protection of intellectual property right, ability of mobilised government resources, and research institution quality are the main reasons why R&D effort rises with level of development.

Ulku (2007a) employs various panel data techniques on patent and R&D data for 20 OECD and 10 Non-OECD countries for the period 1981-1997. The study finds that innovation has a positive effect on per capita outputs of both developed and developing countries. However, only the large market OECD countries are able to increase their innovation by investing in R&D and the remaining OECD countries need to promote their innovation by using the know-how of other OECD countries. One percent increase in innovation raises per capita income by around 0.05 percent in both OECD and non-OECD countries, while a 1percent increase in R&D stock increases innovation by about 0.2 percent only in large market OECD countries. Although these provide strong evidence for R&D based growth models, it suggests that innovation is endogenously created in the economy and it promotes economic growth, it lacks the support for constant returns to innovation with respect to R&D. This implies that innovation, like capital stock, leads to only short term increases in the growth rate of output, and is not able to explain perpetual economic growth.

Yaman and Tiken (2008) examine the returns to R&D in 60 countries covering the period 1960-2000employing OLS and panel data analysis. The study finds that poor countries have higher returns on R&D.

Samimi and Alerasoul (2009) analyse the effect of R&D expenditure on economic growth in developing countries over the period of 2000-2006employing fixed and random effect models. The study estimates show that the coefficients of labour and capital are positive and significant but the R&D expenditure variable coefficient has been negative and insignificant. The study argues that because of low R&D expenditure in developing countries the effect of R&D on per capita GDP growth is insignificant.

For India, Philip (2006) examines relationship between R&D expenditure and per capita GDP growth in India using sectoral data for the period 1950-2006 employing the Granger causality test. The study finds that, on the basis of the trace value, R&D and GDP are cointegrated, and that R&D expenditure is significant at 5 percent level but GDP is insignificant. This empirical evidence shows that the R&D expenditure in India causes economic growth in the long-run.

Mohapatra and Sahoo (2008) focus on the trends and patterns of agricultural research and development expenditure in India over the period 1960-2005.The study observes an increasing trend in real R&D expenditure in agriculture both by centre as well as states and no evidence for private sector contribution. Within agricultural research investment, there exists inequality in favour of the irrigated areas as most of the technologies developed are skewed towards the well endowed regions. The study finds that India agriculture R&D expenditure helps to increase the per capita output growth.

Herstatt, Tiwari, Buse and Ernst (2008) focus on R&D innovation system of India at different region of India, like Delhi, Mumbai, Pune and Bangalore over the period of 1991 to 2008. The study finds that IPR and availability of skilled labour play important role in India in attracting R&D activity. Further, the study finds that R&D effort is declining in Indian due to the magnitude of growth, raising property rights and the resulting demand for skilled labour.

With regard to R&D spill overs, Luintel and Khan (2004) study the trade related R&D spillover and economic growth using panel data for G7 countries over the period 1965-1999 employing time series and panel data methods. The study finds that Japanese R&D benefits all members of G7 except the US but only in a marginal way. A 1percent rise in Japanese R&D stocks increases the output of all members of G7 by 0.015 percent except the US where it hurts US output by 0.056 percent. The net spillover generation from Japan is negative (-0.04) percent, whereas Japan benefits mainly from the US. The US and Germany are the main spillover generators. The study concluded that R&D spillover of the G7 countries have positive effect on GDP growth.

Coe, Helpman and Hoffmaister (2009) focus on the impact of R&D spillover on total factor productivity applying panel co-integration method. The study finds that institutional factors are important determinants of economic growth, in particular, the impact of

institutional factor on the degree of R&D spillover and the contribution of R&D capital to total factor productivity. Countries where the case of doing business and the quality of education system are relatively high tend to benefit more for their own R&D effort, from R&D spillover and from human capital formation, Strong R&D participation is associated with higher level of total factor productivity.

Le and Bodman (2007) examine the R&D spill overs and GDP per capita growth of 50 developing countries using panel regression over the period 1980-2000. The focus is on the R&D spill overs through the specific channel of the emigration of high skilled workers from developing countries to more developed countries. In addition, the study also examines the role of remittances in driving economic growth in developing countries. The study finds that the coefficient of R&D spill overs on GDP growth is significantly positive at 5 percent level while that of remittances is highly significant at 1 percent level. This reflects that the impact of remittances on economic growth is more direct and more immediate than that of R&D spill overs. In addition, the benefit from R&D spill overs is very much dependent on a country's capacity of adoption and implementation of new technologies.

The brief literature review shows that most of countries continuously increase the R&D expenditure to increase economic growth. The studies identify that R&D expenditure, patent and intellectual property rights, expenditure on education and infrastructure, that provide new technology and knowledge, play important roles to accelerating income growth. A comparative and stable R&D expenditure policy can be an effective tool for promoting R&D innovation and accelerating economic growth. Another important step in designing an effective R&D expenditure policy is to learn from the mechanism and experience in other countries where successful high R&D innovation outcomes are experienced.

Theoretical Model

Modern endogenous growth theories draw attention to endogenous technological change to explain the growth patterns of world economies. A number of authors have suggested that new ideas are the engine of growth. According to the new growth theory, pioneered by Romer (1986), technological innovation is created in the R&D sectors using human capital and the existing knowledge stock. It is then used in the production of final goods and leads to permanent increases in the growth rate of output. At the heart of these models is their postulation that endogenously determined innovation enables sustainable economic growth, given that there are constant returns to innovation in terms of human capital employed in the R&D sectors. Therefore, R&D is a key long-run determinant of productivity and economic growth. R&D constitutes the search for new technology and therefore new goods, and the central purpose of growth theories is to understand the factors behind long-run growth and to explain differences in growth performances of economies. In the neoclassical growth model of Solow (1957), the long run growth rate of the aggregate capital accumulation completely depends on the exogenous technological progress and population growth rate. To study endogenous economic growth, many models

(Romer, 1986; Aghion and Howitt, 1998; Grossman and Helpman, 1991b; Jones, 2002) use technological progress as a production process like production of output.

The empirical models build on the R&D based growth model of Romer (1990). Romer's model is based on three premises: (i) growth is driven by technological change, (ii) technological change arises as a result of intentional actions taken by people who respond to market incentives, and (iii) patent (designs) used to produce new products are non-rival i.e. they can be replicated with no additional cost. The model has three sectors: research and development (R&D) sector, intermediate goods sector, and final output sector. The final output is produced according to Cobb-Douglas production function:

$$Y(H, L, X) = H^{\alpha} L^{\beta} \int_0^{\infty} X_i^{1-\alpha-\beta} di \quad (1)$$

where H, L, x are respectively human capital, labour and producer durables. Each producer durable is produced by a monopoly in the intermediate goods sector using λunits of forgone consumption and the design of that durable is bought from R&D sector. The creation of new designs in R&D sector evolves according to the following equation,

$$A^0 = \delta H_A^{\theta} A \quad (2)$$

where H_A is total human capital in R&D sector, A is knowledge stock and A^0 is the new designs (technological change or innovation). The most crucial postulation of the Romer's model that leads to sustainable economic growth is the fact that production of new designs is linear in human capital employed in the R&D sector and knowledge stock i.e. θ=l, as per the Romer's growth model in order for the growth rate of output to grow continuously. This has two implications: first, devoting more human capital to research leads to a higher rate of production of new designs, and second, the larger the total stocks of designs and knowledge are, the higher the productivity of a skilled scientist in the research sector. After a new design is produced, it enters into an economy in two distinct ways: a new design enables the production of a new intermediate good that can be used to produce output, and it also increases the total stock of knowledge and the productivity of human capital in the research sector.

Total capital evolves according to the following equation:

$$K(t) = Y(t) - C(t) \quad (3)$$

Because it takes λunits of forgone consumption to create one unit of any type of producer durable, this accounting measure of K is related to durable goods that are actually used in production by the rule:

$$K = \lambda \sum_{i=1}^{\infty} X_i = \sum_{i=1}^{A} X_i \quad (4)$$

Because of the symmetry in the model, all available durable goods are supplied at the same level and can be denoted as X. Since A determines the range of durables that

can be produced, and since λunits of output are required per unit of durable goods, it is possible to solve for X from the equation that K=λAX. Substituting X=K/λA into the production function in equation (1) results in the final form of the production function in Romer's model:

$$Y(H, L, X) = (H_Y A)^{\alpha}(LA)^{\beta}K^{1-\alpha-\beta}\lambda^{\alpha+\beta-1} \quad (5)$$

Increasing returns to scale arises in both R&D and final output sectors because both sectors use non-rival knowledge stock A as an input. Stock of knowledge A enters into the R&D sector directly and into the final good production process indirectly through knowledge spill overs. The most important implication of this model is that countries can attain perpetual economic growth by promoting R&D sector and investing in human capital.

In the empirical analysis, the human capital in the R&D sector (H_A) and flows of innovation (A^0) are measured by R&D expenditure (R&D stock) and patent applications (patent flows) respectively. Both R&D stock and patent flows have been normalised by labor series to control for the size of the economy. In the literature, the knowledge stock, H_A has been taken into account using different techniques: (i) the R&D expenditure proxy for knowledge accumulation over time as well as the human capital in the R&D sector, (ii) the first lag of patent flows in the panel data analysis can serve as an instrument for knowledge, (iii) the differences in the levels of knowledge stock across states are accounted for in both fixed effects and random effect analyses. Other variables included in the regression analysis are expropriation imports of manufacturing goods as share of total trade in manufacturing goods and the share of Indian trade in the NSDP of each state. The imports of manufacturing goods account for technology spill overs and the share of Indian trade controls for the effect of economic alliance with the states on the numbers of patent. Applications made in the Indian Patent Office by the inventors of different states and university enrolments are included in the analysis to capture the effect of overall human capital of India on innovation level.

In the study of endogenous growth model, where technological change is essential for economic growth, the technological innovation is created in the research and development sectors by human capital. Similarly, R&D spill overs measured by patent activity is also a part of human capital. The significant positive implication of the model is that an economy with a large stock of human capital will experience faster growth. The model also suggests R&D spillover may help less developed countries to derive growth benefits from the rest of the world.

Data and Econometric Methodology

This paper uses data for 17 states of India for the period 1998 to 2008 with 170 observations. The data has been obtained from various sources. The data on GDP and per capita GDP, growth rate of GDP and expenditure on education has been obtain from the Centre for Monitoring the Indian Economy (CMIE). The data on exports, imports and FDI

has been taken from RBI bulletin. The data on R&D expenditure has been taken from Indistat.com. The R&D expenditure is defined as total expenditure on R&D performed on national territory during a given period, which includes the R&D performed within a country and funded from abroad but excludes payments made abroad for R&D. It comprises R&D expenditure of business enterprises, government sector, higher education and non-profit firms. The patent data has been obtained from Economic Survey of India. The data provide detail information on the number of patent applications filed at the Indian Patent Office by domestic residents. The 17 states of India have been classified into two groups on per capita income basis as developed states with percapita income more than the national average of Rs.16595 and less developed states with per capita income less than Rs. 16595.

The Table 1 shows the mean and standard deviation of variables used in the empirical analysis. The log of mean R&D expenditure in developed states is 4.465 whereas the less developed states mean R&D expenditure is 3.811 showing the gap between the two groups of states of India. The mean patent is more in developed states of India, the mean value is 3.76 and in less developed states the mean value is 2.61. In the less developed states, R&D expenditure is also low, 3.81 compared to the 4.47 of the developed states.

Table 1. Descriptive Statistics of Variables in R&D Expenditure Analysis

Variable	India	All 17 states	Developed states (in log)	Less developed states (in log)
GDP/NSDP (at constant prices)	1829098.00 (618234.30)	85323.60 (68264.58)	11.26 (0.85)	10.86 (0.85)
GDP/NSDP per capita	34630.22 (66099.04)	16594.98 (7080.79)	9.95 (0.29)	9.33 (0.43)
GDP/NSDP growth rate	6.46 (2.12)	5.97 (4.58)	1.76 (0.61)	5.56 (5.42)
R&D expenditure (at constant prices)	13836.92 (7644.29)	72.35 (47.27)	4.47 (0.47)	3.81 (0.53)
Patent	-	132.24 (268.57)	3.76 (2.31)	2.61 (1.97)
Development expenditure (centre and states)	298269.60 (182240.00)	-	-	-
FDI	46685.44 (61844.87)	-	-	-
Enrollment/Education expenditure	6973451.00 (2155543.00)	3401.43 (2198.24)	7.96 (0.66)	7.95 (0.62)
Exports	219877.30 (184275.00)	-	-	-
Imports	292972.80 (283051.60)	-	-	-
Employment	-	73.57 (55.10)	4.35 (0.76)	3.76 (0.72)
Infrastructure Expenditure	-	394.42 (266.75)	5.95 (0.74)	5.46 (0.95)
Expenditure on Institutions	-	1442.95 (921.50)	7.04 (0.66)	7.04 (1.20)
Agglomeration	-	225.33 (288.01)	4.64 (1.23)	4.90 (1.18)

Empirically, the effect of R&D expenditure on per capita GDP is estimated by OLS, and at the states level on NSDP by panel fixed effects and random effects methods. The estimating linear regression model is specified as,

$$Ln\ (GDPper\ capita)_t = \beta_0 + \beta_1 ln(R\&D\ Expenditure) + \beta_2 ln(GDP) + \beta_3 ln(FDI) + \beta_4 ln(Development\ Expenditure) + \beta_5 ln(Enrollment) + \beta_6 ln(Exports) + \beta_7 ln(Imports) + u_t \quad (6)$$

The OLS estimates are presented in Table 2. The estimated results show that the effect of R&D expenditure on per capita income is negative and it is significant at 1 percent level. The low R&D investment may be the reason for such negative effect on per capita income growth, as shown by Samimi and Alerasoul (2009). The effects enrolment, imports

and foreign direct investment on per capita GDP growth is positive and significant, while the effect of exports is negative. A one unit increase in FDI increases per capita income by o.37 percent. Similarly, the effect of enrollment, the measure of human capital of the economy, is strongly positive. However, the positive and significant effect of patents on per capita income implies a raise in income by 0.11 percent with R&D spill overs. The effect of development expenditure on per capita GDP is also significantly positive. A percentage increase in investment development expenditure increases per capita income growth by 0.134 percent. The results suggest that strong patent activity tends to boost incentives to innovate and hence effective enforcement of intellectual property rights is an effective strategy to stimulate technological progress in India.

Table 2. The OLS Estimates of Effects of R&D Expenditure and R&D Spill overs (Patent) on per capita GDP of India

Dependent variable: Ln (per capita GDP)

Variable	R&D Expenditure	R&D Spill overs
ln(R&D expenditure)	-0.274* (4.40)	-
ln(Patent)	-	0.112* (2.68)
ln(GDP growth rate)	0.632** (2.29)	-0.009 (0.46)
ln(Development expenditure)	0.068 (0.02)	0.134** (2.52)
ln(FDI)	0.369*** (1.97)	0.001 (0.009)
ln(Enrollment)	1.946* (3.27)	-
ln(Exports)	-0.943* (3.34)	-0.221*** (1.88)
ln(Imports)	0.367 ***(1.97)	0.302* (3.55)
Constant	-3.454** (2.20)	6.188* (22.86)
R-square	0.94	0.95
F	17.38	638.84

Note: Absolute t-values in parentheses. * significant at 1 percent level ** significant at 5 percent level *** significant at 10 percent level.

The panel data models control the problem of bias caused by unobserved heterogeneity between the states. The panel models also capture the dynamics that are difficult to detect with cross-sectional data. The fixed effects model takes individual state effects is constant in the regression equation. The FE model is specified as,

$$Y_{it} = \alpha_i + \beta_j X_{jit} + \eta_i + u_{it} \quad (7)$$

where η_i term is presumed to capture the unobservable, and non-measurable characteristic that differentiate states and $E(u_{it}|X_{jit}) = 0$. In the fixed effect model η_i are fixed over the time and represents a parametric shift of the regression function varying from individual to individual, while slope parameters are constant in both individual and time dimension. The random effects model also known as error correction model includes a non-measurable stochastic variable which differentiates individual states. The η_i effect is random individual rather than fixed. The RE model is specified as:

$$Y_{it} = \alpha + \beta_j X_{jit} + \varepsilon_{it} \quad (8)$$

where $(\varepsilon_{it} = \eta_i + u_{it}), E(\varepsilon_{it}|X_{jit}) = E(u_{it}|X_{jit}) = 0$ and $E(\varepsilon_{it}^2|X_{jit}) = (\sigma_\eta^2 + \sigma_u^2)$.

If it is assumed that η_i and Xs are uncorrelated random effects model is appropriate, whereas η_i and Xs are correlated then fixed effect model is appropriate. Further, if the number of time series data is large and the number of cross-section units is small, fixed effects is efficient, whereas if N is small and T is large random effects estimator is more efficient then fixed effects estimator.

The estimating panel data regressions follows the framework of Romer (1990) where real per capita growth rate of GDP is related to the initial levels of state variables, such as R&D expenditure, expenditure on education and infrastructure. The empirical panel model is specified as:

$$Ln\ (GDPper\ capita)_{it} = \beta_0 + \beta_1 ln(R\&D\ Expenditure) + \beta_2 ln(NSDP) + \beta_3 ln(Patent) + \beta_4 ln(Employment) + \beta_5 ln(Infrastructure) + \beta_6 ln(Institutions) + \beta_7 ln(Agglomeration) + u_{it} \quad (9)$$

The Table 3 presents the panel estimates of R&D expenditure on per capita income. The OLS estimates how that R&D expenditure has a positive and significant effect on per capita income with a coefficient of 0.451. Surprisingly, education has a negative impact on per capita income which may be due to low levels of investments in education and poor returns to human capital. In the panel estimation, the results show that R&D expenditure has a positive but insignificant effect on per capita income. The effect of education is significantly positive in fixed effects model, and an insignificant low effect in random effects model. The positive contribution of infrastructure variable is significant at 1 percent level suggesting a conducive institutional setup such as intellectual property rights, patent protection, recognition and rewards for innovation, and protective and efficient legal systems that is necessary for the R&D expenditure to have an impact on economic growth. This is evident from the positive and significant effect of R&D expenditure on per capital NSDP of developed states compared to insignificant effects in less developed states, as shown in the random effects estimates presented in Table 4. In the developed states of India, an increase in R&D expenditure increases per capital NSDP by 0.53 times, but in less developed states the effect is only 0.14.

The endogenous growth theory suggests that there is a strong relationship between patent activity (R&D spill overs) and economic growth by stimulating productivity growth. The Table 5 presents the estimated results for patent activity and per capita income in all 17 states. The estimated effect of patent on per capita income of states is positive and statistically significant in all three estimation methods. The OLS estimate shows that ten percent increase in patent activity will lead to an increase of 1 percent increase in per capita income. The panel estimates show that a unit increase in patent increases per capita income in states between 0.06 and 0.08. Similarly, the effect of education on per capita income in states is also positive and statistically significant in all specifications, and employment also increases per capita income in states of India. However, the effects of infrastructure, institutions and agglomeration on income per capita are negative in both OLS and panel estimates, showing the significant role of infrastructural and institutional factors in

promoting patent activity and R&D spill overs. The coefficients of infrastructure and institutions are statistically significant. The results imply that a vibrant economic environment is therefore necessary to spread the externality effects generated by knowledge growth and innovation. Again, the necessity of enabling environment to innovation and knowledge spill overs through patent activity to have impact on per capita income is brought out clearly by the differential effects of patent in developed and less developed states of India (Table 6). While the positive effect of R&D spill overs on per capital NSDP of developed states is statistically significant, the effect of patent on per capita income in less developed states is negative and insignificant. In the developed states of India, a ten percent increase in patent activity increases per capital NSDP between 1.1 and 1.7 percent. The patent activity has no impact on per capita income in less developed states of India.

Table 3. Panel Estimates of Effects of R&D Expenditure on per capita NSDP of States of India

Dependent variable: Ln (per capita NSDP)

Variable	OLS	Fixed effects	Random effects
ln(R&D expenditure)	0.451* (7.66)	0.008 (0.12)	0.943 (1.39)
ln(GDP)	0.122* (3.24)	0.070** (2.49)	0.083* (2.83)
ln(Education)	0.581* (7.78)	0.264** (2.31)	0.002 (0.62)
ln(GDP growth rate)	0.124* (4.12)	0.068* (3.68)	0.082* (4.30)
ln(Employment)	-0.044 (0.79)	-0.020 (0.30)	-0.015 (0.24)
ln(Infrastructure)	0.054*** (1.68)	0.033 (1.06)	0.059*** (1.88)
ln(Institutions)	0.044 (1.52)	0.067* (3.38)	0.066* (3.11)
ln(Agglomeration)	-0.009 (0.38)	-0.019 (0.96)	-0.023 (1.11)
Constant	10.100* (18.91)	5.941* (9.53)	7.281* (12.37)
R-square	0.68	0.74	0.73
F statistic/Wald chi	38.01	45.50	365.91
N	170		

*Note: Absolute t-values in parentheses. * significant at 1 percent level ** significant at 5 percent level *** significant at 10 percent level.*

Overall, the estimated panel fixed and random effect models for the effects of R&D on per capita income of states of India during the1998-2008 show that the R&D spill overs effect is more dominant that the R&D expenditure effects. Such effects are stronger in developed states than in less developed states. The innovations to have some effects on income, it seems that proper infrastructure facilities and enabling institutions that promote, protect and reward innovations and patents matter a lot.

Table 4. Panel Estimates of Effects of R&D Expenditure on per capita NSDP of Developed and Less Developed States

Dependent variable: Ln (per capita NSDP)

Variable	Developed states		Less developed states	
	Fixed effects	Random effects	Fixed effects	Random effects
ln(R&D expenditure)	0.091 (0.87)	0.532* (3.19)	0.039 (0.42)	0.139 (1.56)
ln(GDP)	0.667 (1.33)	0.005* (3.19)	0.081*** (2.04)	0.210* (4.49)
ln(Education)	0.326** (2.05)	0.478* (4.11)	0.100 (0.55)	0.385* (2.82)
ln(GDP growth rate)	0.032** (2.02)	0.067* (3.00)	0.074* (2.80)	0.116* (3.01)
ln(Employment)	0.134*** (1.75)	0.031 (0.91)	-0.105 (1.02)	-0.376* (4.04)
ln(Infrastructure)	-0.604 (0.15)	0.313 (0.91)	0.129 (1.41)	0.146*** (1.77)
ln(Institutions)	0.082* (4.99)	0.091* (3.60)	0.073* (3.06)	0.100* (3.07)
ln(Agglomeration)	0.046 (1.42)	-0.009 (0.38)	-0.032 (1.18)	0.046 (1.42)
Constant	5.623* (7.53)	11.065* (16.74)	6.490* (6.75)	8.738* (10.06)
R-square	0.88	0.72	0.67	0.53
F statistic/Wald chi	64.22	164.13	16.40	116.57
N	80		90	

*Note: Absolute t-values in parentheses. * significant at 1 percent level ** significant at 5 percent level *** significant at 10 percent level.*

Table 5. Panel Estimates of Effects of R&D Spill overs on per capita NSDP of States of India

Dependent variable: Ln (per capita NSDP)

Variable	OLS	Fixed effects	Random effects
ln(Patent)	0.109* (2.98)	0.081** (2.22)	0.068** (2.54)
ln(per capita GDP)	0.510* (3.15)	0.593** (2.41)	0.561* (2.91)
ln(R&D expenditure)	0.229 (1.61)	0.065 (0.32)	0.092 (0.54)
ln(Education)	0.335** (1.84)	0.761** (2.21)	0.636* (2.66)
ln(GDP growth rate)	0.066 (0.98)	0.077* (1.33)	0.076 (1.35)
ln(Employment)	0.577* (5.06)	0.114 (0.57)	0.301*** (1.92)
ln(Infrastructure)	-0.182* (2.86)	-0.176*** (1.90)	-0.178** (2.20)
ln(Institutions)	-0.036 (0.74)	-0.136* (2.95)	-0.114* (2.65)
ln(Agglomeration)	-0.033 (0.64)	-0.035(0.57)	-0.046 (0.81)
Constant	3.363*** (1.68)	1.083 (0.45)	1.623 (0.74)
R-square	0.59	0.45	0.45
F statistic/Wald chi	26.54	13.08	144.77
N	170		

*Note: Absolute t-values in parentheses. * significant at 1 percent level ** significant at 5 percent level *** significant at 10 percent level.*

Table 6. Panel Estimates of Effects of R&D Spill overs on per capita NSDP of Developed and Less Developed States

Dependent variable: Ln (per capita NSDP)

Variable	Developed states		Less developed states	
	Fixed effects	Random effects	Fixed effects	Random effects
ln(Patent)	0.117* (3.78)	0.177* (5.18)	-0.082 (0.86)	-0.019 (0.54)
ln(per capita GDP)	0.397 (1.31)	0.149 (0.60)	0.914* (4.01)	0.911* (4.29)
ln(R&D expenditure)	-0.243 (0.95)	-0.240 (0.98)	0.211 (1.01)	0.161 (0.83)
ln(Education)	1.410* (3.51)	0.205 (0.72)	0.043 (0.13)	-0.014 (0.05)
ln(GDP growth rate)	0.022 (0.38)	-0.034 (0.44)	-0.006 (0.45)	-0.006 (0.013)
ln(Employment)	-0.311 (1.58)	0.273** (2.38)	0.975* (4.68)	0.884* (4.60)
ln(Infrastructure)	-0.101*** (1.72)	0.049 (0.79)	-0.068 (0.32)	-0.070 (0.39)
ln(Institutions)	0.101 (0.59)	0.402** (2.23)	0.281* (3.48)	-0.239* (3.44)
ln(Agglomeration)	-0.081 (0.91)	-0.022 (0.25)	-0.136*** (1.73)	-0.138** (1.96)
Constant	-1.690 (0.68)	4.391 (1.57)	0.788 (0.26)	1.365 (0.48)
R-square	0.84	0.76	0.50	0.49
F statistic/Wald chi	35.86	3.96.69	7.85	83.13
N	80		90	

*Note: Absolute t-values in parentheses. * significant at 1 percent level ** significant at 5 percent level *** significant at 10 percent level.*

Conclusions

Research and development expenditure and the consequent innovations and R&D spill overs are crucial for modern economic growth. This paper has utilised a panel data from 17 states of India for the period of 1998-2008 to analyse the effect of R&D expenditure by centre and states and R&D spill overs on per capita income of India and states respectively. The OLS estimates of all India data show that R&D expenditure has negative impact on per capita income in India. Such negative result could be due to various reasons. As the R&D expenditure is just 0.83 percent in GDP, it may not induce any substantial innovation to have a significant effect on per capita income. The panel estimates also show that R&D expenditure has no impact on per capita income of the states in India. However, the random effects model shows a positive and significant effect of R&D on per capita income of developed states, the same is insignificant in less developed states. In the case of R&D spill overs analyses of states, the estimated results suggest that the effect of patent on per capita income of states is positive and significant. Again, the patent effect on income is positive and significant in developed states, but insignificantly negative in less developed states of India.

The empirical results of this model support the endogenous growth theory in that R&D spill overs contribute to economic growth. Further, the significant coefficients of infrastructure, institutions and education in the estimated results have straightforward theoretical as well as empirical implications. R&D expenditure in infrastructure and education development is necessary to generate R&D spill overs and thereby economic growth. Similarly, focus on institutional reforms to promote IPRs and patent regimes and legal regulations are important for realising the potential benefits of innovations and its spread. Primarily, the governments in India need to focus on R&D expenditure and innovation activities in agriculture, industry as well as in education sector, especially

technical education. Governments also need to formulate a favorable IPR law to protect patent activity not only in production but also in processing, designs and innovations.

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GEOSPATIAL ANALYSIS OF IMPACT OF LEATHER TANNING INDUSTRIES ON GROUNDWATER QUALITY FOR HUMAN USE IN DINDIGUL PANCHAYAT UNION, TAMIL NADU, INDIA

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Abstract

Groundwater is the portion of the precipitation that penetrates the soil and becomes a part of the Groundwater system. Groundwater is the major replenishable natural resource available to man. Groundwater is an important source of water supply throughout the world. Its use in irrigation, industries, municipalities and rural houses continues to increase. Shortage of Groundwater in areas where excessive withdrawals have occurred emphasize the need for accurate estimation of the available subsurface sources and of the importance of proper planning to ensure the continued availability of water supplies. Water resources have been the most exploited natural system since man strode the earth. On one hand rapid population growth, increasing living standards, wide spheres of human activities and industrialization have resulted in greater demand for good quality of water and while on the other, pollution of water resources is increasing steadily.Tanneries, being the most polluting of all the industries, discharge the highly contaminated waste water which affects the quality of groundwater. There were about 38 tannery units located in the study area, Dindigul panchayat union. The effluents that discharge from these industries penetrates the ground and has affected the quality of the groundwater. Hence in the present study, an attempt is made to analyze the impact of leather tanning effluents on groundwater quality for human use in Dindigul panchayat union, for a time period from 1988 to 2009. Groundwater samples are collected at 25 sample locations at random covering all the village panchayats in the study area. These Groundwater samples are subjected to chemical analysis to check the quality of Groundwater for human use and especially the critical parameters like-TDS, pH, BOD, COD, TH and based on the results, contour maps are developed for all parameters using ARC/MAP software.

Keywords: *Groundwater quality, Leather tanning industries, Chemical analysis, Critical parameters.*

Introduction

Water is one of the most important renewable resources on the earth. Groundwater is the major replenishable natural resource available to man. It is an important source of

water supply throughout the world. Its use in irrigation, industries, municipalities and rural houses continues to increase. Shortage of groundwater in areas where excessive withdrawals have occurred emphasize the need for accurate estimation of the available subsurface sources and of the importance of proper planning to ensure the continued availability of water supplies. Water resources have been the most exploited natural system since man strode the earth. On one hand rapid population growth, increasing living standards, wide spheres of human activities and industrialization have resulted in greater demand for good quality of water and while on the other, pollution of water resources is increasing steadily. Tanneries, being the most polluting of all the industries, discharge the highly contaminated waste water which affects the quality of groundwater. There were about 38 tannery units located in the study area, Dindigul panchayat union. The effluents that discharge from these industries penetrates the ground and has affected the quality of the groundwater. Hence in the present study, an attempt is made to analyse the impact of leather tanning effluents on groundwater quality for human use in Dindigul panchayat union, between 1988 to 2009.

Review of Literature

Singh (1988) has done a study on the quality of human water supplied to Jamelpur town, Bihar state. The water samples collected from the study area were compared with the prescribed limits of World Health Organization (WHO) and Indian Council for Medical Research (ICMR) and is found that the total hardness of the samples is observed to be much higher than the desired level. Anand (1995) has undertaken a study to analyze the impact of nitrate concentration on the Groundwater quality of Kaveri delta region and concluded that the higher nitrate concentration in the study area is a health-affecting constituent. Mahamaya Chattopadhyay et al., (1996) have analyse the Groundwater quality from samples collected during four periods in Killiar basin, southern Kerala. Hydrogen ion concentration (pH), Biochemical Oxygen Demand (BOD), Nitrate (NO_3), Total Suspended Solids (TSS) and Total Dissolved Solids (TDS) were analyse and the results show that the values of all the parameters are found to be higher than the tolerance limit. The report concludes that the human interferences in the form of eco-unfriendly landuse practices and sewage disposal from the city corporation were the major causes for the present situation in the study area.

Siddaraju et al., (1997) have made an attempt to study the chemical quality of Groundwater of Mysore city, Karnataka. Samples from 75 bore wells were tested and the results indicate that the concentration of Total Dissolved Solids (TDS), Magnesium (Mg), Bicarbonate (HCO_3), Nitrate (NO_3) and Sulphate (SO_4) are higher than the acceptable limit. The authors have concluded that the disposal of solid waste and open drain system are the major causes for the higher proportion of these pollutants. Shanmuga Sundaram (1998) has made an attempt to study the physical and chemical quality of 151 Groundwater samples to evaluate its suitability for domestic and other purposes at Thondamuthur union of Coimbatore district in Tamil Nadu. The water samples were checked for Electrical Conductivity (EC), Total Dissolved Solids (TDS), Hydrogen ion concentration (pH), Total

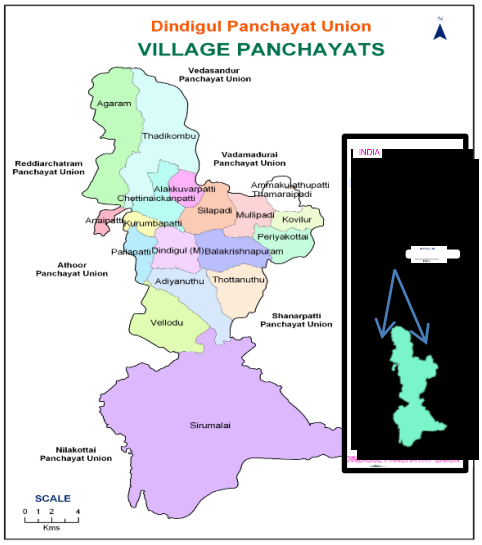
Hardness (TH), Nitrate (NO_3), Chloride(Cl^-), Iron (Fe), Fluoride (F^-) and Sulphate (SO_4). The results reveal that 139 samples have contaminants below the potable limit while 12 samples have contaminants exceeding the potable limit. The non-potability is due to the presence of higher percentage of Total Dissolved Solids (TDS), Total Hardness (TH), Chloride (Cl^-), Iron (Fe) and Nitrate (NO_3) content.

Tripathy (1999) has undertaken a study to monitor the water pollution caused by factories located in Krishna basin in Maharashtra state. The various water quality parameters including Hydrogen ion concentration (pH), Chemical Oxygen Demand (COD), Bio Chemical Oxygen Demand (BOD), Total Hardness (TH), Sulphate (SO_4), Sodium (Na), Calcium (Ca) and Magnesium (Mg) were studied from the river water samples for the period between 1984 and 1997. The results report that all the parameters are noticed to be above the tolerance limit during the period of study. The waste disposals from the sugar factories and distilleries are found to be the primary sources of pollution loads in the river basin. Bhagavan et.al., (2001) have analyse the Groundwater samples collected in bore wells and open wells in the earthquake rupture zone near Killari, Maharashtra. Hydrogen ion concentration (pH), Turbidity, Total Dissolved Solids (TDS), Alkalinity, Total Hardness (TH), Magnesium (Mg), Sodium (Na) and Chloride (Cl^-) were analyse. The authors have concluded that the concentrations of anions are found to be more than the acceptable level.

Mondal and Singh (2005), have attempted to develop a mass transport model to study the leather tannery pollutants in Dindigul town. Adekunle et al., (2007) have assessed the level of some physical, chemical, bio chemical and microbial water quality parameters and proved the seasonal variations and found that the well waters are not suitable for human consumption, as all the parameters are found above the desirable values. In this context, the present study envisages investigation on the groundwater quality status for human use in Dindigul panchayat union, for the year periods 1988 and 2009. Under these circumstances, the present paper aims to analyse the impact of leather tannery effluents on the groundwater quality for human use for the years 1988 and 2009.

Study Area

Dindigul panchayat union is situated in Dindigul District, Tamil Nadu. It lies between 10°14'45" and 10°31'00" North latitudes and 77°45' and 78°4'30" East longitudes covering the Survey of India (SOI) topographic map 58 F/14, F/15, F/16 and 58 J/3 extending over an area of 378.71 sq.km. The area consists of 18 administrative units i.e., village panchayats namely Adiyanuthu, Agaram, Alakkuvarpatti, Ammakulathupatti, Anaipatti, Balakrishnapuram, Chettinaickanpatti, Kovilur, Kurumbapatti, Mullipadi, Pallapatti, Periyakottai, Silapadi, Sirumalai, Thadikombu, Thamaraipadi, Thottanuthu and Vellodu. Among these, Sirumalai village panchayat is a hilly area located in the southern part of the study area (Figure 1).



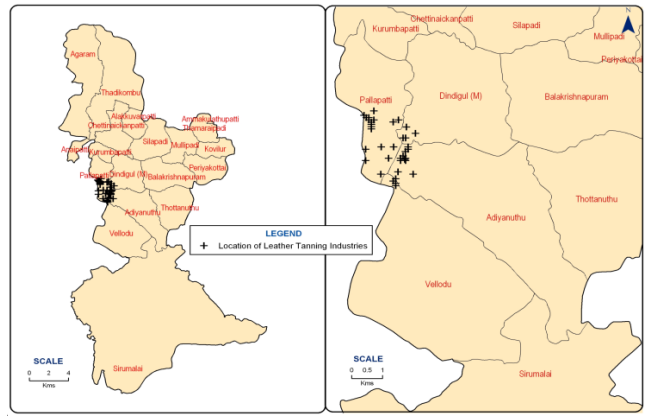


Fig. 1. Study Area Location **Fig. 2. Location of Leather Tanning Industries**

Location of Leather Tanning Industries

Out of the 61 leather tanning industries located in Dindigul District, 38 leather tannery units (62.3 percent) are located in Dindigul panchayat union. The 38 leather tannery units that are located in Dindigul panchayat union were captured using GPS (Global Positioning System) survey and mapped. These 38 leather tanning industries are distributed in Pallapatti (19), Adiyanuthu (12) village panchayat, Dindigul Municipality (4), and Vellodu (3) village panchayat. It is quite obvious that the leather tanning industries are concentrated in the central western part of the study area (Fig 2). In the study area the leather tannery industries may have an effect on the quality on goundwater and soil as they discharge about 6,88,000 litres to 15,48,000 litres per day of waste water with toxic effluents like, Chloride, Chromium, Nitrate, Sodium, Calcium, Magnesium, Copper, Iron etc. Since the effluents of the leather tanning industries have degraded the Human water quality, an attempt is made to analyze the groundwater quality for human use in Dindigul panchayat union.

Data Base and Methodology

In the present study, the groundwater quality for human use for the study area is assessed based on the groundwater data collected for two different year periods - 1988 and 2009. For the year 1988, the groundwater quality analysis data results were collected from the Groundwater Division, Public Works Department, Dindigul. For the year 2009, the sample locations are the same locations where the Groundwater Division and Public Works Department is periodically monitoring. The collected groundwater samples are subjected to chemical analysis to check the quality of groundwater for human use for 13 parameters

namely Hydrogen ion concentration (pH), Chloride (Cl^-), Nitrate (NO_3), Calcium (Ca), Magnesium (Mg), Sodium (Na), Total Dissolved Solids (TDS), Total Hardness (TH), Chemical Oxygen Demand (COD), Bio Chemical Oxygen Demand (BOD), Chromium (Cr^{6+}), Copper (Cu) and Iron (Fe). Based on the results obtained, contour maps are developed for all parameters using ARC/MAP software. Inverse distance weighted method is used to create groundwater quality maps. No distortion of isoline was interpolated. The Indian Standards for groundwater quality for human use is shown in Table 1. The methodology followed to assess the groundwater quality for human use in Dindigul panchayat union is shown in Flow Chart 1.

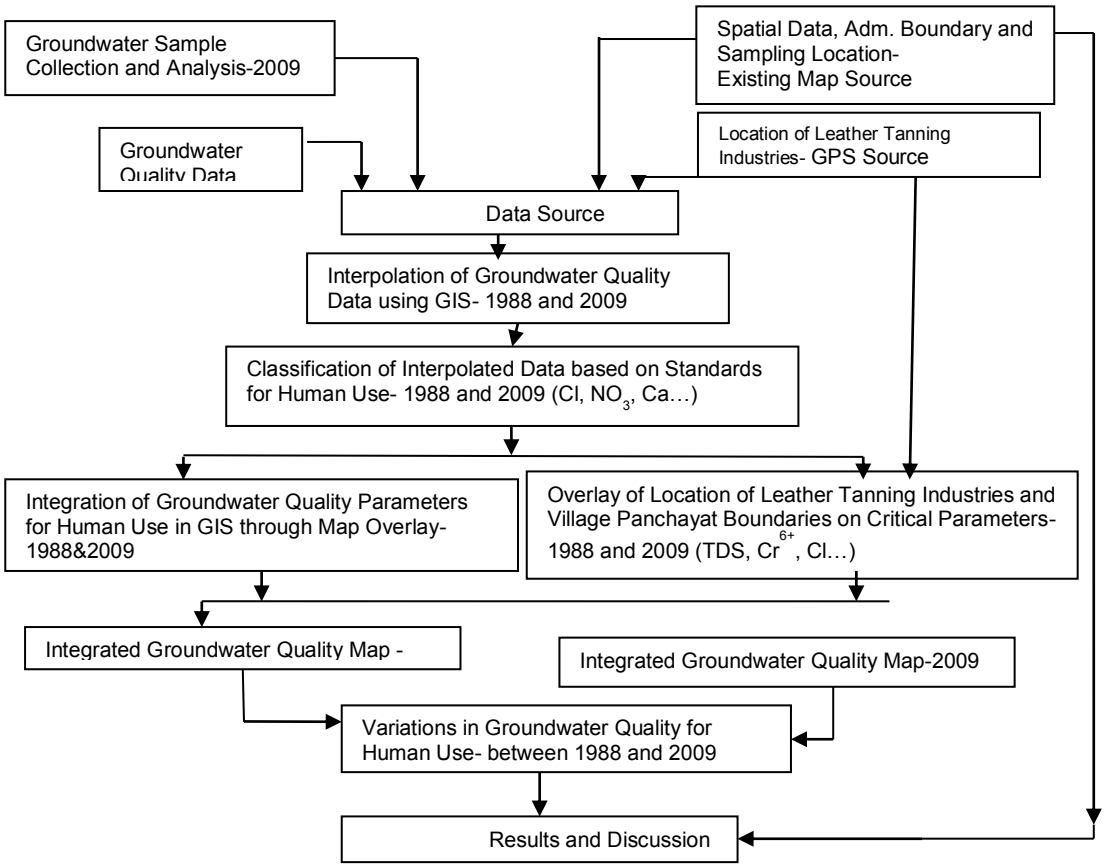


Chart 1. Methodology

Results and Discussion

1. Chemical Analysis of Various Parameters:

The chemical analysis of the groundwater quality for human use is shown in Table 1

Table 1. Groundwater Quality Analysis (Parameters, Standards, Classes, Years and Area)

Parameters	Good			Moderate			Poor		
	Standards	1988 sq.km	2009 sq.km	Standards	1988 sq.km	2009 sq.km	Standards	1988 sq.km	2009 sq.km
Chloride	**< 250**	11.55	6.65	**250-1,000**	368.27	119.16	**> 1000**	29.88	283.89
Nitrate	**< 45**	324.98	118.61	**45 -100**	84.72	215.67	**> 100**	-	75.42
Sodium	**< 200**	340.46	65.21	**-**	-	-	**> 200**	69.24	344.49
TDS	**< 500**	0.71	5.94	**-**	-	-	**> 500**	408.99	403.76
Calcium	**< 75**	34.88	13.70	**75-200**	344.16	175.03	**> 200**	30.66	220.97
Magnesium	**< 30**	-	7.01	**30-100**	37.53	53.73	**> 100**	372.17	348.96
TH	**< 300**	0.89	35.03	**300-600**	34.22	178.29	**> 600**	374.59	196.38
COD	**< 40**	403.93	347.63	**-**	-	-	**> 40**	5.77	62.07
BOD	**< 1.5**	14.73	21.61	**-**	-	-	**> 1.5**	394.97	388.09
Chromium	**< 0.05**	404.66	30.07	**-**	-	-	**> 0.05**	5.04	379.63
Copper	**< 0.05**	19.08	0.78	**0.05-1.5**	390.62	401.69	**> 1.5**	-	7.23
Iron	**< 0.3**	51.83	2.02	**0.30-1.0**	342.93	34.90	**> 1.0**	14.94	372.78

In assessing the groundwater quality for human use, each parameter is categorized into 3 classes such as good, moderate and poor based on the chemical constituents of the groundwater. If the concentration of the parameter is within the limit of tolerance value, then the area is demarcated as good (not affected). If the value is within the admissible level, then it is referred as moderate (moderately affected). And if the value exceeds the tolerance limit, then those areas are classified as poor (highly affected). Based on the chemical analysis of the groundwater quality for human use, the following inferences are derived.

Parameter within the Permissible Limit

The concentration of pH is noted to be within the permissible limit (6.5-8.5) throughout the study area in both the periods.

Parameters in which the Area Under Good has Decreased and Poor has Increased

The study of the distribution of chloride states that the area under good has decreased from 11.55 (2.82 percent) to 6.65 sq.km (1.63 percent) and the poor area has increased from 29.88 sq.km (7.29 percent) to 283.89 sq.km (69.29 percent). The concentration of sodium shows that the good class has decreased from 340.46 (83.10 percent) to 65.21 sq.km (15.92 percent) whereas the poor area has increased from 69.24 (16.90 percent) to 344.49 sq.km (84.08 percent) between the two periods. The spatial distribution of calcium reveals an increase in poor class from 30.66 (7.48 percent) to 220.97 sq.km (53.94 percent) and decrease in good area from 34.88 (8.52 percent) to 13.70 sq.km

(3.34 percent). A study on chemical oxygen demand reveals an increase in area under poor (5.77 to 62.07 sq.km; 1.41 to 15.15 percent) and a decrease in good area (403.93 to 347.63 sq.km; 98.59 to 84.85 percent) between 1988 and 2009. The distribution of chromium proves that good area has declined from 404.66 to 30.07 sq.km (98.77 to 7.34 percent) and poor area has increased from 5.04 to 379.63 sq.km (1.23 to 92.66 percent). The iron concentration between 1988 and 2009 reveals that the area under poor class has shown an increase (14.94 to 372.78 sq.km; 3.65 to 90.99 percent) and the good class has decreased (51.83 to 2.02 sq.km; 12.65 to 0.49 percent).

Parameters in which the Area Under Poor has been Newly Identified in 2009

The study on nitrate reveals that the area under poor has newly developed in 2009 (75.42 sq.km; 18.41 percent). It could also be noted that the area under good class has decreased from 324.98 to 118.61 sq.km (79.32 to 28.95 percent) between 1988 and 2009. The spatial distribution of copper states that poor area has developed newly in 2009 (7.23 sq.km; 1.77 percent). Also the area under good has shown a decrease from 19.08 to 0.78 sq.km (4.66 to 0.19 percent).

Parameters in which the area Under Poor has Decreased and Good has Increased

The study of total dissolved solids has proved that the area under good has increased from 0.71 to 5.94 sq.km (0.17 to 1.45 percent) whereas the area under poor has decreased from 408.99 to 403.76 sq.km (99.83 to 98.55 percent). The spatial distribution of total hardness shows that the poor area has decreased (374.59 to 196.38 sq.km; 91.43 to 47.93 percent) and area under good class has increased (0.89 to 35.03 sq.km; 0.22 to 8.55 percent). The study on bio chemical oxygen demand proves that the area under poor class has decreased (394.94 to 388.09 sq.km; 96.40 to 94.73 percent) and area under good class has increased (14.73 to 21.61 sq.km; 3.60 to 5.27 percent).

Parameters in which the Area Under Good has been Newly Identified in 2009

The study of the spatial distribution of magnesium states that the area under the good class has newly developed in 2009 (7.01 sq.km; 1.71 percent). It could also be noted that the poor class has undergone a decrease (372.17 to 348.96 sq.km; 90.84 to 85.17 percent) between 1988 and 2009.

Analysis of Critical Parameters

The analysis of the six critical parameters for groundwater quality for human use like Chloride, Chromium, COD, BOD, TH and TDS are analyse in the study area between 1988 and 2009. The result reveals the following conclusion. The area under poor class in chloride (Fig 3a) concentration has increased from 7.29 to 69.29 percent. The area that falls under poor class in chromium (Fig 3b) has increased from 1.23 to 92.66 percent. Also, the area under poor class in chemical oxygen demand (Fig 3c) has increased from 1.41 to 15.15 percent. The area under poor class under bio chemical oxygen demand (Fig 3d), total

hardness (Fig 3e) and total dissolved solids (Fig 3f) has shown a decrease (96.40 to 94.73 percent, 91.43 to 47.93 percent and 99.83 to 98.55 percent respectively) between 1988 and 2009.

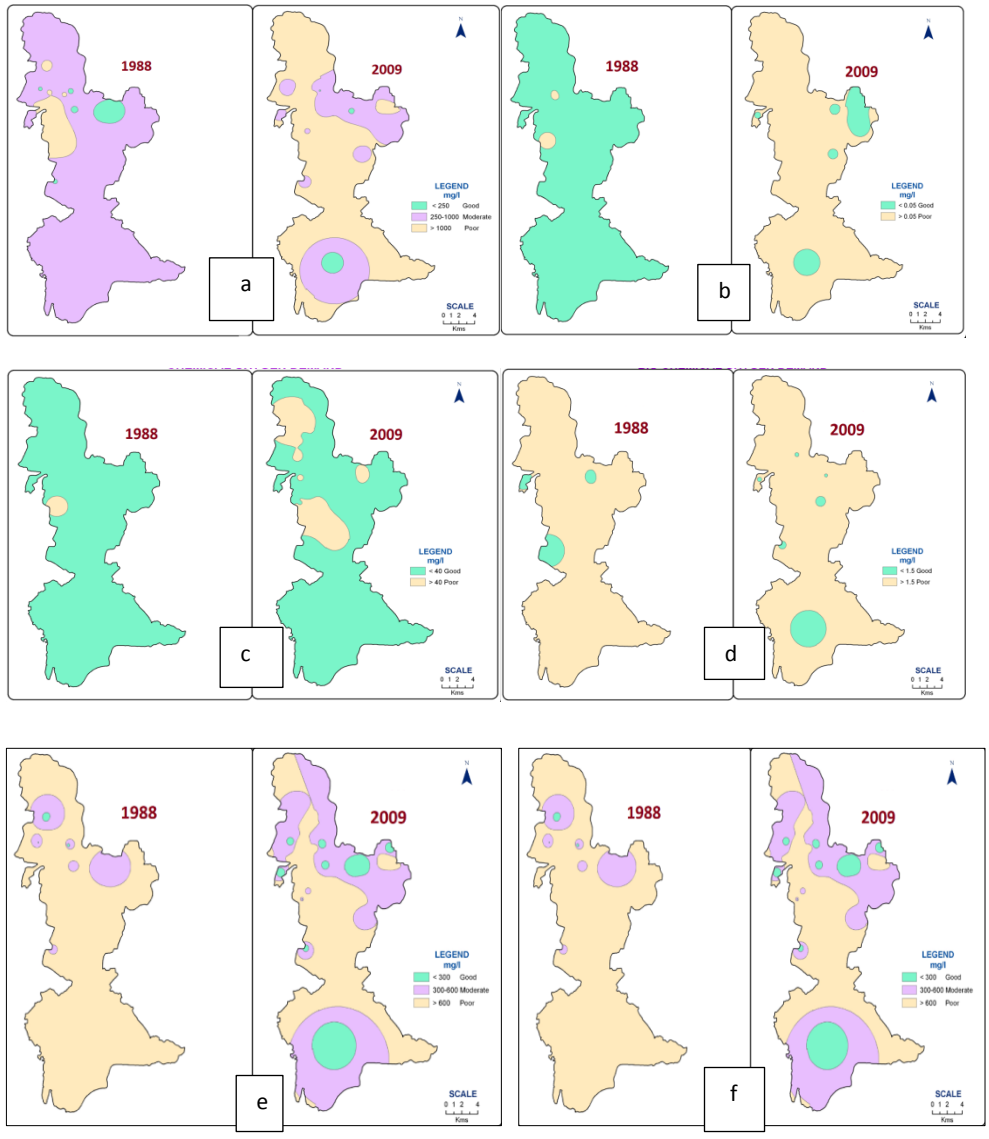


Fig. 3. Groundwater Quality for Human Use (a) Chloride, (b) Chromium, (c) Chemical Oxygen Demand, (d) Bio Chemical Oxygen Demand, (e) Total Hardness and (f) Total Dissolved Solids

Among these parameters, the area under the poor class has increased in chloride, chromium and chemical oxygen demand between 1988 and 2009. This increase in poor class is noticed especially in Pallapatti, Adiyanuthu and Vellodu village panchayats and

Dindigul Municipality. In the parameters like Bio Chemical Oxygen Demand, Total Hardness and Total Dissolved Solids, the poor class has decreased between 1988 and 2009, but to a negligible extent.

Analysis of Integrated Groundwater Quality for Critical Parameters

The study made on the integrated groundwater quality for human use based on overlaying all the maps of critical parameters one above the other reveals the following inferences. The area under good quality has decreased between 1988 (374.89 sq.km; 91.50 percent) and 2009 (15.46 sq.km; 3.77 percent). At the same time, the area under the poor class has increased from 24.68 sq.km (6.03 percent) to 298.33 sq.km (72.82 percent) between the two periods. The study area map is overlaid over the integrated maps of both the periods and are analysed (Fig 4 Table 2). It could be noted that the areas under poor category has increased between 1988 and 2009.

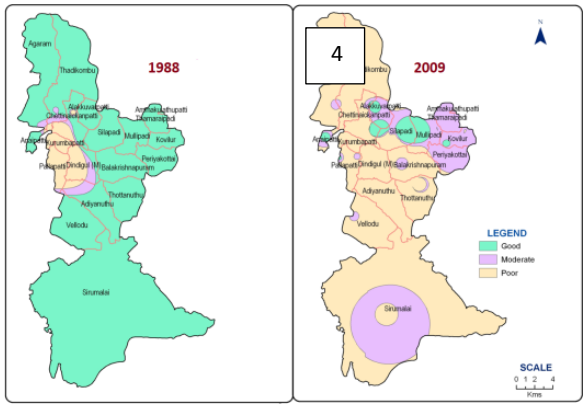


Table 2. Integrated Groundwater Quality for Human Use

Type	Area (sq. km)	
	1988	2009
Good	374.89	15.46
Moderate	10.13	95.91
Poor	24.68	298.33

Fig. 4 Integrated Groundwater Quality with Village Panchayat Boundary

Analysis of Variation of Groundwater Quality

A study on the variation of groundwater quality for human use between 1988 and 2009 reveals the following inferences (Fig 5a and Table 3). Certain areas which were classified good in 1988 but became moderate in 2009 is noticed in Thamaraipadi, Ammakulathupatti, Kovilur, Anaipatti, Sirumalai and Agaram village panchayats, covering about 23.23 percent of the study area. The areas that are good in 1988 but became poor in 2009 are seen in Agaram, Thadikombu, Vellodu, Thottanuthu, Balakrishnapuram and parts of Sirumalai and Chettinaickanpatti village panchayats, totally covering 64.63 percent of the study area. The areas that were moderate in 1988 and became poor in 2009 are seen in Thadikombu, Agaram, Adiyanuthu village panchayats and Dindigul Municipality together occupying 2.42 percent of the study area. These areas that totally cover an area of 369.85 sq.km (90.27 percent) are the most alarming areas, where the groundwater quality for human use is noted to be highly degraded.

Analysis of Variation of Groundwater Quality in the Leather Tanning Industrial Locations

An attempt is also made to study the variation of groundwater quality for human use in the areas where the leather tanning industries are located. The results prove that those areas were noted to be poor in 1988 and still remaining poor in 2009 (Fig 5b).

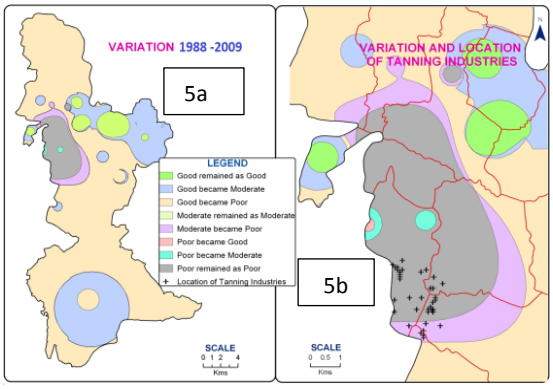


Fig. 5. Variation and Location of Leather Groundwater Quality

Table 3. Area Under Variation of Tanning Industries

Type	Area (sq.kms)	Area in %
Good remained as Good	15.17	3.70
Good became Moderate	95.19	23.23
Good became Poor	264.73	64.63
Moderate remained as Moderate	0.01	0.002
Moderate became Poor	9.93	2.42
Poor became Good	0.09	0.02
Poor became Moderate	0.70	0.17
Poor remained as Poor	23.88	5.83

Findings

The general slope of Dindigul panchayat union is from south to north. The major river of the study area, Kodaganar, has its origin from the hill tracts located in the southern part of the study area. The toxic effluents from the leather tannery industries, located in the western part of the study area, mixed in the groundwater might have been carried through the under groundwater throughout the study area, as the slope is from south to north. It could be concluded that the highly worsened quality of groundwater quality for human use in the western part of the study area including Pallapatti, Adiyanuthu and Vellodu village panchayats and Dindigul Municipality may be due to the protrusion of toxic effluents from the leather tanning industries. But in the remaining areas of the study area, the decrease in the quality of groundwater for human use may be due to

1. The influence of leather tannery effluents in the groundwater in the leather tannery industrial areas might have extended to the adjoining village panchayat areas, which are quite far away too.
2. Over exploitation of groundwater for human use and other purposes in the study area.
3. Even in the northern part of the study area that are away from the location of leather tannery industries, the quality of the groundwater is found to have deteriorated which may be due to the fact that the leather tannery effluents might have drained through river Kodaganar, passing through this area. Hence, it is essential to take steps in order to protect the degrading groundwater quality for human use in the study area.

Conclusions

By adopting suitable recommendations, further deterioration of the quality of the groundwater for human use could be minimised and controlled. If chromium and sodium chloride are removed, the effluent will have only organic load, which can be effectively treated in an effluent treatment plant. Then the treated effluents with organic nutrients can be used to raise the fodder grass. Such tannery could appropriately have called as "Green tannery', with zero effluent discharge and therefore resulting in zero pollution. This would help the study area in preserving its deteriorating groundwater quality for human use. The leather tanning industries should seek opinions from an array of consultants, technicians, chemical engineers, geologists, geographers, veterinarians and medical experts. Only then, the environment can be protected and handed over safely to the future generation.

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Archives - 1

THE MADRAS GEOGRAPHICAL ASSOCIATION

Formerly Known as The Journal of The Madras Geographical Association
(Volume I, 1926-1927, pp. 1-21)

The **Madras Geographical Association** has been established in Madras for providing a Geography centre there, by those who have come under the spell of *Modern Geography* and have realised its supreme value as a cultural discipline and as a practical introduction to the study of the World of To-day.

At their meeting held at Willingdon Training College, Madras, on the 31st March 1925, it was decided to form a Geographical Association at Madras, in order chiefly to promote the study of Geography, in South India, and also, of South India. It was then resolved that an invitation should go forth to all that might be desirous of helping in this object, and to settle necessary details and measures at a meeting, later on, of all those interested, who would become members of the Association.

A Committee was appointed for the purpose. This Committee in its Circular stated as follows :-

“Geographical studies occupy a commanding position in every educational system of the civilized countries. In Great Britain, the Universities have Chairs of Geography; the highest degrees may be taken with Geography as the subject; and even for the I.C.S. Examination, Geography is one of the many optionals that may be presented. In various other ways also-Societies, Magazines, Museums and Schools of Geography-practical effect has been given to the abiding place Geography holds in the activities of the nation. As a potent instrument of liberal education in schools and colleges, Geography is unique, in that it is both the handmaid of all the sciences and their common meeting-place. Its intense practicality and touch with the real facts of life round about, invest it with special importance, helping to make practical men of the students.

"It is, however, a matter for regret that Geography has not, as yet, come into its own, in South India. It is, therefore, doubly necessary, for those who feel its importance, to gather together in an Association, to help in winning for it its proper place and in setting its studies on right lines. In and by such an Association, teachers may exchange notes, observers may speak of their observations, notes of lessons may be circulated, books, maps, plans, charts, models and diagrams may be made easily available, lantern lectures may be arranged for, excursions undertaken, and specialists invited and heard. This central

organisation will thus gather together much useful knowledge and diffuse it and make it available far and "wide, even to those living in outlying towns and districts, remote from access to the currents of modern geographical thought."

The response was encouraging. The Committee reported on the formation. It framed the Rules; and arranged for the First Formal Meeting at the Senate House, Madras, on 19th February1926.

The following ladies and gentlemen were present at that Meeting.

PRESENT

Mr. S. Lakshmana Iyer.
Mr. R. Krishna Rao Bhonsle,
Mr. Rao Bahadur
Mr. M. S..Sabhesan
Mr. V. R. Narayana Iyer
Mr. K. Karunakara Nair
Mr. T. S. Venkatadri Iyer
Mr. V. K. Sourirajan
Mr. K. Ramaswami
Mr. R. Ananthanarayanan
Mr. C. N. Duraiswami
Mr. K. Venkataraghavachari
Mr. Indra Mohan Palit
Mr. D. Michael.
Mr. Tanab Syed Ameeruddin.
Mr. S. Rajarathnam.
Mr. D. W. Wolfinden.
Mr. S. V. Krishnan.
Mr. D. Manuel.
Mr. L. R. Sundaresan.
Mr. S. Gnanachariam.
Mr. V. N. Visvanatha Rao.
Mr. G. Mahadevayyar.
Mr. N. Krishnamachari.
Mr. N. S. Narasimha Ayyangar.
Miss. J. M. Gerrard.
Miss. E. D. Birdseye.
Miss. F. A Baker.
Mr. K. K. Raghavacharya.
Mr. M. Subramaniam.
Mr. N. Subrahmanyam.
Mr. W. Duraiswami Ayyangar .
Mr. A. Appadorai.
Mr. E. W. Green-(Chairman).

The Madras Geographical Association was then formally constituted with the ladies and gentlemen then present., The rules framed by the Committee were adopted; and the Working Council was asked to consider the financial aspects of the starting of a journal. With the election of office bearers, that meeting came to an end.

The Inaugural Meeting came off on Tuesday, the 16th March 1926, at The Presidency College, Madras; the Hon. Sir C. P. Ramaswami Aiyar took the chair and Dr. J. H. Cousins M.A., D.Litt., delivered the Inaugural Address.

The meeting was favourably noticed in the Press: and the leader of The Madras Mail, which is subjoined as Appendix A to the report of the Inaugural Meeting, will be read with delight.

The Working Council has issued a Memorandum on the Establishment of a School of Geography at the University.

The proceedings of the Inaugural Meeting and this Memorandum are printed in this number as part of the Transactions of the Association.

The Frontispiece reproduces the Group Photograph taken just before the Inaugural Meeting.

THE INAUGURAL MEETING OF THE MADRAS GEOGRAPHICAL ASSOCIATION

The Madras Geographical Association held its Inaugural Meeting on Tuesday the 13th March 1926 at 5.30 P.M., at the Presidency College, Madras.

PRESENT

Rao Bahadur M. R. Ry. V. T. Krishnamachari, Diwan Bahadur
M. R. Ry. S. Bhavanandam Pillai
Rao Bahadur M. R. Ry. R. Krishna Rao Bhonsle
Rev. A. J. Saunders
Mr. R. W. Ross
Mr. E. W. Green
Miss J. M. Gerrard
Miss E. D. Birdseye
Miss M. W. Barrie
Mr. R. D. Anstead
Mr. A. Swaminatha Iyer
Mr. V. Vellodi
Mr. V. N. Visvanatha Rao
Mr. N. Subrahmanyam
Mr. N. Krishnamachary
Mr. K. Narasinga Rao
Mr. R. Seshagiri Rao
Mr. S. Viraraghavachary
Mr. A. N. Schwartz
Mr. C. N. Duraiswami
Mr. V. K. Sourirajan
Mr. L. R. Sundaresan
Mr. S. Lakshmana Iyer
Miss P. Narayana Kutty Amma
Miss S. Kurivilla
Miss R. Job
Miss P. Lakshmi
Miss P. Santappa
Miss Mr. S. Venkataratnam
Mr. F. A. Baker
Mr. Sankar Singh
Mr. S. Rajarathnam
Mr. R. Ananthanarayanan
Miss S. Gomaz
Miss M. A. Thambai
Miss J. Kadamba
Miss P. C. Srinivasan
Miss A. Devadasan
Miss R. Crouston
Mr. D. W. Wolfinden
Mr. D. Manuel
Mr. D. Michael
Mr. S. V. Krishnan
Mr. T. S. Venkatadri Iyer
Mr. V. R. Narayana Iyer
Mr. N. R. Kedari Rao
Mr.NS.Narasimha Iyengar
Mr. Janab Abdul Rhadir
Mr. S. Natarajan
Mr. K. C. Ramakrishnan
Mr. A. Aaron
Mr. S. Chidambara Iyer
Mr. G. Mahaieva Iyer
Mr. K. S. Appasawmy Iyer
Mr. M. Subramaniam
Dr. J. H. Cousins
Rao Bahadur M.R.Ry.H. Narayana Rao
Mr. A. K. Krishnaswami Iyer
Mr. Sarangapani Ayyangar
Mr. Venkatachalam
Mr. S. Muthukrishna Iyer
Mr. G. V. Sithapathi
Mr. A. K. Venkatesan
Mr. K. K. Nair
Mr. Indra Mohan Palit
Mr. K. Venkataraghava Chari
Mr. B. Sanjiva Rao

The Hon'ble Sir C.P. Ramaswami Aiyar and seventeen others (whose names could not be noted).

Rao Bahadur M. R. Ry. H. Narayana Rao formally opened the Session; and in moving that the Hon'ble Sir C. P. Ramaswami Aiyar do take the chair, spoke as follows :-

"Ladies and Gentlemen,

“It is my pleasant duty to-night to welcome you on behalf of the Association. Before requesting the Hon. Sir C. P. Ramaswami Aiyar to take the chair, I desire to speak briefly on the place of Geography since this is our first meeting.

"It was only two months ago, Sir P. C. Roy deplored that there were first class M. A. 's, ignorant of the bare elements of Geography; and Sir Michael Sadler when he was in Madras, related some of his talks with the B. A.'s, which left on him similar impressions.

"Macaulay in his historic minute insisting on English Education for Indian youths, poured his ridicule on Education based upon ancient Oriental Classics pointing, among other things, to 'Geography made up of seas of treacle and seas of butter.'

“Like most things of Macaulay, we have here confusion of issue, and exaggerated half truth. For, one might, with equal truth, point to Western Classical and Mediaeval beliefs-to the Elysium, the New Atlantis, the Griffin, the Unicorn, the fire-eating Salamander, or 'the Anthropophagi and men whose heads grow beneath their shoulders.' It is as if one tried to seek in the Atlas, Laputa or Utopia and fix on 'this solid' world, Falstaff or Tartuffe, Rosinante or Sindbad's Roc, or the Phoenix that 'Solitary bird, that ever rises from its ashes:

"The real issue, the true contrast, is not between Oriental classics and Western classics; but between Ancient Education and Modern Education.

"In imparting that modernity, which we all desire so intensely, no study offers itself as the best avenue to it as Modern Geography.

"From Macaulay to Michael Sadler it is four generations; but the fact is that Geography is still one of the persistently and consistently neglected subjects. Whatever may be the case regarding the much-travelled Anglo-Saxon race, Geography is a double necessity to the Indian, who is untravelled and has been in isolation for long. To ignore Geography is to live like frogs in a well.

“Here, let me clear some underlying misconceptions.

“Geography, as studied until lately, merited the reproach, levelled at it, of making boys cram place-names, lengths of rivers, and heights of mountains. It was so in England itself, and, therefore, in the Madras University. It was, at any rate, something, even on that

footing. And until 1911, there was the What-and-where Geography which was compulsory for the Matriculation; there was also the How-and-why Geography, and this was a subject for the Intermediate, then called the F.A., forming, as examination subject, a compulsory alternative to the compulsory Physiology. It managed to escape the Madras prejudice against Geography, by virtue of the sonorous name of Physiography-no less than Huxley himself having written a well known text-book under that name.

“Between 1905 and 1910 there was a radical change in England, and, therefore, also in Madras; but, while the English change was for the better, the Madras change was for the worse.

"The year 1911 is a landmark in Madras Education. Then, when the Matriculation Examination was supplanted by the Secondary School Leaving Certificate, Geography was suffered to have a secondary place in the Secondary School and was banished from College, the mask name of Physiography having been, by that time, torn off its face.

“This was wholly unfortunate. For, it was just about this time that Great Britain had founded the Oxford School of Geography, and mainly under its influence, remodelled her Geography studies. Falling into line with other countries of the Civilised West, she has given Geography the pride of place in school, has recognised Geography as a subject by itself for the Tripos, and has placed Geography on a par with other subjects presentable for the Indian Civil Service and other Higher Services; and almost every University there boasts a School of Geography.

“Madras, which takes her cue from England, did not, unfortunately, hear it. The Madras prejudice against Geography has been found impossible to overcome, during' these fifteen years. Many earnest workers have thrown up the sponge in sheer disgust.

"Modern Geography attained its form in Germany, through the labours, three generations ago, of Humboldt the naturalist and Ritter the philosopher; and they created between them a School of Geography that has won universal fame, The German School has led the way and has maintained the first rank, with such brilliant names as Ratzel and Suess.

"Fully one generation later, Reclus and Vidal de la Blanche did similar work in France. It was one generation later on still when, owing to the labours of Prof. Patrick Geddes at Edinburgh and Prof. Herbertson at Oxford, Great Britain came into line. The place of Geography in the British Isles and in the British Empire is secure, with the sole exception of India.

"The need of a School of Geography is obvious, when the scope and nature of Geographical studies are considered. Geography is a science, by virtue both of its aims and of its methods; and a distinct science, at that, with an individuality of its own by virtue of methods peculiar to geographical thought. The principle of spatial distribution, the principle of co-ordination, the principle of causality, with the building of conclusions upon concrete

facts alone, underlie the studies. There is no science that is self-contained, with the possible and doubtful exception of Mathematics. Geography builds upon materials furnished by all other sciences, takes her data from almost every other, science, as well the human sciences of Sociology, Economics, or Politics, as of the natural, like Physics, Chemistry or Biology, which latter alone are called, 'Science', in Madras. It is clear that Geography has to be very "progressive, keeping up with the march of mind in all these directions. Now, all the scientific studies in a modern state are concentrated at the University and the University controls the scientific life of the nation. It is therefore an imperative duty resting upon the University to have a School of Geography in order that geographical studies be vitalised and be a reality. Otherwise, Geography will be reduced to the despicable position of purveying the second. Hand thoughts of abroad.

“An Association like this has its place and mission, alongside of whatever the University may care to do or not to do. There is need for an institution of Geography coordinating effort of school with school, of school with college, of college with University, of progress at borne with progress abroad, of teachers with scholars, and of learned men with the general public. Our aims are not mainly academical nor pedagogic. We wish to promote intensive studies about South India and interpret South India to us.

"Both Dr. Cousins and Sir C. P. Ramaswami Aiyar have travelled wide over the fields of Literature and Art, as well as over lands and seas. Dr. Cousins has surveyed mankind from Erin to Nippon. He was intimately connected with the moulding of Geographical studies for Ireland; and his association with Prof. Herbertson lends an additional charm to our meeting. Having lit his torch at the Oxford School, he now lights the torch at Madras with special appropriateness. Sir C. P. Ramaswami Aiyar, with his Hydroelectric schemes and Irrigation schemes and with the Portfolios of Railways and Waterways, is actively helping in the moulding of the life of the people in South India; which, in short, is making Geography.

“I request the Hon. Sir C. P. Ramaswami Aiyar to take the chair,"

The motion was seconded by Mr. E. W. Green and carried. Sir C. P. Ramaswami Aiyar took the chair, and called on the Secretary to make a statement.

The Secretary (Mr. N. Subrahmanyam) next made this statement:-

"Sir Ramaswami Aiyar, Ladies and Gentlemen,

“It is customary, on an occasion like this, to present at this stage, the report of work done in the previous year. To-day, it is my pleasant duty, because we are just at the very beginning, not to glance backwards but to look forwards.

“The idea of an Association of the kind has been forcing itself on many an earnest mind, especially as there has been a deplorable neglect of Geographical Studies, in this side of India. My learned friend, Mr. M. Subramaniam, and I had many a discussion about it, but it was not until last year when Miss Gerrard threw herself into the idea, in her own

eager way, that a start was made. "Mr. Green, from the moment it was broached to him, has been all help to it, watching over its progress and giving it his counsel, time after time. A preliminary meeting was held last year; the Committee appointed by it reported on the formation; and here we are at last the Association duly constituted and in sessions for its Inaugural Meeting.

"The sphere of usefulness of an Association like this is dependent, in the first instance, on the wide support that it receives, on the subscriptions and donations it secures, on the excursions it organises, on the publications it issues, and on the collection and circulation of books, maps, slides and such other objects of geographical interest that it is able to obtain and diffuse. We trust that sooner or later, all this will be forthcoming. But the usefulness of the institution depends, in much greater measure, one may say almost entirely, upon the diligence of members and their substantial contribution to thought. The Association solicits and welcomes contributions from every quarter and in every shape. Only so will the Association have good work to its credit and fulfil somewhat of its mission. It is fervently hoped that the Association will go on, with everyone contributing to its work."

Sir C. P. Ramaswami Aiyar next called upon Dr. J. H. Cousins, M. A., D. Litt., to deliver the Inaugural Address. Dr. Cousins then spoke as follows:-

"Ladies, Sir C. P. Ramaswami Aiyar, and Gentlemen,

"I am rather appalled at the position that I occupy to-day, standing here to give the Inaugural Address of an Association which is unique not only in Madras Presidency, but in India itself; because there are a large number here, to whom Geography has been an intimate study for a good many years in which I have been neglecting it, not through want of interest, but through stress of other circumstances. And, I feel rather a humbug in a way, in being in this position-not a humbug as regards my intense interest in the work for which the Association stands, but as regards the actual contemporary contribution that one daring to give the Inaugural Address of such an Association should be expected to have made. My connection professionally with Geography is now, I regret to say, a matter of ancient history. It goes back before 1913 when I left Ireland, though I have since done some little geographical teaching in India. At the same time, I suppose, there is, as the first speaker said, some special link or 'charm' in having present at such a meeting one who had an intimate association with the late lamented Professor Herbertson of Oxford. I was associated with Professor Herbertson when he came to Ireland in 1912 to conduct a summer school for teachers of geography in the Royal College of Science in Dublin. As a result of my work as geography master in the High School, Dublin, and my publication of a text book of modern geography, I was appointed his demonstrator for the course; and when his work finished, I was appointed in the same capacity to Professor Grenville Coll, the great geologist.

"But passing away from personalities, I would first emphasise the fact that the inauguration of this Association is in the nature of a protest; that is, a protest against the general undesirable attitude of indifference with regard to a very important element in

educational systems, materials, and methods; an element which always evokes enthusiasm from those who know really anything about it. But in addition to this element of protest in the movement here inaugurated, there is, what is more important than mere protest, a very definite intention to embark upon constructive activity which will bring before the minds of those who have the power to influence educational schemes, something of the reality that is involved in the study of Geography. Already, I have heard a few remarks preliminary to this meeting, which indicate that quite the same illusions are abroad, in both official and non-official circles, here as in other countries, with regard to what Geography is. In endeavouring in this address to dispel some of these illusions, I shall have to repeat many things that are platitudes to those who know; yet it is necessary to do so in order to illuminate those who do not know.

"What is the place of Geography in Education? The first answer to that would be glibly, the place of Geography is all over the place. I harbour the belief that education will never become truly educational, until it is given what we may technically call a geo-centric basis; that is, until it centres itself in the world we live in. But, before we can give a reasoned answer to the question, 'What is the place of Geography in Education?', it is necessary to remind ourselves as to what Education really is.

"A new life comes into existence, That new life is endowed with all kinds of powers, some latent, some already. Slightly developed; all sorts of predilections, racial and otherwise, from heredity; all sorts of innate desires; demanding satisfaction. If such an individual was let loose, without any kind of control, amongst other individuals similarly uncontrolled, the end would be disaster. There could be no human progress, unless, "out of the accumulated experience of life, the elder generation was able to pass on, to the members of the next generation, that experience of life which had taught them that there are certain activities that are inimical to the life of the community and the individual, and certain other activities that are beneficial. Education in this sense may therefore be defined as the sum total of human experience to be passed on to the next generation; and the purpose of education may, from the human standpoint, be defined as an effort, not only to give scope for development to the latent powers of the new individual, but to put those developed powers into harmonious relationship with his and her environment. I think that is a fair working definition of Education.

"Now, the application of that definition of Education to Geography is this: that the environment of each individual hail two "main aspects; first, the human environment into which It comes and with which it is most intimately associated; and, secondly, the natural environment, out of which both the elder generation and the new generation get the materials for their sustenance. These are the two aspects, the historical environment of humanity and the natural environment of humanity. In a strict sense, Geography deals mainly with the latter. And Geography may be defined as the Science of Human Environment; but relegating the study of the human side of that environment to history, and taking the natural side as the special field of its practical and theoretical study, We cannot

read history truly save in the light of Geography, and Geography has light shed upon it from the past history of humanity.

"Now, this natural environment of humanity that is the subject of study in geographical education has three special groups, which are easily carried in one's memory, and which give a framework through which one can contemplate the vast mass of interacting factors in our environment and see them without panic, in an orderly and illuminating manner. If we look around us and question our environment, we shall see that there are certain factors that are inevitable to our life, that can be grouped under the general heading of passive factors, that is to say, the factors related to the composition of the world under our feet; the material composition of the earth, and the orders into which the substance of the earth has been built up. In every study, there is always 'the material or substantial aspect; but in Geography it is an aspect that calls for study under the two familiar names of Geology or the substance of the earth and Geography, as it is ordinarily regarded, that is, the regional distribution of land and water on the surface of the earth. In scientific terminology, we have thus the substantial or material side of our study. In the philosophical terminology of India, we have the '*thamasic*' or inertia aspect.

"But associated with the first aspect of our environment we have a group of other factors which we may call the active factors, factors which act upon the materials of our life and change them into other forms. The active factors in our environment are obviously, the meteorological factors; the factors that relate to the weather and the climate, two terms which have a different connotation. A, visitor to Ireland grumbled: In Ireland you have no climate; you have only weather.' There is scientific truth in this apparently jocular conjuring with meteorological terminology; I climate' being the more or less constant quality, and I weather' the condition which varies from day to day, sometimes from hour to hour. These active climatic factors may be called the energetic factors in our environment, the '*Rajasic*' factors of Indian Thought.

"These passive and active factors have produced, by their interaction, another group of factors with which humanity is intimately associated. This third Group, I shall call the *vital factors* in human environment, the factors of life. Without the "influence of climate on rock substance, we would not have had the soil that is so useful for growth; we would not have had the ultimate development of the principle of .growth through humus in the soil; and life as we know it, would not have come into existence. This third group of factors, which has worked up to the stage in which humanity can exhibit its Rowers, is the high peak of geographical study; the' consciousness' aspect of it, or to put it in Eastern terminology, the '*Sathvic*' aspect. Under the caption of vital factors you can extend as far as you like into the geographical study of human culture, observing the differences that arise because of geographical circumstances.

"Such is a rough sketch of the field of geographical study,' divided into three areas, which we can separate for purposes of study but which are always interacting, always in immediate association with one another.

“Now, the study of these factors in a geographical system of education leads, as I found in my work as a teacher, and, as I feel sure, all teachers of practical geography have found, to three special kinds of satisfaction; (1) a satisfaction of the knowledge side of the students and myself, (2) a satisfaction of the cultural, and (3) the substantial satisfaction of the practical side. And I would like to develop somewhat these three aspects of satisfaction that arise out of the teaching and learning of Geography for the encouragement of those who are working at Geography, and for the information of those who do not realise what it stands for.

"With regard to the knowledge aspect: the gathering of details of information from the ends of the earth as well as from one's own local area and the sifting and co-ordinating of these leads to wonderful illumination of the mind. When I was in Brussels in 1925, I visited the *Palais Mondial*. It is a huge building divided into twelve rooms. You entered room No.1 and saw pictures and models of the early geological history of the solar system, and then went through a succession of rooms in which every graphical, pictorial and plastic means was used to give the observer a clear idea of the various stages of developing environment and civilisation through which humanity had passed and is passing. India was there, liberally represented; and it should bring shame to us to know, and realise, how people in other parts of the world know everything about us, and we little or nothing of them, especially in the geographical sense. In that vast compendium of geographical and history study, there were thirteen million card references--the result of a lifetime of devoted enthusiasm and industry for a subject of knowledge which Indian educational systems have hardly begun to look at. And this is only one of many geographical activities in other countries.

“Such a collection of knowledge enables us to realise the enormous extent to which geography controls human evolution and expression. In the North of Ireland, for example, where I was born and lived till I was twenty four, we had the idea that we were the finest people on earth. We were energetic and full of initiative. But "when I grew to years of discretion and took my holidays in the South-West of Ireland, which is mild and foggy, I found that my North Ireland energy, the product of a bracing climate, gradually faded out, and I became one with the group of the Irish who are referred to as the lazy Irish. Then there are areas of extreme cold where life is not at a high state of tension; and there are areas of extreme heat where also life cannot be active. In the intermediate areas which change from heat at one season to cold at another, a rapid adjustment of one's clothing and activities is induced. You will see people selling sun-hats at one time of the year, and at another selling snow shoes. But while you are wearing the snowshoes, the merchant has to anticipate the sun-hats, which must be made for the next season. This alternation works towards developing an alertness of mind by necessitating the exercise of anticipation, preparation and organisation. The great business organisers belong to the temperate zones, the zones of variable climate. Their children who overflow into the zone of extreme heat retain the habits of their parents; but the virtue which they claim for the habit belongs originally to Nature. The philosophies of India are as much a matter of temperature as of temperament. These instances are only typical of what is taking place everywhere with

regard to the influences that control the different activities and expressions of humanity. When this fact is realised, so-called vices and virtues assume a different complexion. They are seen as climatically influenced expressions of racial temperament which elaborate themselves into differences of all kinds, even up to the expression of the highest thing in humanity itself, its spiritual consciousness. Such a study ought to be to make the nations understand and sympathise with one another as various groups of one great entity, the human entity, all labouring under this limitation and control. Such is a brief glance at the knowledge aspect of geographical education.

"The second satisfaction, that of culture, that arises from the study of Geography, is to educationists of the utmost importance. It touches the definite influence that geographical study has upon the new being who comes into existence; who will go on acting in one way or other and who has to be shepherded into proper paths towards harmonious relationship with the rest of the flock. In a proper geographical system all sorts of observations have to be made regarding the three groups of factors already spoken of. Now, observation leads to alertness and watchfulness of mind; and children rapidly develop these faculties when they are given the opportunity. I could tell you many stories about little ones I have noticed both East and West, who were lacking in initiative, but who, when they found a teacher who encouraged them, became bright and happy children. A slight touch of the pleasure of geology used to bring me loads of stones from children whose vacation had been enriched by interest in Mother Earth. The stones were mostly useless geologically, but educationally they were gold.

"Observation necessitates record, and one of the most beautiful things in education is to see children developing this faculty. Children delight to make plan of their houses, of the next street and ultimately of larger areas; and thus they develop a fine capacity of recording details accurately. They may make mistakes and their conclusions may be wrong; but I have found examples of complete efficiency of observation and record even in the very young. At Madanapalle College, we studied weather forecasting, and the students became able, in a rough way, to tell what tomorrow's weather would be. We watched a cyclone one year, and deduced its origin, career and end-official details some days later entirely confirmed us. There was no mystery about it, it was just a matter of knowing and applying plain facts. The inspiring influence on both teachers and students of such observation, deduction and application to the facts of life, is a cultural power of very great importance which Geography offers to education.

"Such study also, strange as the statement may appear, offers a means to the true expression of the emotional nature of the student. If the emotions cannot find natural expression, they will unfortunately find unnatural expression; and I have found that a keen interest in picking up interesting stones and watching the weather is a splendid vent for the accumulating energy, especially of boys, a very fine way of allowing them to work off the creative energy that is growing in them. From such study we develop an emotion of reverence for the Great of Life that permeates every atom of the life that is manifested in us. When I went to Oxford to call on Dr. Herbertson, I had to wait for him to finish his

lecture. He came out with his cheeks red and eyes shining, and said, "I have had a grand hour!: A grand hour, lecturing on Geography! Herbertson was a scientific mystic, looking out for the signs of one same life permeating everything, and then with the grasp of knowledge and the skill of the scientist, taking facts and presenting them to the student in such a way that Geography ceased to be a dry subject, and became a magnificent spiritual romance.

"In such high enthusiasm we have a fine influence in cultural development. Moreover, out of reverence for the Supreme Life, we develop a collateral respect for all other lives that are contained in it. Not long ago I saw a group of small boys at a properly conducted school, observing, not killing, a rat which had got into a particular place in which it could be seen. That is the kind of humanitarian influence that geographical study can bring to us. There is also a physical cultural aspect to geographical education The gathering of local details as to rocks, soil, vegetation, and the sub-human and human denizens of a district means a good deal of healthy walking. And in the collecting and recording of facts and examples, there is a fine opportunity for the exercise of team work and labour distribution which exerts a controlling influence on the growth of the personality of the student.

"Then there is a third satisfaction, the utilitarian aspect of geographical education. A good many people, indeed, think that Geography is a matter of commerce, of production and consumption. is that; but, as we have now seen, it is much more than that. There are certain aspects of 'Commercial' Geography which are not quite - healthy as one would like them to be, such as the utilisation of geographical knowledge for purposes of mere exploitation of races and Nature, for wholly selfish gain. But in the highest sense the utilitarian aspect of geography brings together the human family as consumers and providers of necessities. Herein lies a wide and fascinating field of study-not of commercialised geography, which educationally is almost valueless, but of the Geography of Commerce which studies the interactions of human needs and Nature's provision for such needs. and in the vast organisation of production, transport and distribution, discloses the forces that are at work towards the achievement, through present interdependence, of future human unity.

"Now, I must pass on to give you a summarisation for the information of the teachers here as to how geographical education can be worked out. We are not looking only to bring Geography as a subject in the University. Our ultimate aim is the geographising of all education; the attainment of the geo-centric attitude of relating everything to life in its deepest sense. The whole study can be put into a single paragraph:

"Changes of temperature, caused by the movements of the earth, set up movements in the atmosphere which are felt as winds; these, according to their direction, are wet or dry. These climatic influences, acting on materials of the habitable surface of the globe, have awakened and developed the latent powers of growth and life both natural and human.

"The question of the order in which the three factors of environment should be studied will have to be answered according to circumstances. In Ireland, where wind and rain are a constant menace to life and its pre-arrangements, the natural answer of the young student to the question: 'What is the most prominent natural feature in your life?' is- the 'weather. But in India, with long periods of climatic stability (even in the wet monsoon to which one grows accustomed), the answer may be otherwise. But the order, active, passive and vital, follows the order of nature. Whatever be the variations set up in natural phenomena by the movements of the earth and the tilt of its axis, these variations hang upon the primary fact of heat derived from the Sun. That fact is perpetually before the student. It has placed the Sun God at the centre of every religious system either in personification or metaphor. Its effects and implications are ever ready to the hand of the teacher. It is the natural way of approach to the study of environment, and to the development of habits of correct observation and true judgment.

"Whatever be the order of study of the factors in environment, there must of necessity be both a quantitative and qualitative gradation to meet the needs of the growing consciousness of the student It is not proposed that the study should follow a straight line moving from one group of factors to the next over a number of years. It should be carried out in a series of concentric circles, each circle enclosing a complete survey of the whole field of environment at its own particular degree of simplicity or complexity. These circles of natural environment will correspond with the circles of human environment. That is to say, the materials of observation will first be drawn from local sources. The method will be empirical, based on the experiences of the student. This will lay the foundation of the inductive or scientific process of the mind which examines observed facts and from these derives principles. But the study will naturally lead to comparisons, and these will be drawn from a wider area of environment than the local, viz., the National and in due time the International. As the circle widens, principles acquired from local observation will be applied and corrected. Thus the deductive or philosophical process of the mind will be healthily developed. In the later stages, when the mind of the student has found wings, and can soar to the skies without fear, the study of the more subtle and remote elements in supermundane environment will complete the materials of Geocentric education and give the data for the synthetical study that belongs in its fulness to the college career of the student.

"It is not necessary in this general study of principles to work out a detailed curriculum and time-table. It may, however, be said that these principles are not mere theorisings. I have myself worked through the method here outlined both in Ireland and India, and know the enthusiasm, attention, accuracy and speculation that it evokes in both students and teachers. Its effect on collateral studies is very marked; the memorisation of names and facts is expedited; the necessity for the calculating and recording of interesting details adds zest to the learning of language and mathematics, and provides a training in accuracy of observation, completeness and clearness of record, and soundness of judgment.

"But while we do not enter here into details of school machinery we shall set out the components of the Geocentric study in three concentric circles which may be subdivided according to circumstances.

"PRIMARY STAGE: *Active factors:* Use of the thermometer; school records and graphs of temperature; use of barometer and records of pressure; use of rain-gauge and hygrometer, and records; interrelationship of temperature, pressure and rainfall; local seasons. *Passive factors*: Local irregularities in land surface; elementary surveying; modelling; composition of local rocks; boundaries and directions of local river systems. Vital factors: Local natural "vegetation and wild animal life related to seasons; collection of plants and shells; sketches and photographs; local population and village organisation.

"SECONDARY STAGE: *Active factors:* Influence of altitude, latitude and sea on temperature; exchange and comparison of records with other schools in the National area, and comparison of statistics from other countries; mapping of areas of temperature; same as regards pressure; same as to humidity; interrelation in seasonal changes over large areas, e.g., monsoon; forecasting. *Passive factors*: World relief; railway routes; chain and table survey; map projections; geological history; fossils; metals; soils; world drainage; basins of oceans, depths, tides, currents, trade routes. Vital factors: Cultivated vegetation and domesticated animal life as influenced by the above; distribution of population related to climate and relief; agriculture, industry, commerce, social organisation, culture, religion.

"ADVANCED STAGE: Synthetical study of national, regional, and continental areas under the above aspects, with statistics, graphs and maps.

"It will be seen that such a Geocentric scheme of education co-ordinates the natural and human sciences, and by this co-ordination imparts illumination and warmth to both. It introduces the student in a natural and interested manner to subjects, such as astronomy and botany, in which possible specialisation will be stripped of the limitations and want of balance that now trouble particularised study. And this Geocentric education, made vivid by association with the study of human evolution, and ennobled by the realisation of its sacred purpose of releasing the imprisoned ego into full and happy associated life, has within it the power of lifting humanity towards higher degrees of individual and collective experience.*

" If these things that I have said are true, and I know that every teacher of real Geography will say that they are true, there is something very curious in the fact that Geography is where it is in the curricula of the Schools and Universities of India. For all substantial purposes of education, it might as well be omitted. We have no option in our life on earth. Geography in all its aspects is compulsory on every one of us every day. It should be equally compulsory in education, if a full cultural development of humanity is to be achieved. But education in India. as elsewhere, is not yet at the level of being a true cultural institution.' It is almost entirely vocational; it prepares candidates for the public services,

* Dr. Cousins has fully worked out these ideas in his Tract on Educational Fundamentals, The Brahmavidya Library, No. 7, Madras

whereas it should be developing all-round individual for Public Service; it fits people to earn a living, but makes little or no effort to encourage them in the splendid adventure of wealthy, happy informed, intelligent life. The tendency of an incomplete education towards priggishness is lamentable. I had a student of the weaver caste once.

"When I installed looms to develop an industrial education, I said to the weaver boy, "Now you have a grand opportunity to help other students by teaching them weaving." With a dignity that was intended as a rebuke to my misunderstanding of his purpose in being a student of mine, he said: 'Excuse me, sir; I am being educated. Educated ! Rather, being puffed up, and lifted to an eminence of mental mediocrity from which to look down on reality with false contempt ! That is one of the commonest and most obnoxious effect of bad education. It stresses the clerical and non-productive aspects of life, and does not look to that great other aspect of productivity on which the total wealth of a country depends. "We have therefore got to do something to give an idea of dignity to geographical education. The Universities could give that dignity, but unfortunately the Universities labour under very grave illusions with regard to geographical education. They have not got any idea of what it means. In my first, and, as it happened, my last appearance in the Academical Council of the Madras University, I had to speak against a resolution before the Council to the effect that the establishment of a School of Geography was not desirable! Happily. so completely reactionary a resolution was defeated. A similar resolution was defeated the following year, and there is an opportunity for the geographically-wise members of the Council to agitate for a School of Geography. If a completely equipped school cannot at once be started, at least a Chair of Geography be established, both in the Madras and Andhra Universities. It should be the business to carry this matter forward and to convince educational authorities that an academically worthy syllabus leading up to a B. Sc. degree in Geography can be presented. A collateral work can be the establishing of some geographical laboratories. For a few rupees you can get sufficient paraphernalia to give a good intelligent start of the geographical work. One would not want to map it so fine as that extraordinary Museum of Geography in Berlin. Is it too much to ask some wealthy Indian or group of Indians to give a sufficient endowment to make such an organisation possible, either through this particular Association or year marked in the Madras University in its new era, or in the Mysore University, or the new Andhra University? So far as I am personally concerned, it is my intention to act on the fresh impetus which the formation of this Association has given me, by starting in October next a geographical laboratory in the Brahmavidya Ashrama at Adyar, of which I have the honour to be Principal, and to place its work at the disposal of the Madras Geographical Association."

The Hon. Sir C. P. Ramaswami Aiyar, then, said:-

“In the first place, let me say, that I count myself fortunate in having been here this evening, and listened to the wholly practical. and yet so finely emotional speech, made by Dr. Cousins to us, in regard to the inauguration and maintenance of a School of Geography. It is getting so late, that I would fain have resumed my seat, after thanking Dr. Cousins for the illumination that he has vouchsafed to many of us, and for the many ideas that have

been implanted in us during his instructive discourse. But I find, somewhat to my consternation, that I am expected to deliver what is called a Presidential Address. I have, however, too great sympathy with people who are anxious to go home, to start on a formal Presidential Address at this time. But let me make a few-very few observations on some of the matters which have struck me during the course of the remarks.

“After thanking Mr. H. Narayana Rao for the very kind words with which he introduced me to the audience, it strikes me that I must just say a word upon the first sentence which emanated from Dr. Cousins. He said that he - a specialist in this subject-he said that he was a kind of ‘humbug,' while it seems to me that I have not yet arrived at any definite conclusion as to what particular epithet would be applicable to me for having the temerity to embark on a new and uncharted sea.

"The next observation that occurs to me is as to the very comprehensive manner in which Mr. Narayana Rao, after adverting to the fact that I had something to do with Irrigation, with Ports, with Transports, and things of that kind, said that I was "making Geography" These reasons might have been very satisfying to Mr. Narayana Rao, but not to me.

“Nevertheless, I may claim two titles to be here to-day, though not in the particular exalted position to which I have been raised by being the President of this evening's function. I now enjoy, but have also been a victim to, geographical study. During the days when I was a student, Geography, as practised and idealised by Dr. Cousins, was not the main feature of the system or curriculum under which we laboured, or shall I say, groaned. One result of my study has been that on account not so much of encouragements but more on account of penalties with which I was visited, I remember a few important facts vividly even to the present day. I remember, for instance,- I have never forgotten this from 1891- that the height of Mount Everest is 29,002 feet. I am clear on that. It was, on pain of falling below our general minimum, we had to remember it. I remember the exact length of the various great rivers of the world. Even now it is not clear where the Brahmaputra rises, but I was definitely told that the length of the Brahmaputra was 1895 miles, or some such figure. Geography so drilled into us was a congeries of isolated, dry, uninteresting, sporadic and dreary facts. If this had been my whole geographical education, I should have come here only in the role of a victim to protest against the apotheosis of Geography that has been effected this evening.

"But it was not, fortunately. My Geography, I suppose, the Geography of those who have spent sometime in the study of "Literature -my Geography was also learnt in very many different, wholly extraneous ways. For instance, through Shakespeare's 'Tempest', we all got to know a great deal about a certain Island, which is more real to me than many real ones, and a particular fen in that Island where Caliban and Setebos had a great deal to do. But that Geography, albeit imaginary, had stuck to my mind more than this isolated list of facts and figures, which passed for Geography. To us, who have read Scott, are not the Highlands of Scotland more real than many neighbouring places? Scott, Dumas, Shakespeare. Stevenson, these are the people who teach Geography to many of us.

"Later on, how the human aspect of Geography and its relation to climate were illustrated to me. I shall explain by a very short example. It was long after my Geography lessons were over, I was reading Henri Taine's descriptions of England and the English people. In a somewhat cruel, but telling, passage, he referred to the politics of the English and the French. He referred to the democratic and Parliamentary Institutions and tried to demonstrate why, in spite of their laudable efforts, the French have not been able-notwithstanding their intellectual activity and alertness-to make a success of their Parliamentary System. There followed a description of the fogs and dullness of England, which according to him, has made the English dull, sedate, but very combative, and yet steady people. Whereas, by their climate, France produces the mercurial type, full of alertness, each one of the individuals thinking he is as good as his neighbour, with the result that the leader was never obeyed and Parliamentary Institutions never came to success. These things-what you call the human aspect of Geography-were learnt by me, not from geographical treatises, but from pure literature, which did not pretend to be Geography.

"Geography is, as I understand it, from what Dr. Cousins told us, the study of the relationship between man and his environment, between man and his natural surroundings, and the expression of man's conduct and behaviour, with reference to the climate and the country in which he lives.

"Now, if there is one thing which Western sciences have enabled us to perceive directly, what our ancients perceived intuitively it is this, that very much depends on one's surroundings. Not only one's intellectual equipment but also one's moral equipment depends greatly on one's surroundings, and Geography is the history and account of one's surroundings. Geography occupies and must occupy a prominent place in any system of cultural development. If we understand Geography, in the Wider, bigger sense, to comprehend, not only the description of the earth and its products, but the relation of man with the factors which produce culture and civilisation, if we realise that Geography to-day is different from Geography of old because of the facilities of transport and because of the shrinking of the world-if we realise all that, we shall realise above "all things, the essential unity of human endeavour. So shall we envisage Geography as a kind of *Epitome of Human Activity and Human Culture.*

"If so understood, it seems to be difficult to see why Geography should not have had its proper place in the scheme of education. This has been perhaps because of its want of missionary and propagandist endeavours. A beginning has been made this evening. I hope everyone who has listened to the inspiring and illuminating discourse of Dr. Cousins will be a missionary for the purpose of spreading true ideas of Geography, and of giving it its proper place in the: scheme of education."

Miss Birdseye, Vice-President, thereupon moving a vote of hanks, said:-

"All of us have known Sir C. P. Ramaswami Aiyar as a scholar and a gentleman; and, to-day, we are able to see "how deep his interests are and how wide his outlook. We

are thankful to him for having come to us in the midst of heavy council work, and given s instructive sketches. We trust he will come to us often, and tell us of some of the great works he has on hand. Electric power, Irrigation and Transport are among some of the vital interests in any country; and I am sure, I am voicing the wishes of all here, then I invite him to speak in detail next session upon some of these great themes in their bearings on South India.

"Dr. Cousins is known as a traveller, scholar, art critic, and poet. He is a Geographer, besides; and in his rich experiences, he has been making a field-study, as it were, of this great Globe, upon the spot and at each spot.

"We must congratulate ourselves on having had two such scholars to speak at our Inaugural Meeting. On behalf of all here, I wish to say how grateful we feel for their Addresses. I have much pleasure in moving a hearty vote of thanks to them."

Mr. S. Lakshmana Iyer, Vice-President, next rose and said:-

"I second the motion. I thank also the guests who have responded to our invitation. I hope that efforts made to win for Geography its right place in Education, will be crowned with success."

The motion was carried and the meeting formally terminated.

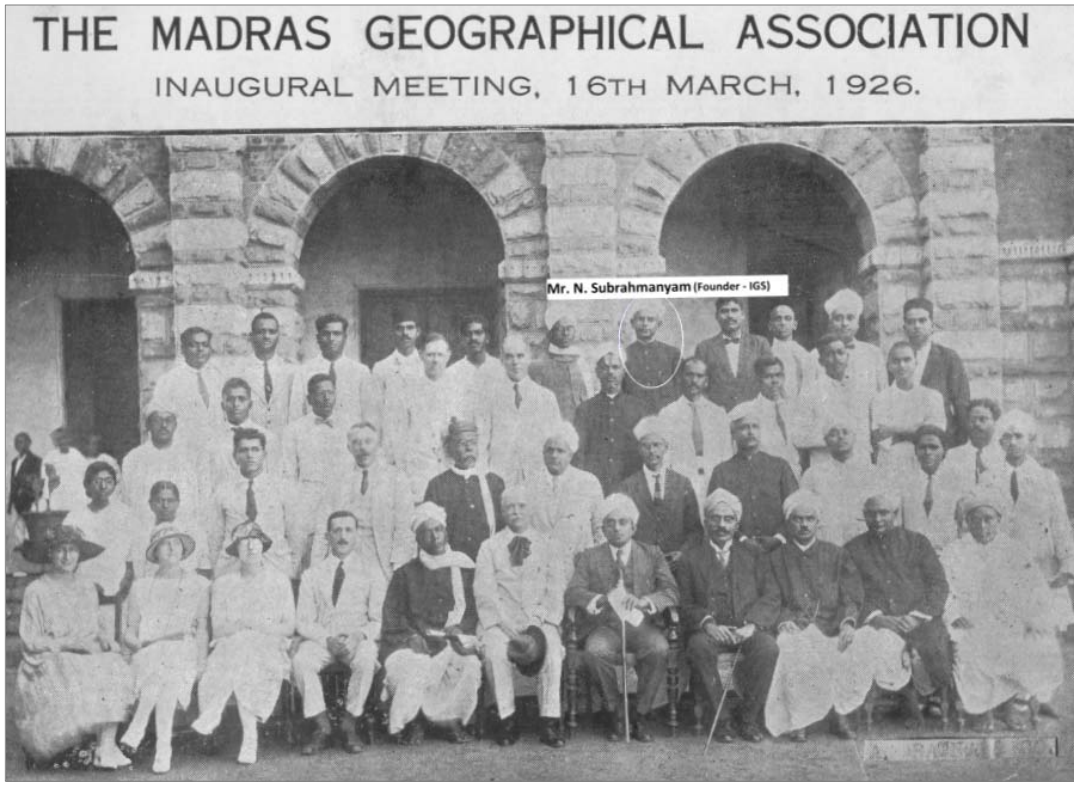
APPENDIX A

THE MADRAS MAIL of Monday 22nd March 1926, had an appreciative leader on the Inaugural Meeting, which we reproduce below;-

"Ge……

"This is not a contraction of the trans-Pacific exclamation "gee whizz," though that expression of surprise would not be unfitting to the subject that calls forth this article. I' Gel' was the earth goddess of the ancient Greeks. "Graphe" was writing. Hence, Geography in the minds of the generation now using hair restorer the word will conjure up dreary hours of gazing on maps so far removed from reality that Mr. G. K. Chesterton when a boy, got a shock, on first visiting Yorkshire, to find that it was not, as his atlas has taught him, coloured yellow. Other hours of memorizing capes and bays, imports and exports will also come wearily back. In the meantime much has been done to rationalise the study and teaching of Geography. The generation now at school is put into vital and interesting contact with the whole lore of Ge. Direct knowledge of the substances and forces that make up the world of human environment has put mere memorisation in a secondary place. Observations, excursions, and other means of linking the adventure of science and the imagination with life, make geographical study not only a study but a romance and an enthusiasm. Unfortunately this new aid to education applies hardly at all in India. A year ago a resolution came before the Academical Council of Madras University to the effect that the

establishment of a School of Geography in connexion with the University was not desirable. A few days ago another resolution was introduced declaring such a school to be unnecessary. Both resolutions put the University behind the times, and happily were defeated. The way is clear for a positive resolution demanding a School of Geography. That the subject is on the way to recognition is shown by the formation of the Madras Geographical association whose inauguration in the Presidency College a few days ago was marked by earnestness and determination. The Association is the first of its kind in India, and Madras may be proud of its initiative. Dr. Cousins in his Inaugural Address uttered a much needed protest against title tendency of education in India to turn students away from productive employment to the non-productive professions. It seems clear that the study of the earth, Ge, and its powers and mystery as a prominent part of school curricula would tend to give more social respect to the fundamental work of tilling soil, and would induce students to labour diligently with a view ultimately to applying their furnished and trained minds to enriching their country and themselves by bettering agricultural production and distribution. The Universities can help this desirable psychological change by establishing Schools of Geography with diplomas, and ultimately giving the subject University status in a science degree based on geographical specialisation.



APPENDIX B

Several of those present at the Inaugural Meeting sat for the Group Photograph which was taken at 5:25 p.m., on Tuesday, the 16th March, 1926. It was taken at the Presidency College, Madras, in the Open Court to the South of the Eastern Portico. Messrs. A. Ratna & Co., Madras, who took the Photograph, have made the block and it is printed as the Frontispiece to this number. Here are the names of the persons in the Group:-

Sitting (from left to right):- Miss F. A. Baker, Miss J. M. Gerrard, Miss E. D. Birdseye, (Vice-President), Mr. E. W. Green, Mr. S. Lakshmana Iyer, (Vice-President), Dr. J. H. Cousins, (Inaugural Lecturer), Hon. Sir C. P. Ramaswami Aiyar (Inaugural Chairman), Diwan Bahadur, Mr. S. Bhavanandam Pillai, Rao Bahadur, Mr. H. Narayana Rao (President), Mr. M. Subramaniam (Member, Working Council), Mr. A. Swaminatha Iyer.

Standing, First Row (from left to right):- Miss Gnanavolivu, Miss Vedanayagam, Mr. D.W. Wolfinden (Treasurer), Mr. R, D. Anstead, Rao Bahadur, Mr. R, Krishna Rao, Bhonsle, Rao Bahadur, Mr. V. T. Krishnamachari, Mr. N. R. Kedari Rao, Mr. R. Seshagiri Rao, Mr. L. R. Sundaresa Aiyar, Mr. Sankar Singh, Mr. D. Michael, Mr. N. S. Narasimha Ayyangar.

Standing, Second (and Middle) Row (from left to right):- Mr._____, Mr. S. V. Krishnan, Mr. M. V. Vellodi, Rev. A.J. Saunders, Mr. R. W. Ross. Mr. S. Veeraraghava Chari, Mr. D. Manuel, Mr. D. Thambusami, Mr. S. Rajarathnam, Mr. R. Ananthanarayanan.

Standing, Third (and Topmost) Row (from left to right):- Mr. V. R. Narayana Iyer, Mr. K. K. Nair, Mr. T. S. Venkatadri, Janab Ahdul Khadir, Mr. A. N. Schwartz, Mr. N. Krishnama Chari, Mr. N. Subrahmanyam (Secretary), Mr. Indra Mohan Palit, Mr. K. Venkataraghava Chari, Mr. V. N. Visvanatha Rao, Mr. B. Sanjiva Rao.

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Archives - 2

THE ESTABLISHMENT OF A SCHOOL OF GEOGRAPHY AT THE UNIVERSITY

Formerly Known as The Journal of The Madras Geographical Association
(Volume I, 1926-1927, pp. 25-30)

Geography, as a University subject, holds, today, in civilised countries, a prominent place, in any scheme of liberal education. Its total neglect here has been due to various contributing causes, and it is the purpose of this Memorandum to draw the attention of the authorities to it, with a view to remedy this state, and to win, for Geography, its proper place in the University.

Geography, as now studied abroad in school and college, is entirely different from the dry-as-dust routine, which compelled students to pass through the treadmill of a textbook, memorize place-names, and disconnected facts, statistical and other, in a dismal way. A revolution has taken place in this matter; and Geography, as studied there to-day, is the most vitalising of all studies, imparts reality to the concepts arrived at from other studies, comprehends all the factors of control, environment, and human culture, and is preoccupied with a rational understanding of other lands and peoples as well as one's own. Unlike the What-and-where type of work, which was the sole subject of geographical studies formerly, and which, as such, fell into general apathy, Geography, to-day, is concerned with the investigation of the Why-and-where-fore, and, what is more, with the seeking and finding of the Whence-and-whither, alike of Places, Peoples, and their Work.*

Here, in Madras, until of teen years ago, Geography of the What-and-where type was a compulsory subject for the Matriculation; and, under the name of Physiography, it was the sole alternative given to Physiology, which otherwise was a compulsory subject of the F. A. Examination, the equivalent of the present Intermediate.

In the radical re-modelling of the courses, that came into effect in 1911, Geography was dropped altogether from College course, but has been continued as a compulsion for the Matriculation. Exceedingly few however, are the candidates for the University Matriculation (about 30 in number), as compared with the vast majority for the Secondary, School-Learning Certificate (for which there sit over 15,000 candidates every year). The neglected position assigned to Geography in the S.S.L.C. Course has reduced to the

*Vide De Martonne's *Geographic Physique*; Jean Brunhes's *Geograplie Humaine de la France*; Russell Smith's *Industrial and Commerial Geography;* and Russell Smith's *Human Geography*

vanishing point the geographical knowledge of the student, who enters the University through the door of the S.S.L.C. The College student is thus very ill-equipped with that knowledge of the modern world, which is admittedly a sine qua non, and which no other subject but Geography (as studied in the modern way) can impart. Dismal memories of the old-time Geography drill in place-names and disjointed facts have raised such a wall of prejudice, hat such of our educators as have not watched the revolution that its study has undergone, have been unable to appreciate, at its true worth, how powerful an instrument of education Geography is. To those that carry in mind such unpleasant associations, the world, '*Geography*', scarcely, denotes all that Modern Geography stands for.

The subject matter of Geography is the wide earth, the high air, and the deep ocean, along with the agencies that play and interplay on them. There is not a science with which Geography is not intimately related. Other sciences deal with but some particular aspects of things, and view them from particular standpoints. Modern Geography receives as data the results of those special studies, builds them into a comprehensive whole, considers the inter-relations, and studies the consequences flowing from such data.

To take, for an example, the Arabian sandy deserts:-

The *Geologist*, who studies the history of the earth through succes-sive epochs, accounts for how the sandy deserts come to be what they are and where they are; but the *Geographer* has to go further, and trace their influence on life.

The *Physicist* investigates the effects of a given condition or temperature, density, pressure, and humidity, and discovers how the presence or absence of some of these conditions accounts for the diversities of climate and weather. The Geographer has to know the places where such conditions obtain generally, and coordinate them; and he has to study, further, the bearings of such data on life there and elsewhere:

The *Botanist*, when he takes up the palm-tree, studies how the several parts of its structure-function, and are adapted to their functions; and how several of the palm s are children of the dry sandy tract. But the moment he passes from that, to consider their home and distribution, their habitat and oecology, he *comes within the range of Geography*. And the Geographer has to gather up the botanist's results add interpret the life of the regions.

Within the scope of the *Zoologist* comes the camel, and in his study of it, he finds how every part is fitted for the life it leads on sandy desert lands, and he has *need of Geography for explaining its habitat*. The Geographer has to know all this of the camel find trace its influence on Life.

The peculiarities of the people of desert lands, their tribes, their culture, their religion, come within the purview of the Anthropologist and the Sociologist, who undertake to describe the Races of Man. And they have to take note of the Geography of the desert for their interpretations.

The *Historian* takes up the tale, and relates how, at a certain epoch, Mahomed arose, and how the religion of Islam, springing from the deserts, spread over the globe, from the pillars of Hercules to distant Cathay. Geography studies the profound influences that are exerted by Islam, over the destinies of men in three continents, in their social, economic, political, and religious life.

All these data-the results of such special studies are gathered up by the Geographer. His mission it is, to build up, into a synthetic and intelligent whole, these isolated and fragmentary pieces of knowledge.

Arabia, in the hands of the Geographer, becomes a real living picture in its totality, The desert sands, the oasis, the thorny shrubs, the date-palm, the camel, the Bedouins, their burnous, their tents and their, caravans, their tribes and their Sheikhs, down to the Sherif of Mecca, with his late master, the Turk, and his present British Protector, the Holy Carpet and the Hedjaz pilgrimage, and the changes envisaged for them by the aeroplane, the railway and the automobile-all these fragments, the results of special studies of parts, are, by the geographer combined and blended into a consistent picture, each part exhibited in relation to the rest. No less than this is the function of the Geographer, and none but the Geographer does it. The ecological studies of the Botanist or the Zoologist, or the human studies of the Historian or the Anthropologist, when they make mention of Arabia, would use a word that is destitute of concrete meaning, but for the picture of Arabia so drawn by the Geographer and presented by him as a living whole.*

Thus, Geography is vital to the proper understanding of other sciences, physical, natural; and human. It draws from them its, materials, and, in its turn, completes them; and those studies remain incomplete without them. It has itself a scientific method of its own, in the principles of *spatial distribution*, of *coordination*, and of causality. It treats of facts as it finds them. In the study of *Human Geography*, it lays stress on *Creative Evolution* and describes the part that is played by a man on the face of the earth, as well as the control exerted by nature, over him. Both the physical and human aspects of the study have been neatly summarised as the *Science of Environment*, and as the *Epitome of Human Activity and Human Culture*. It is, in short, the master-key for understanding the conditions and diversities of human civilisation.

Modern Geography stands for all these things, and it is for this the reason that Modern Geography holds its pride of place in the educational institutions of civilised countries. Its scientific method, its zealous search after facts, its tracing of cause to effect and of effect to cause, its coordination of disjointed facts, its constructive synthesis, its objective treatment, it effort at understanding one's own environment and its cultivation of thought about other lands and peoples-all make it an unrivalled instrument of culture and scientific training. The information it conveys is such as to equip one with a knowledge of the modern world, so as to enable one to understand it. Its method of connecting fact with

* For an instance, reference may be made to the description of Arabia by Buffon in his *Natural History*; or Gibbon's *Roman Empire*, Ch L; or Doughty's *Arabia Deserta*

fact gives one a needed training in perspective and proportion and provides the background and for specialised studies like Biology, Economics, and History. The study of mankind as a whole and in its divisions develops sympathy and understanding for other peoples, into whose lives it gives insight and knowledge. Its pragmatic insistence on concrete facts imparts reality to academical studies, and its rigor and method give discipline the mind. The age we live in; is permeated with science, and Modern Geography brings one in direct contact with it, in its practical bearings.

The commanding world-position of Geography, in the Universities abroad, has, at long last, persuaded the Academic Council of Madras to resolve to admit it, among the optionals, in the Intermediate and to consider its inclusion in the optionals for the B, A. Even that may prove illusory, as happened to the subjects of the B Group and to the range of optionals in the C Group subjects of the S.S.L.C. Course, which turned out to be mere Hobson's choice. There appears to be a lurking suspicion in the minds of some that Geography is a subject unworthy of academical place and honours. What has been stated above, will, it is trusted, show that it is not a whit behind several of the studies which have been regarded as the Blue Ribbon of scholarship at the Madras University.

It may be noted here that in competitive examinations for the Imperial Services and the Indian Civil Service, Geography comes in, at least as equal with most other subjects. It is a matter for regret, that the remarks of the Commissioners are, that Indian students' knowledge of Geography is very poor, That is due, undoubtedly, to the downright contempt, with which Geography' has been treated here. And it is a pity that an opportunity, such as Geography has afforded, should have been thrown away, while the agitation, all along, has been for real equality of opportunity with Britishers, among other things, in the matter of subjects, the Indians can present.

The recognition of Geography as a presentable subject for the Intermediate or even for the B. A. is no ground for shelving the question of the University establishing a *Department of Geography* or *'a School of Geography*,' as it is called. The recognition of History as a subject of academical study, from the primary classes to the Doctor's Degree, has not ruled out the University from constituting a special Department of History. Nor has the University found its duty dis- charged, with the inclusion of *Economics* in the Degree Courses, A Doctor's Degree may be taken in *Mathematics*, and yet the need has been felt for the formation of a special Mathematical Department. Similar considerations are being applied to *Orientalia*, and *Philosophy*. While, such is the case, the formation of a School of Geography cannot be brushed aside, on the bare ground of an A Degree in it being permitted whether hereafter or now.

It cannot but be conceded that Geography as a fit subject of study at University is at least on as indisputable a footing as any of the subjects just mentioned. It has been pointed out above what a huge a complex mass of material, Modern Geography has to handle and organise; with how many sciences, it is intimately bound up; and from how many of them, it derives its data. Those sciences are each progressive, passing from the errors of yesterday into the truths of to-day, since the last word his never been said in science; and, as a result,

the data of Geography are also progressive Geography is a living science, and must keep itself abreast of the latest achievements in science and knowledge.

Further, all the scientific life of the country, in the very nature of things concentrate at the University. The University is the centre of the scientific activities of the nation, and it abandons its duty by, Geography, no other institution can supply its place.

And it should be remembered, that Modern geography is not mere textbook lore, which, by a division of labour; master and pupil summarize and memorize until the day of examination comes round.

Besides laboratory work of the most exacting kind, geography has to make field-study .of things, and Cartography is to it what Drawing is to Engineering. (As an instance, it may be here mentioned, that some of the recent contributions to the world's stock of knowledge in Isostasy and Geodesy have been made by Britishers in the Survey, of India).

Geography has to apply, to local conditions and facts, the principles arrived at elsewhere; only thereby, can it so act, as to make the knowledge, it seeks to impart, real and living. A Geography of South India, in the modern sense, is nowhere existing. None who have read Gabriel Hanotaux's Histoire de la Nation Francaise-the first two volumes of which are on Geographie Humairie - de la France by Jean-Brunhes-can dare to dispute this statement. Such a Geography for South India has to be built up, and it can be built up only at the University. To promote the knowledge of South India, one may venture to state, will not be thought beneath contempt, by a South Indian University. It is only by a special Department of School of Geography established at the University that the University can maintain in its freshness, the knowledge that geography postulates-knowledge that is not the mere dead matter of text-books, but is a process of living thought, ever progressing and creative in character. Besides, a University Department or School of Geography would serve as a clearing-house of thought for this organic and growing subject and would establish contacts and exchanges for teachers, scholars and workers, with one another.

These are some clinching arguments. It is hoped that the authori-ties entrusted with moulding the minds of this generation will realise the importance of Modern Geography, and establish without more loss of time, a Department or School of Geography, at the University.

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Archives - 3

THE MADRAS GEOGRAPHICAL ASSOCIATION

Formerly Known as The Journal of The Madras Geographical Association
(Volume 1, 1926-1927, pp. 72-73)

THE FIRST ANNUAL REPORT

The Council has the honour to present its Report for the year 1926.

In India, infant mortality is appallingly high for men and institutions; and it is a matter for congratulation that this; Association has lived an active first year and has entered on its second year. The Association is now lustily crying for more members and more funds.

The members are 155 strong, of whom one is an honorary member. The subscription from members is Rs.308, of which Rs.225 or 73 per cent has been collected and received. This, again, is a matter for congratulation.

The Council has prepared a full and informing Memorandum on the place of Modern Geography and has sown it broadcast. It has drawn the attention of the Academic Council of the Madras University to the need as well as the importance of a School of Modern Geography. But, then, there are wheels within wheels in the university and it may take a long time before any progressive activity in this direction can be registered by that august body.

The Association will be glad to find that it has been instrumental in quickening geographical thought in Madras and Moffusil. The schools are all astir. The Colleges do not look on Geography with contempt. The University, too, has not gone backwards. A negative result, but still a considerable achievement. Several earnest members of it have realised the necessity of Modern Geography in Modern Education and are wide awake. The seed has not fallen altogether on a rocky soil.

In the short term, the Inaugural Address was delivered by Dr. J. H. Cousins under the presidency of Sir C.P. Ramaswami Aiyar.

Four meetings were held in the long term. Miss. E. D. Birdseye led the way with her paper on "The Geography of the Madras Region". Mr. H. Narayana Rao came up with the next paper on "The Geographical Evolution of the: Madras Region", Mr. M.S. Sabhesan followed with h.is paper on "The Plants of the Madras Region". In November, the Association had the honour of inviting the Marquess of Linlithgow and the Members of the

Royal Commission on Agriculture to the Lantern Lecture on "The Planter's Crops" by Mr. R. D. Anstead.

The Council issued an appeal for a Magazine, and the response has enabled it to start a journal. Two numbers have been issued. The subscription of Rs.2 for ordinary membership covers but the bare expenses of the Association, and no member is compelled to take the Magazine. The magazine rests on the basis of voluntary subscriptions.

The financial bye-laws, framed by the Working Council have been published in the first Bulletin in which were included the Inaugural Address of Dr. Cousins and the Memorandum on a School of Geography in the Madras University.

In fine, the Council hopes that more funds and more embers will be forthcoming and enable the Association to show in the second year more activity and more work.

(*By Order*)

Y.M.C.A., VEPERY,
14th January, 1927.

N. SUBRAHMANYAM,
Secretary.

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WATER BALANCE AND WATER RESOURCES DEVELOPMENT OF THE GARLADINNE MANDAL, ANATAPUR DISTRICT, ANDHRA PRADESH, INDIA

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Abstract

In this study the monthly, seasonal and annual water balance elements, surface water resources and groundwater resources of study area (Garladinne mandal) are analysed to bring out the relationship between; monthly rainfall and monthly groundwater variations and monthly rainfall and monthly groundwater fluctuations. The analysis revealed that there is positive relationship (+0.784) between monthly rainfall and monthly groundwater variations and monthly rainfall and monthly groundwater fluctuations (+0.88). The rainfall recharge of the Garladinne mandal has been worked out by applying Seghal's method, Krishna Rao's method, Radhakrisna et. al method and USGS method. The average of the four methods is taken as the annual groundwater recharge of the Garladinne mandal. The surface water resources and groundwater resources of the Garladinne mandal have been worked out. Finally based on the surface and groundwater resources, water stored in the ponds, lakes and reservoirs, surface run-off and water loss in the form of potential evapotranspiration, the water balance of the Garladinne mandal is also worked out. The correlation of monthly potential evapotranspiration with monthly groundwater level variations and monthly groundwater level fluctuations are found to be +0.085 and +0.01 respectively. However, the correlation of monthly potential evapotranspiration with other water balance elements is found to be very low. Slightly negative correlation has been witnessed between monthly water deficit (- 0.145) and Monthly Aridity Index (-0.11) with monthly groundwater level fluctuations respectively.

Keywords: Groundwater variations, Positive relationship, Rainfall recharge, Water resources

Introduction

Water balance is the comparative study of rainfall and potential evapotranspiration. It plays an important role in applied climatology for development of agriculture and water resources. It is a well established fact that water supply to a region is primarily through precipitation and water loss is entirely due to evaporation and transpiration. The wetness

and dryness is therefore determined by the relative magnitudes of precipitation and potential evapotranspiration. In the present study the water balance elements of the Garladinne mandal have been worked out taking mean monthly rainfall and mean temperature adopting Thornthwaite and Mather (1955) method. Late Prof.V.P.Subrahmanyam was a pioneer worker in the field of water balance studies and has published a monograph in 1982 on application of water balance techniques in India. Subramanyam (1963, 1967 and 1983) has carried out studies in application of water balance studies for the index of continentality, relation to distribution of natural vegetation, continentality trends over India, hydro climatology and water balance of Chandrampalem basin. Studies on water balance approach for assessment of aridity and droughts were carried out by Subrahmanyam and Subrahmaniam (1965), Subrahmanyam and Sastri (1969) and Subrahmanyam and Sharma (1974). Studies on water balance and water resources development of Madurai district, Tamil Nadu is carried out by Sambasiva Rao (1983). Similarly studies on water balance and agriculture development of Madurai district, Tamil Nadu is carried out by Samba Siva Rao (1984). Studies on water balance and irrigation development are carried out by Subrahmanyam and Dhal (1984). The other researchers who have worked in the field of water balance are Ram Mohan (1978) Hema Malini (1979), Rajeswari (1984), Vasthala (1987), Madhuramma (1990), Purusotham Babu (1993), Suresh Babu (1993), Sambasiva Rao (1996,1997 and 2002), Samuel Raj (1996), Gangadhri (1999) and Krishnaiah (2004). The above said researchers have applied water balance studies in the fields of agriculture, water resources and drought studies. Hema Malini et al. (2012) has made an attempt to predict future change in the climate of Addis Ababa and they have applied water balance technique as a major tool to estimate hydrological elements and climate based on the temperature and precipitation of the region. They have concluded that the Addis Ababa region will become drier than the present with rise of temperature of 6^0 C. Likewise, in this attempt, water balance and water resource development of the Garladinne mandal of Anatapur District of Andhra Pradesh have been studied.

Study Area

Garladinne mandal covers an area of about 304.97 sq km and lies in the Anantapur District of Andhra Pradesh in between 14^0 49' 14" to 14^0 57'20" North latitudes and 77^0 35' 48" to 77^0 43' 43" East longitudes (Fig.1). There are 18 revenue villages in Garladinne mandal. The total population of Garladinne mandal is about 53,882 persons (Census, 2011). Geologically, it is mainly comprised of Archean rocks consisting of granitic gneisses with dolerite and quartzite intrusions. The annual rainfall is about 568 mm. The annual minimum temperature of 14^0C is noticed in January and the annual maximum temperature of 42^oC is observed in the month of April. Climatologically, Garladinne mandal is located in dry sub-humid type of climate.

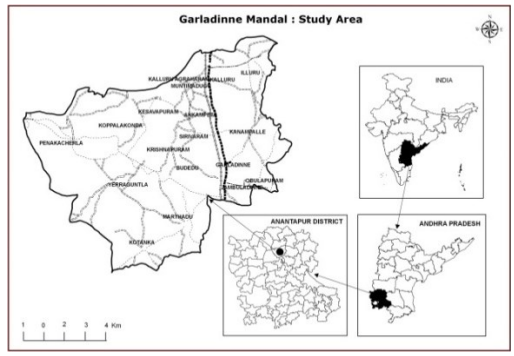

Fig. 1. Study Area

The major objectives of this study are to study the monthly, seasonal and annual water balance elements; to study the surface water resources; to analyse the groundwater level variations, fluctuations and rise and fall in groundwater level on seasonal and annual basis; to work out the groundwater recharge; to evaluate the groundwater potential and extraction at village level and to bring out the water balance of the Garladinne Mandal.

Database and Methodology

The water balance of the Garladinne mandal has been worked out by adopting Thornthwaite and Mather (1955) method. The water balance elements namely precipitation, potential evapotranspiration, actual evapotranspiration, water deficit, water surplus, moisture adequacy, aridity index and moisture index are worked out at monthly, seasonal and annual levels. The monthly seasonal and annual rainfall, rainfall variability and rainfall ratio are worked out adopting Bhargava (1977) statistical methods. The surface water resources of the study are worked out on the basis of mean annual rainfall and geographical area of the Garladinne mandal.

The groundwater resources are studied from the average groundwater level variations collected from 15 controlled wells of the Garladinne mandal over a period of years from 2003-2009. The data collected from controlled wells are used to study the groundwater level variations, groundwater level fluctuations, rise and fall in groundwater level. Assessment of groundwater potential at village level is done by adopting rainfall recharge method. The recharge of the annual rainfall has been worked out by various methods like Seghal's (1970); Krishna Rao (1970); Radhakrisna et al. (1974) and US geological method (1985). The average of four methods is taken as recharge of the Garladinne mandal. The groundwater potential for each village is evaluated on the basis of annual recharge and geographical area of the village. Based on total surface water resources (stored in ponds, tanks and reservoirs), total groundwater potential, the surface run-off and total water resources lost in the form of evaporation and evapotranspiration, the water balance of the Garladinne mandal has been brought out.

Results and Discussion

Monthly Water Balance Elements

The mean monthly rainfall in the study area is less than 10 mm from January to March and in December months. It varies from 10 mm to 50 mm in April, May, and November months. From June to August months the mean rainfall ranges from 50 mm to 100 mm. The mean rainfall exceeds 100 mm in September and October months. The mean potential evapotranspiration (PE) varies from 100 mm to 150 mm in February and from July to November months. The mean PE is above 150 mm from March to June months. The mean actual evapotranspiration (AE) is less than 50 mm from January to April and December months. The mean AE varies from 50 mm to 100 mm from May to July and November months. The AE exceeds 100 mm from August to October months. The water deficit is less than 50 mm from August to December months. The water deficit varies from 50 mm to 100 mm in January, June and July months. It exceeds 100 mm in February, March and May months. In Garladinne mandal water surplus does not exists throughout the year. The moisture adequacy (Ima) values are less than 50% from January to June. The Ima values exceed 50% from July to December months. The Aridity Index value are less than 50% from July, to December months and exceeds 50% in the remaining months.

Seasonal and Annual Water Balance Elements

In Garladinne mandal the rainfall is less than 100 mm in winter and summer periods. It is 145 mm in northeast monsoon period and 370 mm in summer period (Table 1). The average annual precipitation is 568 mm. The PE is less than 500 mm in winter and northeast monsoon period. It is 500 mm and above 500 mm in summer and southwest monsoon periods respectively. The mean annual PE is 1653.The AE is less than 200 mm in winter and summer periods and is more than 200 mm in southwest and northeast monsoon periods. The mean annual AE is 850 mm. The water deficit (WD) is less than 100 mm in northeast monsoon period. It ranges from 100 mm to 200 mm in winter and southwest monsoon period and exceeds 300 mm in summer period. The mean annual water deficit is 803 mm. Water is not surplus in any season in Garladinne mandal. The moisture adequacy is less than 30% in winter and summer periods and it is more than 60% in southwest monsoon and northeast monsoon periods. The mean annual moisture adequacy value is 51%. The water adequacy values are less than 40% in southwest monsoon and northeast monsoon periods but more than 70% in winter and summer periods. The mean annual Aridity Index (Ia) value is 49%.The climatic classification shows semi-arid type of climate in winter and summer periods and dry sub-humid type of climate in southwest and northeast monsoon periods. The annual Moisture Index value suggests that Garladinne mandal normally experiences dry sub-humid type of climate.

Table 1. Garladinne Mandal: Distribution of Seasonal Water Balance Elements

Sl. No	Water Balance Elements	Winter	Summer	Southwest monsoon	Northeast monsoon	Annual
1	P (mm)	2	51	370	145	568
2	PE (mm)	222	500	602	329	1653
3	AE (mm)	58	108	418	266	850
4	WD (mm)	164	392	184	63	803
5	WS (mm)	0	0	0	0	0
6	Ima (%)	26	22	69	81	51
7	Ia (%)	74	78	31	19	49
8	Im (%)	-44.4	-46.8	-18.6	-11.4	-29.4
9	CC	D	D	C1	C1	C1

(Source: Computed by the Authors)

(where, P = Precipitation, PE = Potential evapotranspiration, AE = Actual evapotranspiration, WD = Water deficit, WS = Water surplus, Ima = Moisture adequacy, Ia = Aridity index, Im = Moisture index, CC = Climatic classification, C_1 =Dry sub humid, D = Semi arid)

Surface Water Resources

The seasonal analysis of rainfall of Garladinne station indicates that during southwest monsoon period the maximum average rainfall of 370 mm is found, followed by 145 mm in northeast monsoon period, 51 mm in summer period and 2 mm in winter period. The annual average rainfall of Garladinne station is 568 mm.

In the Garladinne mandal the rainfall variability values are above 100% between January and April and November and December months. During May, June, August, September and October months the rainfall variability values are less than 100%. In winter period the rainfall variability is above 100%. It is less than 100% in summer, southwest monsoon and northeast monsoon periods. The annual rainfall variability is 25% in Garladinne mandal. From the study of rainfall variability it is summarized that the rainfall is very stable from May to October months and greater instability is observed in the remaining months.

The monthly rainfall ratio values at Garladinne mandal station are above 1500% from January to March. In December they vary from 1250% to 1350%. In April and November the rainfall ratio values range from 510% to 950%. In July and October months they range from 400% to 500%. The values of monthly rainfall ratio are less than 400% in May, June and September months. The rainfall ratio is 900% during winter period. In summer it is 250% and in southwest monsoon and northeast monsoon periods the seasonal rainfall ratio varies from 200% to 280%. The annual rainfall ratio is 155%.

The total surface water resources of the study area have been estimated taking into account the average annual rainfall and total area of the Garladinne mandal as follows.

Total surface water resources = Total area x Average annual rainfall

(304.97 km^2 x 568 mm = 173,222,960 m^3)

It is estimated that about 10% of the surface water resources could be stored in the existing tanks having a capacity to store about 17,322,296 m^3 of water. There are about 11 surface tanks in the Garladinne mandal which cover an area of about 220 hectares. They are distributed in the villages namely Penakacherla, Koppalakonda, Yerraguntla, Kotanka, Marthadu, Garladinne, Kanumpalle and Jambuladinne, covering an area of about 220 hectares with the storage capacity of 3,123,692 m^3 which is only 1.80% of the total surface water resources.

Groundwater Resources

The groundwater level variations in Garladinne mandal are studied based on monthly variations in groundwater level of 15 controlled wells over a period of years from 2003 to 2009 (Fig. 2).The actual monthly groundwater levels are recorded from the controlled wells . The ten years monthly groundwater levels for each month are averaged to get the mean monthly groundwater level. The seasonal groundwater levels are averaged to obtain the groundwater level variation. The difference between monthly and seasonal groundwater level variations indicates groundwater level fluctuations.

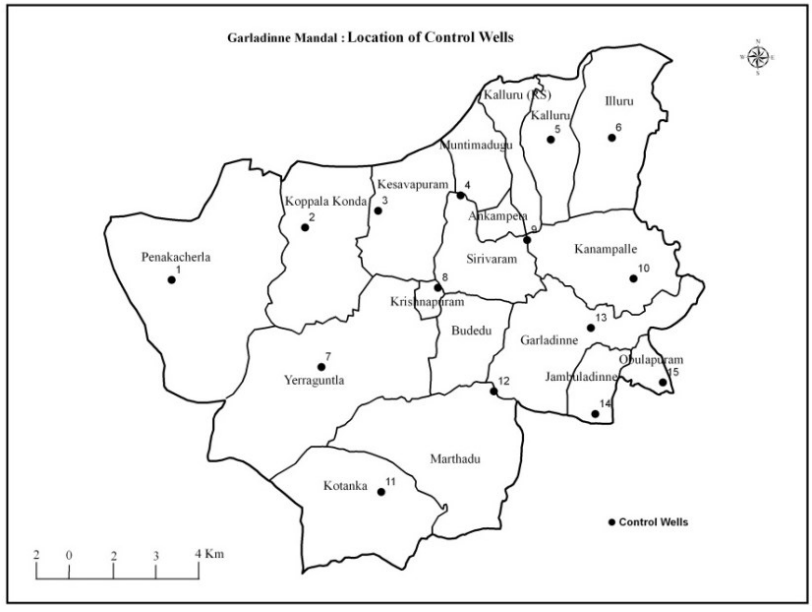

Fig. 2. Location of Control Wells

Seasonal and Annual Variations in Groundwater Levels

The average groundwater level is 4.10 metre during the winter period. During the winter period the minimum groundwater level of 3.37 metre is found in number 13 controlled well and the maximum of 5.19 metre is noticed in number 11 controlled well. The groundwater level is less than 4 metre in controlled well numbers 3, 4, 7, 8, 9, 10, 13, 14 and 15. It ranges from 4 to 5 metre in number 1, 2, 5, and 6 controlled wells. It is above 5 metre in number 11 and 12 controlled wells (Table 2). The average groundwater level recorded during summer is 5.23 metre. The minimum groundwater level is noticed in controlled wells 4 and 7 while, maximum of 6.12 metre is found in number 5 controlled well. It is less than 5 metre in 2, 3, 4, and 7 controlled wells. It is above 5 metre in number 5 controlled well only. In the remaining wells it varies from 5 to 6 metre (Table 2).

In southwest monsoon period the average groundwater level is found to be 5.30 metre. The groundwater level varies from 4. 74 metre in number 1 controlled well to a maximum of 6.44 metre in number 11 controlled well. It varies between 5 and 6 metre in number 2, 3, 4, 6, 7, 8, 9, and 10 controlled wells. In the remaining wells the groundwater level variation is more than 6 metre (Table 2). The average groundwater level of the study area during northeast monsoon season is around 3.97 metres. The groundwater level values range from a minimum of 3.41 metre in number 13 controlled well to a maximum of 5.06 metre in number 11 controlled well. In number 1, 2, 3, 4, 7, 9, 10, 13, 14 and 15 controlled wells water level is less than 4 metre. It varies from 4 to 5 metre in number 5, 6, 8 and 12 controlled wells. Controlled well number 11 recorded groundwater level more than 5 metre (Table 2).

The annual variation in groundwater level ranges from a minimum of 4.35 metre in number 4 and 7 controlled wells to a maximum of 5.65 metre in number 11 controlled well. The groundwater level is less than 5 metre in number 1, 2, 3, 4, 6, 7, 8, 9, 10 13, 14 and 15 controlled wells. The groundwater level is more than 5 metre in number 5, 11, and 12 controlled wells. The average annual groundwater level is 4.76 metre (Fig 3, Table 2). From the analysis of variation in seasonal groundwater levels, it is found that during northeast monsoon period the groundwater level is of less than 4 metre depth. In winter period its depth is of about 4.10 metre. In summer and southwest monsoon periods the groundwater level depth is more than 5 metre. The average maximum depth of 5.30 metre is noticed in southwest monsoon period.

Average, Seasonal and Annual Groundwater Level Fluctuations

The average groundwater level fluctuation is 0.49 metre during winter period. The groundwater level fluctuations vary from a minimum of 0.17 metre in number 12 controlled well to a maximum of 0.72 metre in number 8 controlled well. In number 3, 4, 7, 11, 12 and 15 controlled wells the groundwater level fluctuation is less than 0.50 metre. In other controlled wells it is more than 0.50 metre (Table 3, Fig. 4)

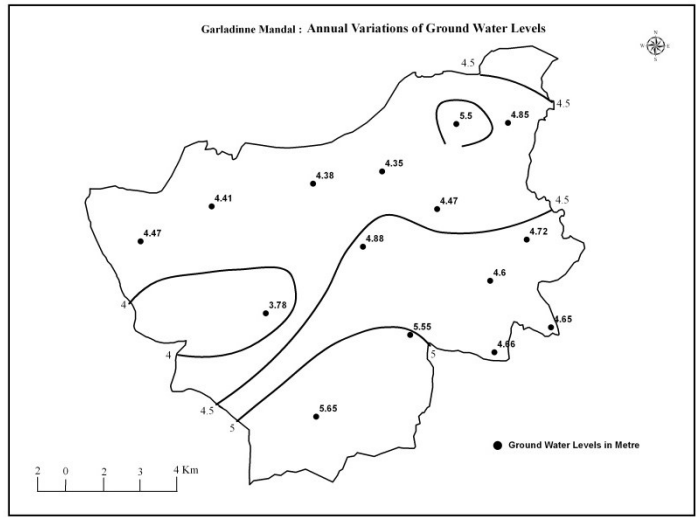

Fig. 3. Annual Variations of Groundwater Levels of Garladinne Mandal

Table 2. Garladinne Mandal: Average Seasonal Variations in Groundwater Levels of Different Controlled Wells (in metres)

Sl. No	Well No.	Winter	Summer	Southwest Monsoon	Northeast Monsoon	Annual Average
1	1	4.53	5.03	4.74	3.60	4.47
2	2	4.17	4.72	5.06	3.69	4.41
3	3	3.99	4.57	5.23	3.73	4.38
4	4	3.82	4.42	5.40	3.78	4.35
5	5	4.79	6.12	6.21	4.30	5.35
6	6	4.30	5.27	5.80	4.04	4.85
7	7	3.82	4.42	5.39	3.78	4.35
8	8	3.62	5.51	5.89	4.52	4.88
9	9	3.54	5.02	5.76	3.59	4.47
10	10	3.78	5.41	5.96	3.72	4.72
11	11	5.19	5.91	6.44	5.06	5.65
12	12	5.09	5.81	6.34	4.98	5.55
13	13	3.27	5.62	6.12	3.41	4.60
14	14	3.52	5.51	6.04	3.56	4.66
15	15	3.39	5.56	6.08	3.48	4.63
Mandal Average		**4.10**	**5.23**	**5.30**	**3.97**	**4.76**

(Source: Computed by the Authors)

During summer the average groundwater fluctuation is 0.51 m in the study area. It ranges from 0.02 metre in number 1 controlled well to a maximum of 0.96 metre in number 13 controlled well. In number 1, 2, 3, 4, 7, 11 and 12 controlled wells the groundwater level fluctuation is less than 0.50 metre. In other controlled wells it is more than 0.50 metre.

The average groundwater level fluctuation found to be 0.40 metre during southwest monsoon period. The minimum groundwater level fluctuation of 0.18 metre is found in number 1 controlled well and the maximum groundwater level fluctuation of 0.77 metre is noticed in number 5 controlled well. In number 1, 2, 3, 4, 7, 8, 9, 10, 11, 12, 13, 14 and 15 controlled wells the groundwater level fluctuation is less than 0.50 metre. It is more than 0.50 metre in number 5, and 6 controlled wells. Northeast monsoon period experiences 0.63 metre of average groundwater level fluctuation. The minimum groundwater level fluctuation of 0.31 metre is found in number 12 controlled well and maximum groundwater level fluctuation of 1.11 metre is noticed in number 5 controlled well. In number 1, 11 and 12 controlled wells the groundwater level fluctuation found to be less than 0.50 metre. In number 2, 3, 4, 6, 7, 8, 9, 10, 13, 14 and 15 controlled wells the groundwater level fluctuation varies from 0.50 to 1 metre. In number controlled well 5 it is more than 1 metre.

The annual groundwater level fluctuations range from 0.31 metre in number 1 controlled well to a maximum of 0.80 metre in 5 controlled well. The average annual groundwater level fluctuation is 0.50 metre. The annual groundwater level fluctuations are less than 0.50 metre in number 1, 2, 3, 4, 7, 11 and 12 controlled wells. In other controlled wells it is more than 0.5 metre (Table 3, Fig.4).From the analysis of seasonal groundwater level fluctuations, it is found that in winter and southwest monsoon periods the fluctuation is less than 0.50 metre. During summer and northeast monsoon periods the average groundwater level fluctuation is above 0.50 metre and as high as 0.63 metre during northeast monsoon period due to high recharge of surface water resources.

Relationship between Monthly Water Balance Elements and Monthly Groundwater Level Variations and Fluctuations

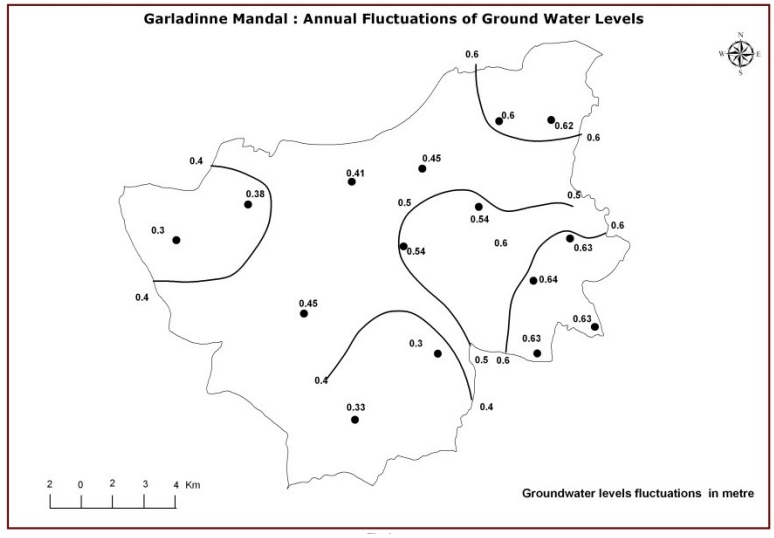

Fig. 4. Annual Fluctuations of Groundwater Levels in Garladinne Mandal

Table 3. Garladinne Mandal: Average Seasonal Groundwater Level Fluctuations of Different Controlled Wells (in metres)

Sl. No	Well No	Winter	Summer	Southwest monsoon	Northeast monsoon	Annual average
1	1	0.67	0.07	0.18	0.47	0.31
2	2	0.52	0.23	0.30	0.52	0.38
3	3	0.45	0.31	0.36	0.55	0.41
4	4	0.38	0.39	0.42	0.59	0.45
5	5	0.63	0.65	0.77	1.11	0.80
6	6	0.50	0.52	0.59	0.85	0.62
7	7	0.38	0.39	0.43	0.58	0.45
8	8	0.72	0.70	0.36	0.52	0.54
9	9	0.50	0.67	0.36	0.69	0.54
10	10	0.56	0.74	0.44	0.82	0.63
11	11	0.22	0.40	0.36	0.35	0.33
12	12	0.17	0.36	0.36	0.31	0.32
13	13	0.62	0.96	0.30	0.79	0.64
14	14	0.59	0.85	0.37	0.80	0.63
15	15	0.39	0.90	0.33	0.79	0.63
Mandal average		0.49	0.51	0.40	0.63	0.50

(Source: Computed by the Authors)

The correlation between mean monthly rainfall and mean monthly groundwater level variations is +0.784. The correlation between mean monthly rainfall and mean monthly groundwater level fluctuations is + 0.88. The correlation between monthly PE and monthly groundwater level variation and monthly groundwater level fluctuation is +0.85 and +0.01, between AE and Groundwater Level (GWL) variation and fluctuation is +0.25 and +0.27 and between monthly WD and GWL variation and fluctuation is +0.23 and -0.14 respectively. The correlation between monthly Ima and GWL variation and fluctuations +0.14 and +0.54 and between monthly Ia and GWL variation and fluctuation is +0.11 and -0.01 respectively.

Rise and Fall in Groundwater Level

The annual rise and fall in groundwater levels of Garladinne mandal have been worked out for the period between 2003 to 2012 (Table 4). From the analysis it is found that in about 14 controlled wells there is fall in groundwater level. The fall in groundwater level varies between -0.19 metre (in number 15 controlled well) and – 5.26 metre (in number 11 controlled well). The fall in groundwater level is less than 1 metre in 3, 4, 6, 10 and 15 controlled wells and varies from 1 to 2 metre in groundwater controlled wells 1, 2, 7, 9, 13 and 14. It exceeds 2 metre in number 8, 11, and 12 controlled wells. In contrast, the controlled well number 5 indicates rise in groundwater level by +0.98 metre. From the analysis of rise and fall in groundwater level it is found that in majority of the wells shows fall in groundwater level. The fall is high mostly in southwestern part of the Garladinne mandal.

Table 4. Garladinne mandal: Annual Rise and Fall in Groundwater Level

Well No.	Rise And Fall in Groundwater Level (in metres)
1	-1.21
2	-1.41
3	-0.44
4	-0.24
5	+0.98
6	-0.22
7	-1.87
8	-2.23
9	-1.07
10	-0.42
11	-5.26
12	-2.12
13	-1.12
14	-1.55
15	-0.19

Groundwater Recharge

Adopting Seghal's (1970) method, Krishna Rao (1970) method, Radhakrishna et. al (1974) method and U.S geological (1985) method, the annual groundwater recharge of the Garladinne mandal has been worked out.

Seghal's (1970) method of groundwater recharge:

$$G = 2.5 (P- 16)^{0.5}$$

where, P = Precitation in inches

Krishna Rao (1970) method of groundwater recharge:

$$G = K (P-X)$$

where, G = 0.2 (P – 400) when P is 400 mm to 600 mm

G = 0.3 (P- 500) when P is 1000 mm to 2000 mm

Radhakrisna et. al (1974) method of groundwater recharge:

According to this method the groundwater recharge is 10% of the annual rainfall.

USGS method (1985) of groundwater recharge: According USGS method (1985) the groundwater recharge is 15% of the annual rainfall.

The groundwater recharge worked out according Seghals method is 101.29 mm which is 17.83% of the annual rainfall. The groundwater recharge worked out according Krishna Rao method (1970) is 33.60 mm which is about 5.91% of the annual rainfall. The groundwater recharge worked out according to Radhakrisna et. al method (1974) is 56.80 mm which is about 10% of the annual rainfall. The groundwater recharge worked out according US geological method (1985) is 85.20 mm which is about 15% of the annual rainfall. The average value of groundwater recharge of the four methods is 69.22 mm which is about 12.18 % of the annual rainfall.

Groundwater Potential and Extraction

The groundwater potential is worked out at village level of the Garladinne mandal by adopting rainfall recharge method. While calculating groundwater potential the area of hilly terrain is deducted from each village area. The groundwater potential varies from 62,298 m^3 in Ankampeta village to a maximum of 2,185,968 m^3 in Penakacherla village.

The total groundwater potential of Garladinne mandal is 17,545,494 m^3. The groundwater potential is less than 750,000 m^3 in Kalluru (RS), Ankampeta, Jambuladinne, Budedu, , Kalluru and Obulapuram villages. The groundwater potential varies from 750,000 to 1,500,000 m^3 in Kesavapuram, Muntimadugu, Koppalakpnda, Sirivaram, Krishnapuram, Kotanka, Illuru and Kannampalli villages. The groundwater potential exceeds 1,500,000 m^3 in Penakacherla, Yerraguntla, Marthadu and Garladinne villages. The groundwater extraction varies from 174,000 m^3/annum in Obulapuram village to a maximum of 2,598,000 m^3 in Penakacherla village (Table 5). The total groundwater extraction of the Garladinne mandal per annum is estimated to be 18,883,500 $m^{3.}$ The total groundwater potential is 17,545,494 m^3. The over extraction of groundwater resources per annum is 1,338,006 m^3.

The village-wise analysis of groundwater potential reveals that in Penakacherla, Koppala Konda, Muntimadugu, Kalluru (R.S), Kalluru, Ankampeta, Sirivaram, Krishnapuram, Yerraguntla, Kotanka Marthadu, Budedu, Garladinne and Jambuladinne villages there is over extraction of groundwater resources. The over extraction varies from 4,742 m^3 per annum in Sirivaram to a maximum of 588,325 m^3 per annum in Kalluru village. In Kesavapuram, Illuru, Kanampalli and Obulapuram villages there is under extraction. The under extraction varies from 23,969 m^3 per annum in Obulapuram village to a maximum of 1,169,546 m^3 in Illuru village. The Mid Pennar south canal passes through Yerraguntla and Marthadu villages. The Illuru distributary canal passes through Yerraguntla, Kesapuram, Muntimadugu, Kalluru and Illuru villages. As these two canals pass through the above said villages there is a source for recharge of groundwater during crop period in kharif season. In Kanampalle and Obulapuram villages the extraction of groundwater resources is low due to low number of tube wells.

Water Balance

Total surface water resources of the study area worked out are: 173,222,960 m^3. (Mean annual rainfall x Geographical area of the mandal) The water stored in tanks, ponds and reservoirs worked out is: 3,123,692 m^3 (1.80%). (Total geographical area of the tanks/ponds x average depth in metres x mean annual rainfall). The total groundwater resources worked out are: 17,545,194 m^3 (10.12%). (Annual recharge x Geographical area of the mandal).

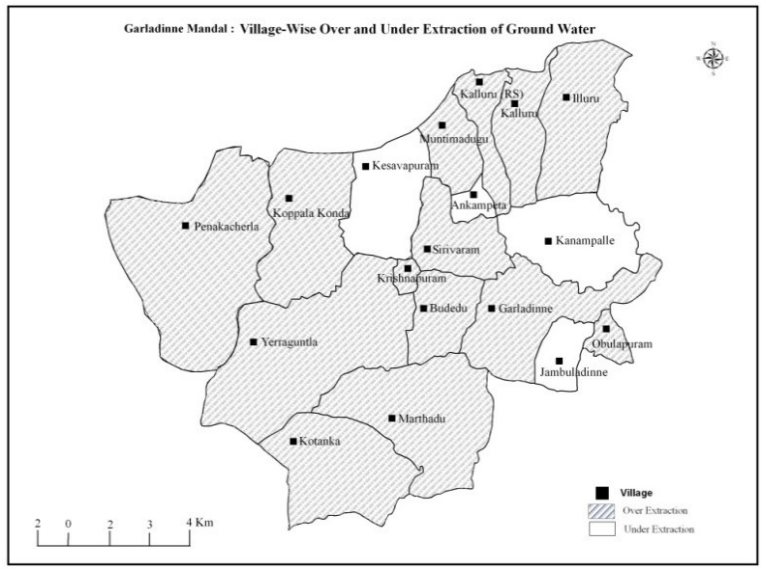

Fig. 5. Village-wise Over and Under Extraction of Groundwater in Garlandine Mandal

Table 5. Garladinne Mandal: Groundwater Over and Under Extraction

Sl. No	Village	Groundwater Potential in m^3	Groundwater Extraction in m^3	Over Extraction in m^3	Under Extraction in m^3
1	Penakacherla	2,185,968	2,598,000	412,032	-
2	Koppalakonda	829,948	942,000	112,052	-
3	Kesavapuram	843,792	636,000	-	207,792
4	Muntimadugu	783,570	804,000	20,430	-
5	Kallru (R.S)	497,000	714,000	217,000	-
6	Kalluru	605,675	1,194,00	588,325	-
7	Illuru	1,433,546	264,000	-	-
8	Kannampalli	768,342	660,000	-	1,169,546
9	Ankampeta	62,298	192,000	129,702	108,342
10	Sirivaram	811,258	816,000	4742	-
11	Krisnapuram	777,341	840,000	62,659	-
12	Yerraguntla	1,957,542	2,514,000	556,458	-
13	Kotanka	1,209,966	1,284,000	74,034	-
14	Marthadu	1,954,773	2,010,000	55,227	-
15	Budedu	676,279	1,086,000	409,721	-
16	Garladinne	1,551,912	1,615,500	63,588	-
17	Obulapuram	197,969	174,000	-	23,969
18	Jambuladinnee	398,015	540,000	141,985	-
Total		**17,545,194**	**18,883,500**	**2,847,955**	**1,509,649**

The water resources lost in the form of surface run off worked out are: 34,644,592 m^3 (20%). The total water resources lost in the form of evaporation, evapotranspiration worked out are: 117,909,482 m^3 (68.07%). (Total surface water resources – (water stored in tanks, ponds and reservoirs + total groundwater resources + total surface run-off). From the analysis of the water balance of Garladinne mandal it is found that out of 173,222,960 m^3 surface water resources about 1.80 % (3,123,692 m^3) are stored in the tanks and ponds. About 10.12% is recharged to groundwater. About 20% (34,644,592 m^3) of water resources are lost in the form of surface run off and about 68.07 % (117,909,482 m^3) water resources are lost in the form evaporation and evapotranspiration.

Conclusions

From the analysis of water balance elements (using Thornthwaite and Mather, 1955 method), it is found that Garladinne mandal comes under dry sub-humid type of climate. The analysis revealed that the study area experiences 803 mm of water deficit annually. The mean monthly rainfall and mean monthly groundwater level variations are positively related (+0.784). The study of seasonal groundwater levels variation indicates that the depth of groundwater level is less than 4 metres. The depth is about 4.10 metres during winter and more than 5 metres in summer and southwest monsoon season. The maximum depth of 5.30 metres is noticed in southwest monsoon period. Similarly positive relationship (+0.88) is found between mean monthly rainfall and mean monthly groundwater level fluctuation. From the analysis of seasonal groundwater level fluctuations it is found that the fluctuation is less during winter and southwest monsoon periods with less than 0.50 metres. However, during summer and northeast monsoon periods the average groundwater level fluctuation is above 0.50 metres. High average groundwater level fluctuation of 0.63 metres is found during northeast monsoon season due to high recharge of surface water resources at that time. From the analysis of rise and fall of groundwater level it is found that ~~in~~ majority of the wells recorded fall in groundwater level. The fall is high in the southwestern parts of the Garladinne mandal. The average groundwater recharge is 69.22 mm, which is about 12.18 % of the annual rainfall. The study of groundwater potential and groundwater extraction at village level highlights that over extraction is occurring in 14 villages and under extraction in 4 villages. The over extraction is about 2,847,955 m^3 and under extraction is about 1,509,649m^3 of water.

At present there are only 11 tanks existing in the Garladinne mandal. To store 10% of the total surface water resources about 50 new additional tanks are required with a minimum area of 50 hectares each in a village with a depth of about five metres of Government land which could be distributed in all villages of the Garladinne mandal. In addition to this about 20% of the surface water is lost in the form of surface run off which could be stored in the new tanks by increasing the area and depth of the existing tanks. About 50 new tanks are required which may be dug under Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS). The watershed development programs can be implemented at micro-watershed level in the Garladinne mandal.

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MORPHOMETRIC MEASURES AND SURFACE RUN-OFF: A STATISTICAL ANALYSIS FOR KANYAKUMARI AND NAMBIYAR BASINS, INDIA

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Abstract

Basin measurements are important from the point of water resources development. The advent of recent geospatial technology has opened new vistas in the study of water resources. The surface water resources of the Kanyakumari and Nambiyar basins in Tamil Nadu is analysed here for its morphometry and surface water resource bases, using remote sensing data and GIS along with multivariate statistics. Size and shape of the basin have a significant and positive relation with run-off.

Keywords: Basin, Resources, Morphometry, Multivariate, Positive relation

Introduction

Water resources in a drainage basin are largely defined by morphometric details and rainfall incidence of the basin, and so also is the hydrological cycle of the basin. The present study examines the geo-hydrological facets in the context of assessing the available water resources in the Kanyakumari and Nambiyar basins in southern Tamil Nadu, India. In the hydrological studies, it is normally hypothesised that relief defines drainage network; greater sinuosity of streams may be related to structural disturbances of the region; and the run-off depends on the size and shape of the basin.

Kanyakumari and Nambiyar basins (Figure 1) are located in Kanyakumari and Tirunelveli districts of Tamil Nadu respectively. The study area is located in between 8º 04' N and 8º 34' N and 77º 05' E and 77º 57' E, spreading over an extend of about 2,918 sq.km. There are many streams directly draining into the sea, as the basins are located in a narrow coastal stretch backed by the hills of the Western Ghats. There are 15 sub-watersheds in the basins under study (Fig. 2).

Database and Methodology

Morphometric characteristics of the two selected basins are described by measuring the relevant parameters for the linear, relief and area dimensions at sub-watershed level. Basin length, area, shape, size, basin slope, and stream lengths are the

parameters measured. Morphometric studies have been a popular methodology towards physiographic understanding of an area. Currently, GIS and remote sensing are more frequently brought in for studying the basin morphometry and water resources (6, 7, 5, 9, 4, 8, 3, 2, 1, 10). Rainfall of the basin is estimated by basin arithmetic means, and the surface runoff is estimated by using the method of SCS curve number. Overlay analysis of land use and land cover layers obtained from remote sensing, the hydrological soil properties, and the daily rainfall data of the sub-watersheds is carried out using GIS.

Drainage features of the basins are identified from the Survey of India toposheets (1:50,000) and IRS-1D LISS III and IRS-1C PAN-merged data products, and digitized in GIS platform. Basin area and perimeter of the sub-watersheds, the number and length of the streams of each order, and the slope characteristics of each one of the selected sub-watersheds were derived using image analysis and GIS. The basin parameters thus computed are tabulated in Table 1. Surface morphometry of the selected sub-watersheds is systematically analysed following suitable methods (Table 2). The SCS model computes runoff from an un-gauged watershed through an empirical relation that uses values of rainfall and watershed coefficient namely the runoff curve number (CN) as input. Curve number is a dimensionless coefficient, which reflects hydrologic soil group, antecedent moisture condition, and land use and land treatment classes. The input GIS layers for this model are watershed boundary map, land use / land cover map, contour map, hydrologic soil group map and rainfall map. To measure the strength of the relationship between the three-morphometric aspects and the two surface water resource parameters (Table 3), factor analysis and multiple regression analysis were adopted.

Table 1. Drainage Basin Characteristics of the Sub-watersheds in Kanyakumari and Nambiyar Basins

Name of the River basin/ Sub-watershed	Area (*A*) sq.km	Perimeter (*P*) km	Basin Length (L_b) km	Main Stream Length (O_L) km	Straight Line Length (E_L) km	Contour Length* (L_C) m	Highest Elevation (*Z*) m	Lowest Elevation (*z*) m
Kanyakumari								
Kodayar	169.93	72.89	16.31	28.85	16.25	509513	1820	92
Perunchani	163.24	64.79	16.78	19.92	14.73	582707	1803	101
Chittar	162.98	67.28	18.75	27.25	18.61	228296	758	88
Kuzhithuraiar	312.93	127.44	25.87	45.62	24.62	175953	940	20
Pazhayar	189.20	69.34	16.74	22.23	13.09	429336	1321	30
Puttanar	218.85	69.70	19.24	22.69	16.70	83182	956	7
Anandanar	194.33	66.64	16.32	24.71	20.47	52422	956	3
Kanyakumari	213.64	73. 52	23.23	7.97	10.67	118058	977	10
Nambiyar								
Uppar	108.33	48.54	18.97	17.60	13.83	51821	700	2.1
Hanuman Nadi	192.73	89.10	30.34	33.67	29.83	135151	1396	6
Radhapuram	190.58	67.34	26.31	30.62	24.73	3015	100	7
Valliyur kal	213.66	96.08	38.60	44.51	38.22	89662	1657	7
Tisaiyanvillai	201.11	77.13	30.75	29.95	24.69	1322	126	12
Upper Nambiyar	257.62	89.53	30.65	38.20	30.15	243269	1663	48
Lower Nambiyar**	132.42	62.70	24.21	24.72	24.35	37561	59.8	10
* 100 m contour interval								
** 20 m contour interval								

Table 2. Methodology Adapted for the Computations of Morphometric Parameters

Morphometric Parameters	Equation
Linear Aspects	
Stream Order	Hierarchical Rank
Bifurcation Ratio	$R_b = N_u / N_{u+1}$ where, N_u –Total number of stream segments of order *u* N_{u+1} – Number of streams of the next higher order
Main Stream Length	Length of the Major Stream
Mean Stream Length	$Lsm = L_u / N_u$ where, *Lsm* – Mean stream length in km, L_u – Total stream length of order *u* N_u - Total number of stream segments of order *u*
Stream Length Ratio	$RL = L_u / L_{u-1}$ where, L_{u-1} - Total stream length of its next lower order
Sinuosity Index	$C_s = O_L / E_L$ where, O_L – Actual path of the main stream in km E_L – Expected straight path of the stream in km
Relief Aspects	
Total Basin Relief	$H = Z - z$ where, *Z* – Highest elevation point in m *z* – Lowest elevation point in m
Mean Basin Slope	$\theta = L_c n / A$ where, L_c – Total length of contours in m *n* – Contour interval in m
Relief Ratio	$R_h = H / L_b$
Ruggedness Number	$R_n = DH$
Area Aspects	
Drainage Density	$D = \sum L_u / A$ where, *D* – Drainage density in km/km^2 $\sum L_u$ – Total stream length of all orders in km *A* – Area of the basin in km^2
Stream Frequency	$F_s = \sum N_u / A$ where, F_s – Stream frequency per km^2 and $\sum N_u$ – Total number of streams of all orders
Infiltration Ratio	$I_r = D F_s$
Drainage Texture	$R_t = N_u / P$ where, *P* – Perimeter in km
Form Factor	$R_f = A / L_b^2$ where, L_b is the maximum basin length in km
Circularity Ratio	$R_c = 4\pi A / P^2$
Elongation Ratio	$R_e = 2\sqrt{(A/\pi)} / L_b$
Length of Overland Flow	$L_g = 1/(2D)$ where, L_g – Length of overland flow in km

Factor analysis was performed in order to bring out meaningful dimensions of the morphometric variables selected, and factors scores are also computed to test the reliability of the factor analysis for the study area. Regression model with factors extracted was attempted to indicate the strength of morphometric parameters and rainfall in explaining the run-off. Residuals of regression model were mapped to evaluate the regression analysis.

Table 3. Surface Water Resource Parameters of the Sub-watersheds in Kanyakumari and Nambiyar Basins

Sub-watersheds	Tot_no	R_bm	Tot-len	C_s	H	Sl	R_h	R_n	D	F_s	I_r	R_t	R_f	R_c	R_e	L_g	rainfall	runoff
Kodayar	1216	3.99	595.43	1.78	1728	16.69	0.106	6054.93	3.5	7.16	25.06	16.68	0.64	0.4	0.9	0.14	1687	73
Perunchani	741	4.01	501.81	1.35	1702	19.64	0.1	5231.97	3.1	4.54	14.07	11.44	0.58	0.5	0.9	0.16	1874	101
Chittar	422	3.3	325.89	1.46	920	3.22	0.036	1118.81	2	2.59	5.18	6.27	0.46	0.5	0.8	0.25	1861	39
Kuzhithuraiar	403	4.26	380.55	1.85	670	7.97	0.036	1339.73	1.2	1.29	1.55	3.16	0.47	0.2	0.8	0.41	1684	652
Pazhayar	771	3.6	534.03	1.7	1291	12.79	0.077	3643.98	2.8	4.08	11.42	11.12	0.68	0.5	0.9	0.18	1711	63
Puttanar	335	4.04	270.16	1.36	949	2.18	0.049	1171.48	1.2	1.53	1.84	4.81	0.59	0.6	0.9	0.41	1729	448
Anandanar	218	5.49	202.14	1.21	953	1.55	0.058	991.26	1	1.12	1.01	3.27	0.73	0.6	1	0.48	1324	503
Kanyakumari	338	5.49	257.66	0.75	967	3.16	0.042	1166.24	1.2	1.58	1.9	4.6	0.4	0.5	0.7	0.41	895	119
Uppar	213	5.75	207.39	1.27	698	2.74	0.037	1336.05	1.9	1.97	3.74	4.39	0.3	0.6	0.6	0.26	734	74
Hanuman Nadi	480	4.54	391.85	1.13	1390	4.01	0.046	2826.05	2	2.49	5.23	5.39	0.21	0.3	0.5	0.25	500	106
Radhapuram	226	4.29	199.8	1.24	93	0.09	0.004	97.5	1.1	1.19	1.19	3.36	0.28	0.5	0.6	0.48	500	111
Valliyur kal	296	4.34	239.72	1.16	1650	2.4	0.043	1851.28	1.1	1.39	1.53	3.08	0.14	0.3	0.4	0.45	417	63
Tisaiyanvillai	85	4.71	88.05	1.21	114	0.2	0.004	49.91	0.4	0.42	0.17	1.1	0.21	0.4	0.5	1.14	692	104
Upper Nambiyar	498	3.5	444.93	1.27	1615	5.39	0.053	2789.18	1.7	1.93	3.28	5.56	0.27	0.4	0.6	0.29	571	36
Lower Nambiyar	173	4.34	133.69	1.02	50	0.33	0.002	50.28	1	1.31	1.18	2.76	0.23	0.4	0.5	0.5	692	125

Note:

***Tot_no** - Total Number of Streams, **R_bm** - Mean Bifurcation Ratio, **Tot_len** - Total Length of Streams, **C_s** - Sinuosity Index, **H** - Total Basin Relief, **Sl** - Basin Slope , **R_h** - Relative Relief , **R_n** - Ruggedness Number, **D** - Drainage Density, **F_s** - Stream Frequency, **I_r** - Infiltration Ratio, **R_t** – Drainage Texture , **R_f** - Form Factor **R_c** - Circularity Ratio, **R_e** - Elongation Ratio, **L_g** - Length of Overland Flow*

Results and Discussions

The association of 19 morphometric parameters with rainfall and run-off is given in Table 4.

Variables of surface water resource are positively and significantly associated with morphometric variables. Shape and size of the basin are highly associated with rainfall, and area of the basin with run-off. Basin length and the parameters regarding stream number and length is seen negatively associated with run-off.

Morphometric and Rainfall Dimensions: A Factorial Solution

Factor Analysis points out four factors as significant one, taking care of about 91 per cent of the variations in the data matrix (Table 5). The first component alone explains 57% of the total variance. Drainage texture (0.97), total number of streams (0.95), drainage density (0.95), stream frequency (0.94), relief ratio (0.93), ruggedness number (0.92), infiltration number (0.92), basin slope (0.92), total stream length (0.92), basin height (0.71), rainfall (0.71), elongation ratio (0.70), form factor (0.70) and sinuosity index (0.63) are positively and significantly loaded with this component (Table 6). This component is suitably named as relief and drainage network dimension. It is to be noted that the length of

overland flow (-0.74) and basin length (-0.61) have high and negative loading with this component.

Table 4. Correlation between Morphometric Parameters with Rainfall and Run-off in Kanyakumari and Nambiyar Basins

Morphometric Parameters	Rainfall	Run-off
Linear and Relief Aspects		
Perimeter	-.036	.438
Length of the Basin	-.756*	-.173
Total Number of Streams	.541*	-.215
Mean Bifurcation Ratio	-.381	.211
Total Length of Streams	.538*	-.134
Sinuosity Index	.661*	.282
Total Basin Relief	.268	-.203
Basin Slope	.623*	-.113
Relative Relief	.600*	-.043
Ruggedness Number	.438	-.259
Area Aspects		
Area of the Basin	.065	.552*
Drainage Density	.528*	-.348
Stream Frequency	.525*	-.323
Infiltration Ratio	.511*	-.306
Drainage Texture	.574*	-.298
Form Factor	.856*	.413
Circularity Ratio	.171	-.072
Elongation Ratio	.876*	.410
Length of Overland Flow	-.399	.144
Surface Water Resources		
Rainfall	1.000	.362
Run-off	.362	1.000

**Significant at 5 % level.*

The first component alone explains 57% of the total variance. Drainage texture (0.97), total number of streams (0.95), drainage density (0.95), stream frequency (0.94), relief ratio (0.93), ruggedness number (0.92), infiltration number (0.92), basin slope (0.92), total stream length (0.92), basin height (0.71), rainfall (0.71), elongation ratio (0.70), form factor (0.70) and sinuosity index (0.63) are positively and significantly loaded with this component (Table 6). This component is suitably named as relief and drainage network dimension. It is to be noted that the length of overland flow (-0.74) and basin length (-0.61) have high and negative loading with this component.

The second component is named as basin size dimension that explains about 18% of the total variance. The variables significantly loaded in this dimension are basin perimeter (0.89), basin length (0.74) and basin area (0.69). Circularity ratio has a high negative loading (-0.92).

The third component explains 11% of variance, and rainfall is positively loaded with this dimension. The variables significantly and positively loaded with this component are area (0.60), rainfall (0.59), elongation ratio (0.55) and form factor (0.54). Thus, this component is named as basin shape and rainfall dimension. The last significant, explaining only 5 per cent of variance, is named as drainage path dimension, and is positively loaded with mean bifurcation ratio (0.57).

Table 5. Factor Analysis: Components and Eigen Values

Component	Description	Initial Eigen Values	Percentage of Variance
I	Drainage and relief	11.37	56.84
II	Size	3.56	17.78
III	Shape and rainfall	2.17	10.86
IV	Drainage path	1.03	5.15

Morphometric and Rainfall Dimensions of the Sub-watersheds: The Spatial Pattern

The factor scores derived for 15 sub-watersheds (Table 7 and Fig. 3a, b, c and d) clearly depict the spatial pattern of the four dimensions derived from the factor solution. In the case of the relief and drainage network dimension, Kodayar and Perunchani sub-watersheds in Kanyakumari basin recorded high factor scores, and high scores may reflect fine drainage network and heavy rainfall in the sub-watersheds; moderate factor scores are seen in Chittar (-0.39) and Kanyakumari (-0.03). A very low score is seen in Kuzhithuraiar sub-watershed (-0.67) due to its coarse drainage texture and density, less relief and comparatively low rainfall. Similarly in Nambiyar basin, the higher scores are seen in Hanuman Nadi (0.74) followed by Upper Nambiyar (0.53), and very low score is seen in Tisaiyanvilai (-1.50) sub-watershed (Fig. 3a).

Factor scores of size dimension is very high (Fig 3b) in Anandanar sub-watershed (1.67) and very low in Kanyakumari sub-watershed (0.08) of Kanyakumari basin. In Nambiyar basin, it is high in Uppar sub-watershed (-0.28) and low in Valliyur kal sub-watershed (-1.71). It is to be noted that the sub-watersheds with compact smaller area have a higher factor score. All the sub-watersheds of Kanyakumari basin have positive factor scores highlighting the compactness; and of Nambiar basin have negative scores, pointing out elongated smaller areas.

Factor scores of shape and rainfall dimension are shown in Fig. 3c. In Kanyakumari basin the shape dimension has a higher score (2.52) in Kuzhithuraiar sub-watershed due to its larger area and less elongated shape; moderate score (0.07) in Puttanar sub-watershed (oval in shape) and Anandanar sub-watershed (circular), due to their moderate area and compactness, and very low scores (-0.58) in Chittar sub-watershed due to its smaller area and less elongated shape. In Nambiyar basin, the higher score (1.06) is seen in Valliyurkal sub-watershed and Tisaiyanvilai due to their elongated shape, and lower scores (-1.63) at Uppar sub-watershed which has a smaller area and compact circular shape.

Drainage Path dimension has a higher factor score (1.39) in Chittar sub-watershed of Kanyakumari basin where the mean bifurcation ratio is less. The lower scores are seen in Anandanar (-1.76) and Kanyakumari (-1.95) sub-watersheds which have greater mean bifurcation ratio. In Nambiyar basin the higher values are seen in Lower Nambiyar (0.70) which has a low mean bifurcation ratio; moderate scores in Radhapuram (0.58); and very low scores in Uppar sub-watershed (-0.92) due to its high mean bifurcation ratio (Fig. 3d).

Table 6. Factor Analysis: Variables and Components

Variable	Component I	Component II	Component III	Component IV
Perimeter	-0.08	0.89*	0.39	0.14
Length of the Basin	-0.61*	0.72*	-0.28	0.003
Total Number of Streams	0.95*	0.19	-0.12	-0.06
Mean Bifurcation Ratio	-0.43	-0.42	-0.14	0.57*
Total Length of Streams	0.92*	0.32	-0.02	0.03
Sinuosity Index	0.63*	0.24	0.47	-0.38
Total Basin Relief	0.71*	0.36	-0.25	0.44
Basin Slope	0.92*	0.13	-0.03	-0.009
Relative Relief	0.93*	0.02	-0.04	0.33
Ruggedness Number	0.92*	0.20	-0.26	0.12
Area of the Basin	-0.09	0.69*	0.60*	0.27
Drainage Density	0.95*	-0.01	-0.27	-0.08
Stream Frequency	0.94*	-0.002	-0.23	-0.13
Infiltration Ratio	0.92*	-0.001	-0.24	-0.15
Drainage Texture	0.97*	-0.03	-0.18	-0.10
Form Factor	0.70*	-0.40	0.54*	0.18
Circularity Ratio	0.03	-0.92*	0.004	0.09
Elongation Ratio	0.70*	-0.41	0.55*	0.16
Length of Overland Flow	-0.74*	0.00	0.19	-0.15
Rainfall	0.71*	-0.22	0.59*	-0.11

* *Significant at 5% level*

Table 7. Morphometric and Rainfall Dimensions - Factor Loading Matrix

Sub-watershed Name	Factor Scores				Regression Residuals
	Component I	Component II	Component III	Component IV	
Kodayar	2.12	0.33	-0.44	1.01	78.53
Perunchani	1.52	0.54	-0.46	-0.14	12.66
Chittar	-0.39	0.45	-0.58	1.39	-122.05
Kuzhithuraiar	-0.67	0.88	2.52	0.91	102.62
Pazhayar	0.77	1.00	-0.21	0.87	-130.88
Puttanar	-0.66	1.31	0.07	-0.13	65.79
Anandanar	-0.61	1.67	0.04	-1.76	43.86
Kanyakumari	-0.03	0.08	0.09	-1.95	-125.50
Uppar	-0.11	-0.28	-1.63	-0.92	62.39
Hanuman Nadi	0.74	-1.42	0.45	-0.47	91.19
Radhapuram	-1.01	-0.46	-0.69	0.58	3.17
Valliyur kal	0.28	-1.71	1.06	-0.57	-13.14
Tisaiyanvillai	-1.50	-0.65	-0.07	0.60	-78.59
Upper Nambiyar	0.53	-0.86	1.02	-0.11	-105.14
Lower Nambiyar	-0.99	-0.87	-1.16	0.70	115.09

Multiple correlation coefficient (R) = 0.88

Coefficient of determination (R^2) = 0.78

Surface Water Resources of the Sub-watersheds: A Regression Model

Regressions were fitted with surface morphometric measures and rainfall as explanatory variables and run-off as explained one, taking the factor scores into account. The four components explain about 78 per cent of variance in run-off. The following is the computed regression model:

$$Runoff = 174.467 - 0.365 \times relief\ and\ drainage\ network + 0.603 \times size + 0.515 \times shape - 0.134 \times drainage\ path\ dimension \pm 27.538.$$

Of the four factor scores, size and shape dimension registered significant positive coefficient. The relief – drainage network and drainage path dimension recorded negative coefficient.

Surface Water Resources of the Sub-watersheds: The Spatial Residual Pattern

Residuals derived from regression equations are plotted in Fig.4. Residual is seen higher in Kuzhithuraiar sub-watershed (102.62) and Kodayar sub-watershed (78.53). Kuzhithuraiar sub-watershed has very high factor scores for size dimension and high factor scores for shape and rainfall dimension. The Kodayar sub-watershed has very high factor scores for relief and drainage dimension, high scores for drainage path dimension and moderate factor scores for shape and rainfall dimension. Moderate high residuals occur in Puttanar (65.74), Anandanar (43.86) and Perunchani (12.66) sub-watersheds of Kanyakumari basin. In Nambiyar basin the higher positive residuals are seen in Lower Nambiyar (115.09) and Hanuman Nadi (91.19) sub-watersheds. Lower Nambiyar sub-watershed, drainage path dimension has moderately high factor score. Hanuman Nadi recorded high factor scores in relief, drainage and rainfall dimension. Lower negative residuals are seen in Upper Nambiyar (-105.14) and Tisaiyanvilai (-78.59) sub-watersheds. The sub-watersheds with high rainfall, agricultural land use and gentle slope generally exhibit positive residuals. Negative residuals are seen in areas with less rainfall, predominantly wasteland and nearly level in the slope.

Conclusions

In the present study, the relationship between the terrain conditions and the surface water resource variables has been analysed by using multiple correlation, factor analysis and regression models. From the regression models, it has been clearly found that the relief and the area of the basin register insignificant, negative relation, with the surface water resource characteristics. Size and shape of the basin register a significant, positive relation. Residuals show a higher positive deviation in most of the sub-watersheds of Kanyakumari basin.

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EFFECTS OF LEATHER TANNING INDUSTRIES ON GROUNDWATER QUALITY FOR IRRIGATION USE IN DINDIGUL PANCHAYAT UNION USING REMOTE SENSING AND GIS

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Abstract

Groundwater has been one of the most useful natural resources to mankind since the time it was discovered. It can be defined as the portion of precipitation that penetrates the soil and becomes a part of the underground water system. This natural resource is classified as one of the most important renewable resource since it helps mankind in several lifestyles such as drinking, washing, bathing etc. It uses extends to industries, municipalities, rural houses and irrigation purposes. Irrigation plays a vital role in Indian agriculture. Irrigation is defined as the artificial application of water to the land to stimulate or make possible the growth of plants. Irrigation is the controlled application of water for crops to supplement the available soil moisture where the yields are limited. The objective of irrigation is to supply the soil with the amount of water required by plants to produce optimum yields. The study area, Dindigul panchayat union, is mainly dependent on well irrigation, for its agricultural activity. Leather tanning industries discharge the highly contaminated waste water which affects the quality of groundwater. There were about 38 tannery units located in the study area, Dindigul panchayat union. The effluents that discharge from these industries penetrates the ground and has affected the quality of the groundwater. Hence in the present study, an attempt is made to analyse the impact of leather tanning effluents on groundwater quality for irrigation use in Dindigul panchayat union, for a time period from 1988 to 2009. Groundwater samples are collected at 25 sample locations at random covering all the village panchayats in the study area. These groundwater samples are subjected to chemical analysis to check the quality of groundwater for irrigation use and especially TDS, pH, BOD, COD, TH, the critical parameters, and based on the results, contour maps are developed for all parameters using ARC/MAP software.

Keywords: *Groundwater quality, Irrigation, Leather tanning industries, Chemical analysis, Critical parameters*

Introduction

Groundwater is defined as the portion of precipitation that penetrates the soil and becomes a part of the underground water system. It is the most replenishable resource available to man. Its use in irrigation, industries, and daily requirements continues to increase. Irrigation is defined as the artificial application of water to the land to stimulate or make possible the growth of plants. It is the controlled application of water for crops to supplement the available soil moisture where the yields are limited. The objective of irrigation is to supply the soil with the amount of water required by plants to produce optimum yields. There were about 38 leather tanning industries located in the study area, Dindigul panchayat union. The effluents that discharge from these industries penetrates the ground and has affected the quality of the groundwater. As the agricultural activity in Dindigul panchayat union is mainly dependent on well irrigation, the study on irrigation plays a vital role in the study area. Hence, in the present study, an attempt is made to analyse the impact of leather tanning effluents on groundwater quality for irrigation use in Dindigul panchayat union, between 1988 to 2009.

Review of Literature

Thomson Jacob, C and Gunnar Jacks (1997) have reported that the disposal of untreated waste water from the hosiery and knitting factories have polluted the groundwater in Tiruppur town in Tamil Nadu. In their study, the physio-chemical characteristics are analysed with groundwater samples collected at Tiruppur. The parameters like Electrical Conductivity (EC), Total Suspended Solids (TTS), Total Dissolved Solids (TDS), Chloride (Cl^-), Sulphate (SO_4), Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) are observed to be exceeding the permissible limits. The authors have reinforced the concept that the in-discriminate use of natural resources for the production of consumer items for economic gain is unethical. The Black Smith Institute (2001) has attempted to study the industrial waste in Lusaka, Kabwe and Kague towns in Zambia, Africa. The liquid waste from soap, cooking oil, paint and fertilizer industries and lead and cadmium processing plants located in these towns, have created a very serious pollution problem. The report recommends that the government legal structure and donor groups should call for a better community representation in the pollution related issues.

Sai Kiran, D and Purnend, M. (2001) in their study have highlighted the probable direction of movement of contaminants from the chemical industries in Ranga Reddy and Medak districts of Andhra Pradesh. By overlaying the slope, drainage and location map of the chemical industries, land use planning of the region is done. Govil Krishna, (2002) has analysed the concentration of heavy toxic metals such as Chromium, Nickel, Copper and Strontium in the groundwater samples in Patancheru industrial area in Andhra Pradesh. The results proved that the proportions of the above said toxic materials have exceeded the tolerance limit. Saxena and Radha Krishna, (2002) have collected 144 groundwater samples and tested for its chemical analysis in Krishna delta region, India. The results have proved that the nitrate concentration is higher than the tolerance limit in 32 water samples.

In this context, the present study envisages investigation on the groundwater quality status for human use in Dindigul panchayat union, for the year periods 1988 and 2009.

Study Area

Dindigul panchayat union is situated in Dindigul district, Tamil Nadu. It lies between 10°14'45" and 10°31'00" North latitudes and 77°45' and 78°4'30" East longitudes covering the Survey of India (SOI) topographic map 58 F/14, F/15, F/16 and 58 J/3 extending over an area of 378.71 Sq.Kms. The area consists of 18 administrative units i.e., village panchayats namely Adiyanuthu, Agaram, Alakkuvarpatti, Ammakulathupatti, Anaipatti, Balakrishnapuram, Chettinaickanpatti, Kovilur, Kurumbapatti, Mullipadi, Pallapatti, Periyakottai, Silapadi, Sirumalai, Thadikombu, Thamaraipadi, Thottanuthu and Vellodu. Among these, Sirumalai village panchayat is a hilly area located in the southern part of the study area. Dindigul (Corporation) is the headquarter of the study area (Figure 1).

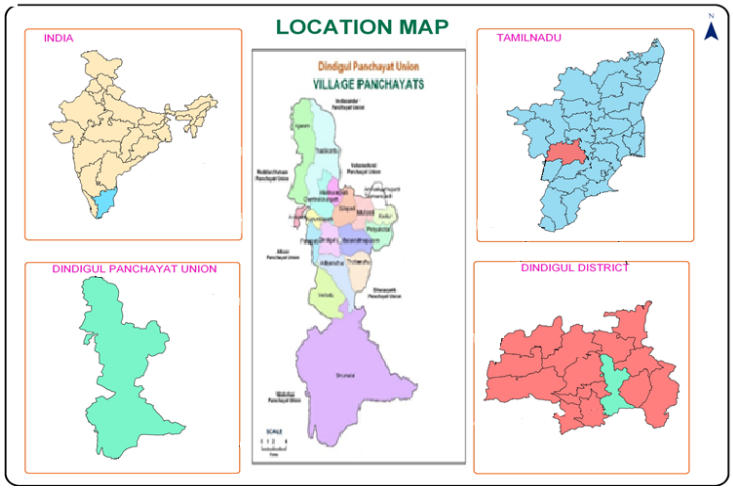

Fig. 1. Location of Dindigul Panchayats
Fig. 2. Location of Leather Tanning Industries

Location of Leather Tanning Industries

A total of 38 leather tannery units (62.3 percent of the district's units) located in Dindigul panchayat union are found distributed in Pallapatti (19), Adiyanuthu (12) village panchayats, Dindigul Municipality (4), and Vellodu (3) village panchayats and are captured using GPS (Global Positioning System) survey and are shown in Figure 2. Toxic effluents like Chloride, Chromium, Nitrate, Sodium, Calcium, Magnesium, Copper and Iron are found mixed in the discharges waste water. As these effluents of the leather tanning industries have degraded the groundwater quality, an attempt is made to analyse the groundwater quality for irrigation use in Dindigul panchayat union.

Database and Methodology

The groundwater quality for irrigation use for the study area is assessed based on the groundwater data collected for two different year periods - 1988 and 2009. For the year 1988, the groundwater quality analysis data results were collected from the Groundwater Division, Public Works Department, Dindigul. For the year 2009, the sample locations are the same locations where the Groundwater Division and Public Works Department is periodically monitoring. The collected groundwater samples are subjected to chemical analysis to check the quality of groundwater for irrigation use for 8 namely Total Dissolved Solids (TDS), Electrical Conductivity (EC), Hydrogen ion concentration (pH), Chloride (Cl^-), Percent Sodium (% Na), Chromium (Cr^{6+}), Fluoride (F), and Sulphide (S^2). Based on the results obtained, contour maps are developed for all parameters using ARC/MAP software. Inverse distance weighted method is used to create groundwater quality maps. No distortion of isoline was interpolated. The Indian Standards for groundwater quality for irrigation use is shown in Table 1.

Table 1. Groundwater Quality Analysis ***(Parameters, Standards, Classes, Years and Area)***

Parameters	Good			Moderate			Poor			Very Poor		
	Standards	**1988 sq.km**	**2009 sq.km**	**Standards**	**1988 sq.km**	**2009 sq.km**	**Standards**	**1988 sq.km**	**2009 sq.km**	**Standards**	**1988 sq.km**	**2009 sq.km**
TDS	**< 400**	0.06	4.34	**400-1000**	21.05	13.62	**>1000**	388.59	391.74	**-**	-	-
EC	**< 250**	-	1.91	**> 250-750**	0.74	15.87	**750-2250**	318.89	186.05	**> 2250**	90.07	205.8
Chloride	**<600**	87.61	35.49	**-**	-	-	**>600**	322.09	374.21	**-**	-	-
Percent Sodium	**< 60**	23.55	6.63	**-**	-	-	**>60**	386.15	403.07	**-**	-	-
Fluoride	**< 0.6**	380.39	316.92	**0.6-2.0**	27.92	91.69	**>2.0**	1.39	1.09	**-**	-	-
Sulphide	**< 2.0**	406.60	402.00	**-**	**-**	**-**	**>2.0**	3.10	7.70	**-**	-	-

Source: *Indian Standards of Industrial and Sewage Effluent Discharge, IS 2490, 1983. All the value is measured in mg/l except Electrical Conductivity and Percent Sodium represented in micromhos/cm and percent respectively.*

The methodology followed to assess the groundwater quality for irrigation use in Dindigul panchayat union is shown in Flow Chart 1.

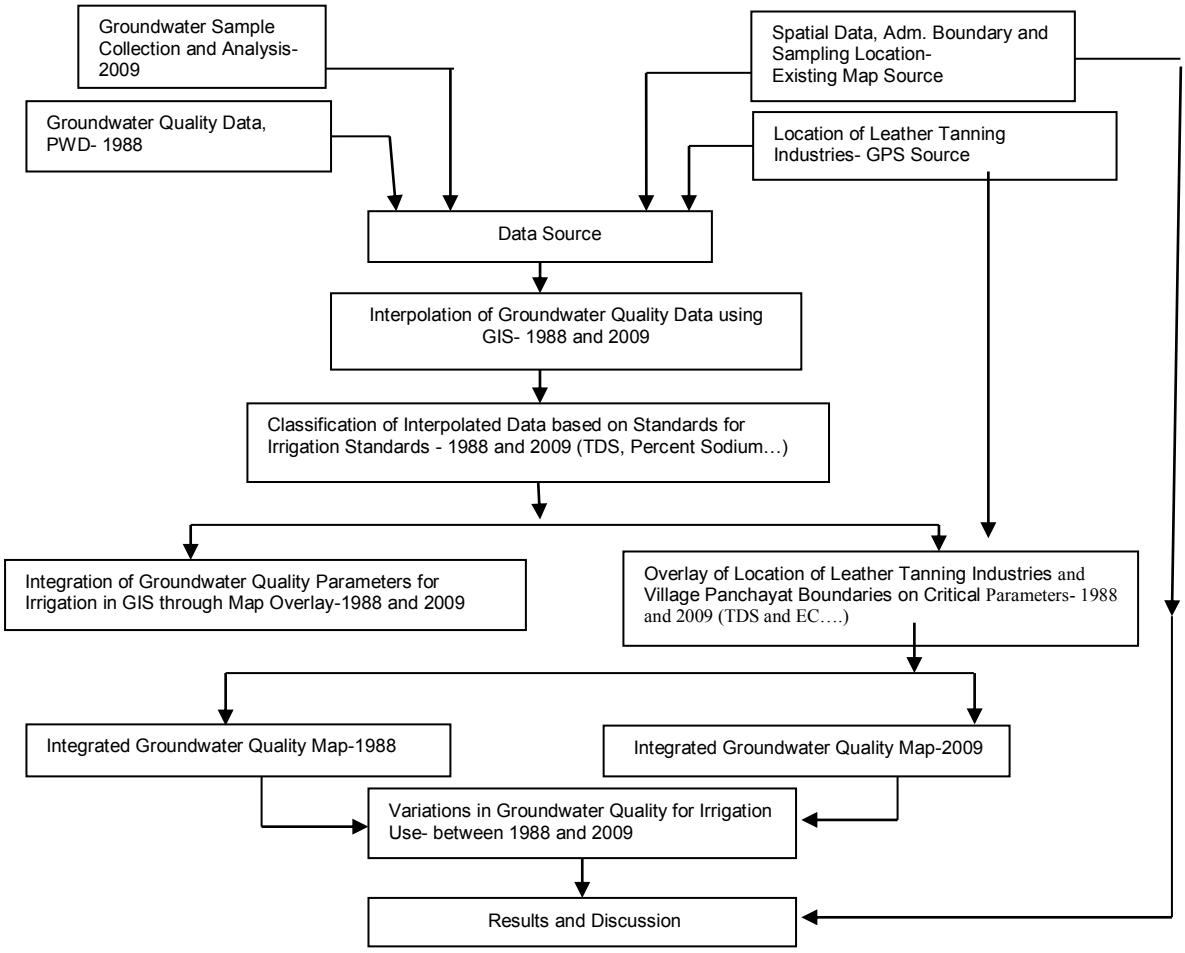

Chart 1. Methodology

Results and Discussion

Chemical Analysis of Various Parameters

In assessing the groundwater quality for irrigation standards, each parameter is categorized into 3 classes such as Good, Moderate and Poor based on the chemical constituents of the groundwater. If the concentration of the parameter is below the tolerance limit, then the area is mentioned as good (not affected). If the value is within the admissible limit, then it is classified as moderate (moderately affected i.e., can be acceptable) and if the value exceeds the tolerance limit, those areas are classified as poor (highly affected). The spatial distributions of groundwater samples for various parameters are described below.

Parameters within the Permissible Limit

The concentration of pH (5.5 to 9.0) and chromium (1.0 mg/l) is noted to be within the permissible limit throughout the study area. The pH values in 2009 are lower than 1988, indicating the possible acidification.

Parameters in which the Area Under Good has Decreased and Poor has Increased

For the parameters namely chloride, percent sodium and sulphide, the area under good has decreased and poor has increased. Between the two periods, the area under good has decreased from 87.61 (21.38 percent) to 35.49 sq.km (8.66 percent) and the poor area has increased from 322.09 (78.62 percent) to 374.21 sq.km (91.34 percent) in the case of chloride (Fig 3a). In percent sodium (Fig 3b), the good area has decreased from 23.55 (5.75 percent) to 6.63 sq.km (1.62 percent) and the poor area has increased from 386.15 (94.25 percent) to 403.07 sq.km (98.38 percent). The study of sulphide (Fig 3c), shows that the area under the good class has slightly decreased between the two periods, from 406.60 (99.24 percent) to 402.00 sq.km (98.12 percent). At the same time, the area under the poor class has increased from 3.10 sq.km (0.76 percent) in 1988 to 7.70 sq.km (1.88 percent).

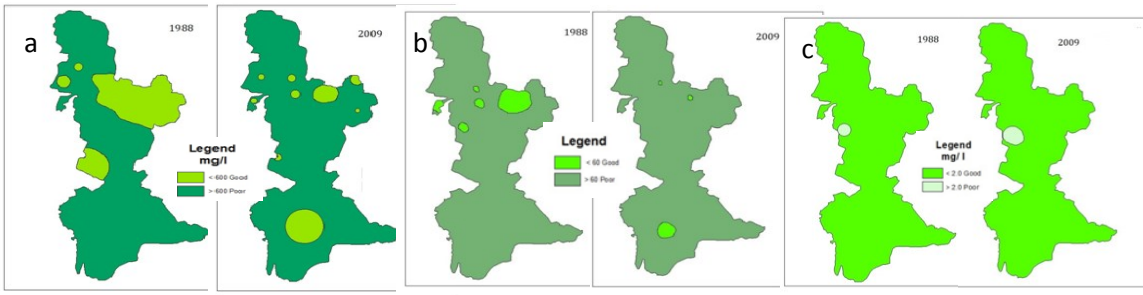

Fig. 3. Groundwater Quality-Irrigation a) Chloride b) Percent Sodium c) Sulphide

Parameters in which the Area Under Good and Poor has Increased

The study of total dissolved solids has shown that the area under good has increased from 0.06 (0.01 percent) to 4.34 sq.km (1.06 percent). The area under poor class has increased between the two periods, ie., from 388.59 (94.85 percent) to 391.74 sq.km (95.62 percent).

Parameters in which the Area Under Poor has Decreased and Very Poor has Increased

In the case of electrical conductivity, the area under poor class has decreased from 318.89 sq.km (77.84 percent) in 1988 to 186.05 sq.km (45.41 percent) in 2009. Simultaneously the area under very poor class has increased from 90.07 sq.km (21.98 percent) in 1988 to 205.87 sq.km(50.25 percent) in 2009.

Parameters in which the Area Under Good and Poor has Decreased

The concentration of fluoride (Figure 4a) shows that the area under good has decreased from 380.39 (92.85 percent) to 316.92 sq.km (77.35 percent). The area under poor class covering 1.39 sq.km (0.34 percent) has also decreased to 1.09 sq.km (0.27 percent) between 1988 and 2009.

Analysis of Critical Parameters

The analysis of the most critical parameters for irrigation standards like total dissolved solids (Fig 4b and 4c) and electrical conductivity (Fig 5a and 5b) are analysed in the study area between 1988 and 2009, and it reveals the following result. It is alarming to note that the area under the poor class, of both these parameters, has increased between the two periods. Poor class with respect to total dissolved solids has increased from 94.85 percent (1988) to 95.62 percent (2009). Electrical conductivity has increased marking more than a two-fold increase in the area from 21.98 percent (1988) to 50.25 percent (2009).

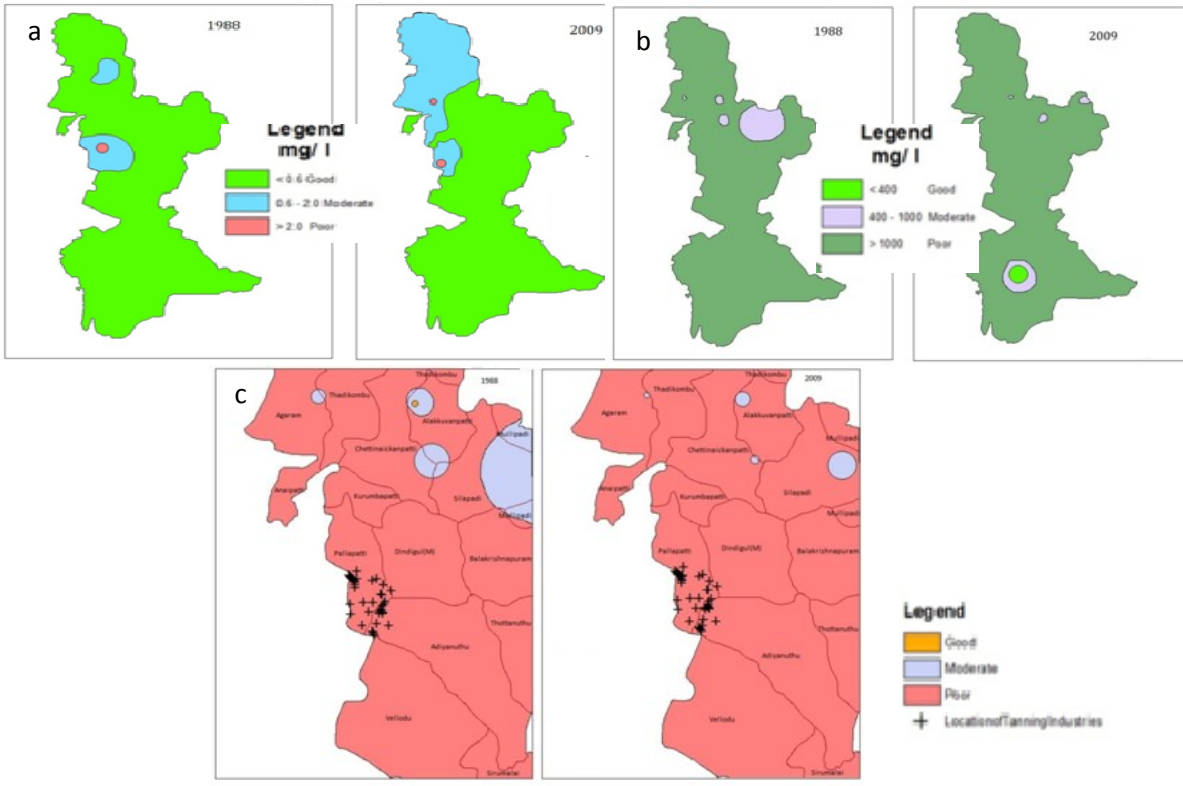

Fig 4. Groundwater Quality-Irrigation a) Fluoride b) Total Dissolved Solids c) Total Dissolved Solids with Location of Leather Tanning Industries

Analysis of Integrated Groundwater Quality for Irrigation Standards

The study made on the integrated groundwater quality for the irrigation standards, prepared by overlaying the spatial distribution maps of all parameters one above the other, reveals the following results (Fig 5c and 6a and Table 2). The area under the good quality of irrigation water has decreased between 1988 (86.48 sq.km; 21.10 percent) and 2009 (35.44 sq.km; 8.65 percent). The area under poor class has increased between 1988 (31.98 sq.km; 7.81 percent) and 2009 (92.94 sq.km; 22.69 percent). It could be observed that in both the periods, the areas where the leather tanning industries are located come under the poor class category.

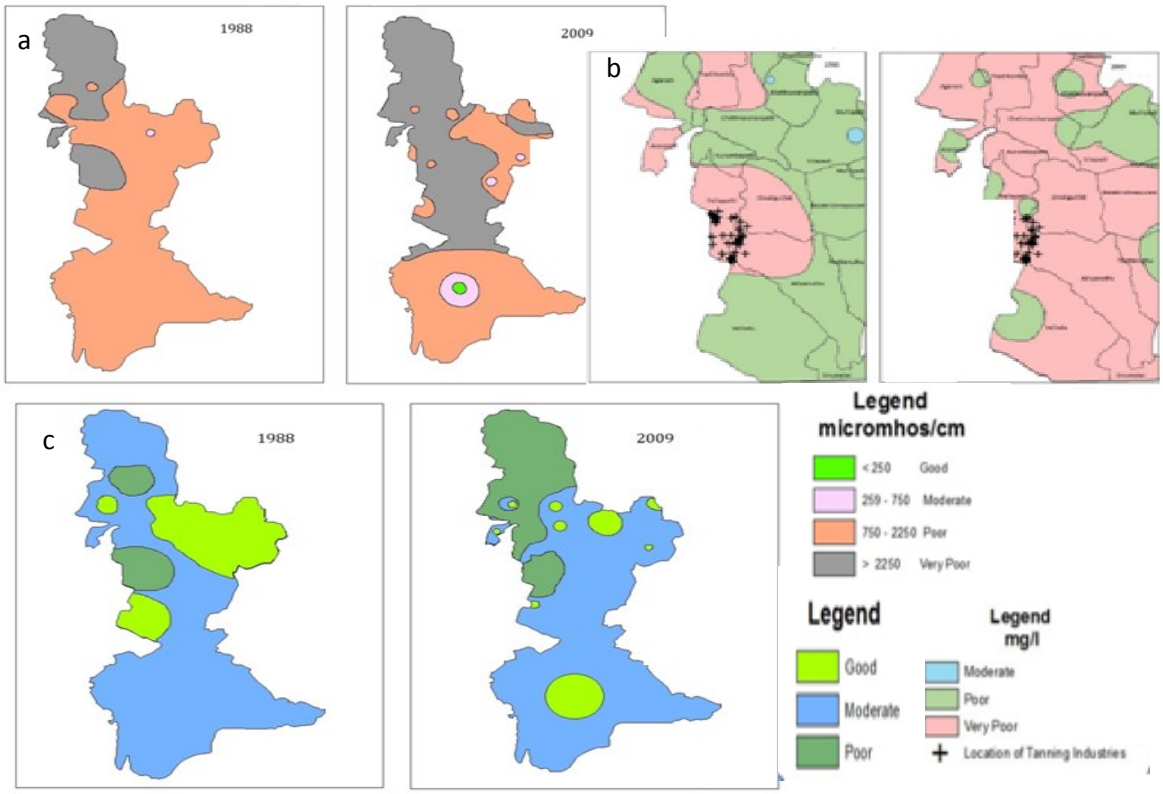

Fig. 5 Groundwater Quality-Irrigation a) Electrical Conductivity b) EC with Location of Leather Tanning Industries c) Integrated Groundwater quality for Irrigation

Table 2. Integrated Groundwater Quality for Irrigation Use

Type	Area (sq.Km)	
	1988	2009
Good	86.48	35.44
Moderate	291.24	281.32
Poor	31.98	92.94

Analysis of Variation of Groundwater Quality

A study on the variation of the groundwater quality of irrigation standards between 1988 and 2009 presents the following inferences (Fig 6b and Table 3). The areas which were good in 1988 and became moderate in 2009, is noted in Periyakottai, Kovilur, parts of Thamaraipadi, Vellodu, Mullipadi, Balakrishnapuram, Alakkuvarpatti and Silapadi village panchayats totally covering 17.62 percent of the study area. The area under good in 1988 but became poor in 2009 is noted in smaller areas in Vellodu and few areas in Agaram village panchayats covering only 0.47 percent of the study area. The area under moderate class in 1988 and became poor in 2009 is noted in Kurumbapatti and major areas in Agaram and Thadikombu and lesser areas in Sirumalai, Anaipatti and Chettinaickanpatti village panchayats that occupy an area of 21.90 percent. The areas totally covering 163.85 Sq.km(39.99 percent) are found to be most alarming, where the groundwater quality of irrigation standards is highly degraded.

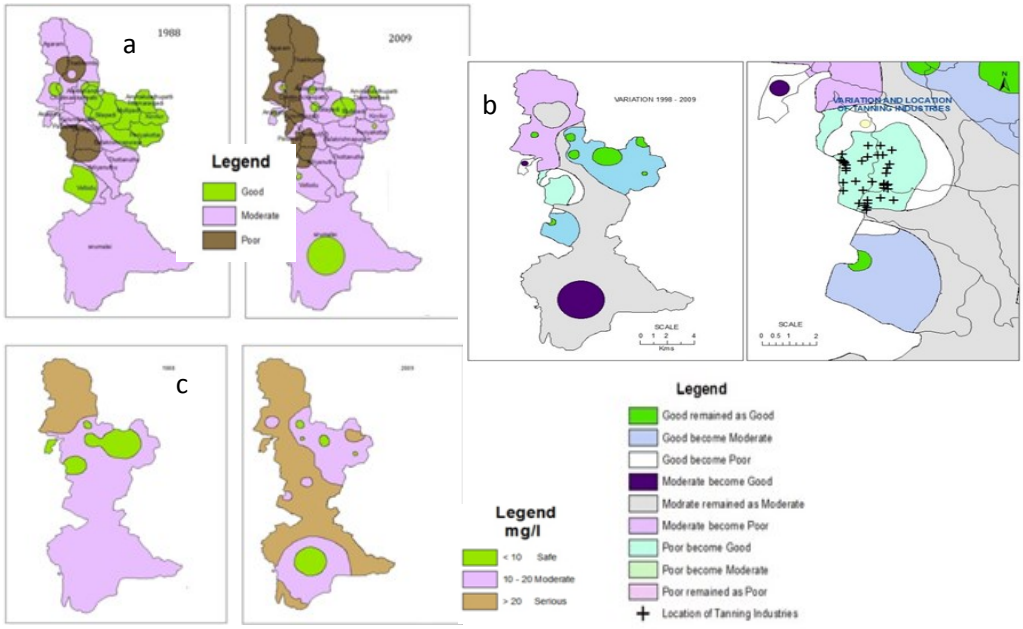

Fig. 5 a) Integrated Groundwater Quality with Panchayat Union Boundary b) Variation and Location of Leather Tanning Industries c) Sodium Adsorption Ratio Tanning Industries

Table 3. Area Under Variation of Groundwater Quality for Irrigation Use - 1988 - 2009

Type	Area (Sq.km)	Area in Percentage
Good remained as Good	12.50	3.05
Good became Moderate	72.19	17.62
Good became Poor	1.91	0.47
Moderate became Good	10.35	2.53
Moderate remained as Moderate	191.00	46.62
Moderate became Poor	89.75	21.90
Poor became Good	0.08	0.02
Poor became Moderate	7.80	1.90
Poor remained as Poor	24.12	5.89

Analysis of Variation of Groundwater Quality in the Leather Tanning Industrial Location

An attempt is also made to study the variation of groundwater quality for irrigation purpose in the areas where the leather tanning industries are located (Figure 6b). The results prove that those areas were noted to be poor in 1988 and still remaining poor in 2009.

Sodium Adsorption Ratio (SAR)

In 1954, the US Salinity Laboratory proposed Sodium Adsorption Ratio to study the direct relation of soils with sodium. This method is widely used for specifying the suitability of groundwater for irrigation purposes. The ratio is calculated using the following formula

$$SAR = \frac{Na}{\sqrt{Ca+Mg/2}}$$

(The values of Na, Ca and Mg are measured in mg/l).

Hence in the present study, SAR is calculated for the years 1988 and 2009, to interpret the suitability of groundwater quality for irrigation purposes and the results are represented in Figure 6c, from which it could be observed that during 1988, the suitability of groundwater quality for irrigation is noted to be safe (<10) in Anaipatti, Mullipadi, Silapadi, Alakkuvarpatti, Pallapatti and Chettinaickanpatti village panchayats covering 37.14 sq.km. It is noted to be serious (>20) in Agaram, Thadikombu village panchayats occupying 70.78 sq.km. In the remaining areas, it is moderate (10-20) totally covering an area of 301.78 sq.km.

During 2009, the suitability of groundwater quality for irrigation purpose is safe (<10) in Alakkuvarpatti, Sirumalai, Pallapatti, Chettinaickanpatti and Periyakottai village panchayats covering 22.81 sq.km. It is moderate (10-20) in Adiyanuthu, Ammakulathupatti, Mullipadi, Balakrishnapuram, Vellodu, Thottanuthu and Kovilur village panchayats occupying 151.60 sq.km. The rest of the areas come under the serious class (>20) occupying 235.29 sq.km. It could be noted that wherever the leather tannery industries are located in the study area, those areas fall under the serious class. Also the SAR analysis shows that the area under the serious class has increased between 1988 (70.78 sq.km; 17.28 percent) and 2002 (235.29 sq.km; 57.43 percent). It could also be noted that the areas where the leather tanning industries are located namely, Pallapatti, Adiyanuthu and Vellodu village panchayats and Dindigul (Corporation) also fall under this serious category.

Findings

Based on the outcome of this study, it could be concluded that the groundwater quality for irrigation standards has depleted between the years 1988 and 2009 in the study area. In the areas where the leather tannery industries are located, the level of parameters for irrigation standards are highly degraded between these two periods.

The areas around the location of leather tannery industries were noted to be poor in the year 1988 and still remained poor in 2009. The irrigation water quality is found to have decreased in areas other than the places where the leather tannery industries are located in the study area. This may be due to (1) The continuous dumping of tannery waste in the neighboring tanks might have raised the salinity status and hence the water might have become unsuitable for irrigation. (2) The late onset and the early withdrawal of monsoon rainfall might have paved no way for irrigation in the areas away from the location of leather tannery industries. (3) The dumping of tannery waste in the nearby streams might have made the river water unfit for irrigation. Such problems are reported in the areas where river Kodaganar flows. Agricultural activity in Dindigul panchayat union is mainly dependent on well irrigation. The degrading quality of groundwater for irrigation will affect the yield on the one hand and the quality of the products on the other hand. Hence, proper steps should be taken to improve the groundwater used for irrigation at the earliest in the study area.

Conclusions

The tanneries, for minimizing the use of salt and chromium, should adopt pollution control technologies suggested by Central Leather Research Institute. Agricultural Universities and scientists should involve in taking necessary steps to reclaim the soil. Scientific study and analysis of soil samples at each village must be taken, analysed and the results must be compared with analysis of samples taken from other places unaffected by tannery pollution. The attention of the people must be draw to this comparison.

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LANDSLIDE AS AN AGENT OF BASIN DEGRADATION: A CASE STUDY OF RAYENG BASIN IN DARJEELING HIMALAYA, INDIA

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Abstract

Landslide is one of the destructive hazards in the Himalayan mountain region. Rayeng basin is not an exception of this phenomenon. In this study, an attempt has been made to explain the causes of landslide, to find out landslide susceptible areas and to suggest mitigation measures. For that intensive field survey and secondary data has been incorporated in this study. Secondary data like topographical maps, geological map, and satellite imageries of the basin have been studied intensively. Landslide in this basin is the function of tectonic activity, geology, soil, rainfall, land use pattern and anthropogenic activities. For determination of landslide susceptibility zone six factors have been considered i.e. slope, lithology, land use, relative relief, drainage density and landform and followed weighted overlay method to combine all the data layers. Finally the basin has been divided into three susceptibility zones i.e. moderately unsteady, highly unsteady and critical. To reduce the affects of landslide damages the areas having weak should be avoided for heavy construction, steep slope must be restricted for tea plantation, unscientific channel diversion must be prohibited, heavy vehicles should not be allowed, vegetal cover must be reinstated and soil conservation method must be adopted.

Keywords: Landslides, Rayeng basin, Landslide susceptibility zones, Weighted overlay method, Mitigation

Introduction

The landslides are one of the significant types of natural hazards. Massive landslides make trouncing of both creature existence and assets. Yet, people livelihood in the mountainous regions is habituated to survive with such events. With the augmented tourism over the precedent few decades, residential areas have been make bigger over mountainous slopes, which of course necessitate new communication system. This disturbs the usual slopes and an environment of the mountainous regions, in that way greater than ever susceptibility to landslide happening. Geomorphic studies of landslides take account of the assessment of vulnerability and causes responsible behind occurrences. Landslides are

the most significant disparaging geomorphic process accountable for degradation of Rayeng Basin. Throughout intense rainfall, the weathering process is accelerated reducing schists and mudstones into silts and fine sands, and succeeding failure of these fine materials triggers landslides in the Rayeng Basin.

Study Area

The mountain stream Rayeng is a right bank tributary of Tista River having 17.50 km from its source to confluence. The shape of the basin is more or less circular or pear shaped and drained by Rayeng River and its tributaries. The most considerable tributary of Rayeng River is the Rambi River. It covers an area of about 145.50 sq.km and falls in the areas of three C.D Blocks of Darjeeling District i.e. Rangli-Rangliot, Kurseong, and Kalimpong - I respectively. The Rayeng Basin lies between .the latitudes 26°54'41" N to 27°02'11" N and longitudes 88°18'20" E to 88°27'33" E (Fig. 1). The basin has complex geological layout. Different geological formations observed in this basin area namely Darjeelin gneiss, Kanchenjungha Augen gneiss, Damuda formation, Paro sub-group, lingtse grani te, feldspathic greywacke marble, Rayeng formation, and Gorubathan formation (after Ray, 1989). Because of a variety of geological formation, the morphological features in the basin area differ in magnitude and dimension. The relief of the basin is marked with sharp change i.e., breaks in slope denote rugged topography. The upper reaches of the basin are vulnerable to landslides. However, the middle and lower parts of the basin are not as vulnerable. The climate of the mountain basin is highly dominated by altitudinal factor of relief. This basin enjoys heavy seasonal rainfall mainly the orographic rainfall. The temperature of the basin declines with increasing elevation. Thus, significant variation in temperature is found between the foot hill area and the hill tops. Annual temperature fluctuates from 24°C in foot hill area and drops to 12°C on the ridges. The average annual rainfall is about 300 cm with an average of 126 rainy days in a year.

Database and Methodology

Study of landslides of the basin incorporate, recognition of affected areas based on the field study and secondary data from earlier study (Table 1 and Fig. 2). Intensive study has been made on the factors associated to landslides such as geology, slope angles, soil, climatic condition, hydrologic conditions, vegetation, and last but not the least i.e. human interferences in the basin. In this milieu, topographical maps, geological map, satellite imageries of the basin have been studied intensively. Meteorological data are collected. On the basis of several factors an effort has been made to prepare a landslides susceptible zones map of the study area. To prepare the landslide susceptibility zonation map of the Rayeng Basin, maps of individual factor are prepared from the topographical map having scale 1:50,000. In this context, slope zone map, relative relief map, drainage density map and land use map are prepared from the topographical maps (SOI) bearing the number, 78 A/8 and 78 B/5. Geological map of basin is also consulted. Moreover satellite images of the concerned area are studied precisely. To compute susceptibility value of the basin, entire area of the basin has been divided into 1 sq.km grid and combined value of rating scheme

for different factors put into the concerned. On the basis of susceptibility value index isopleths map has been prepared.

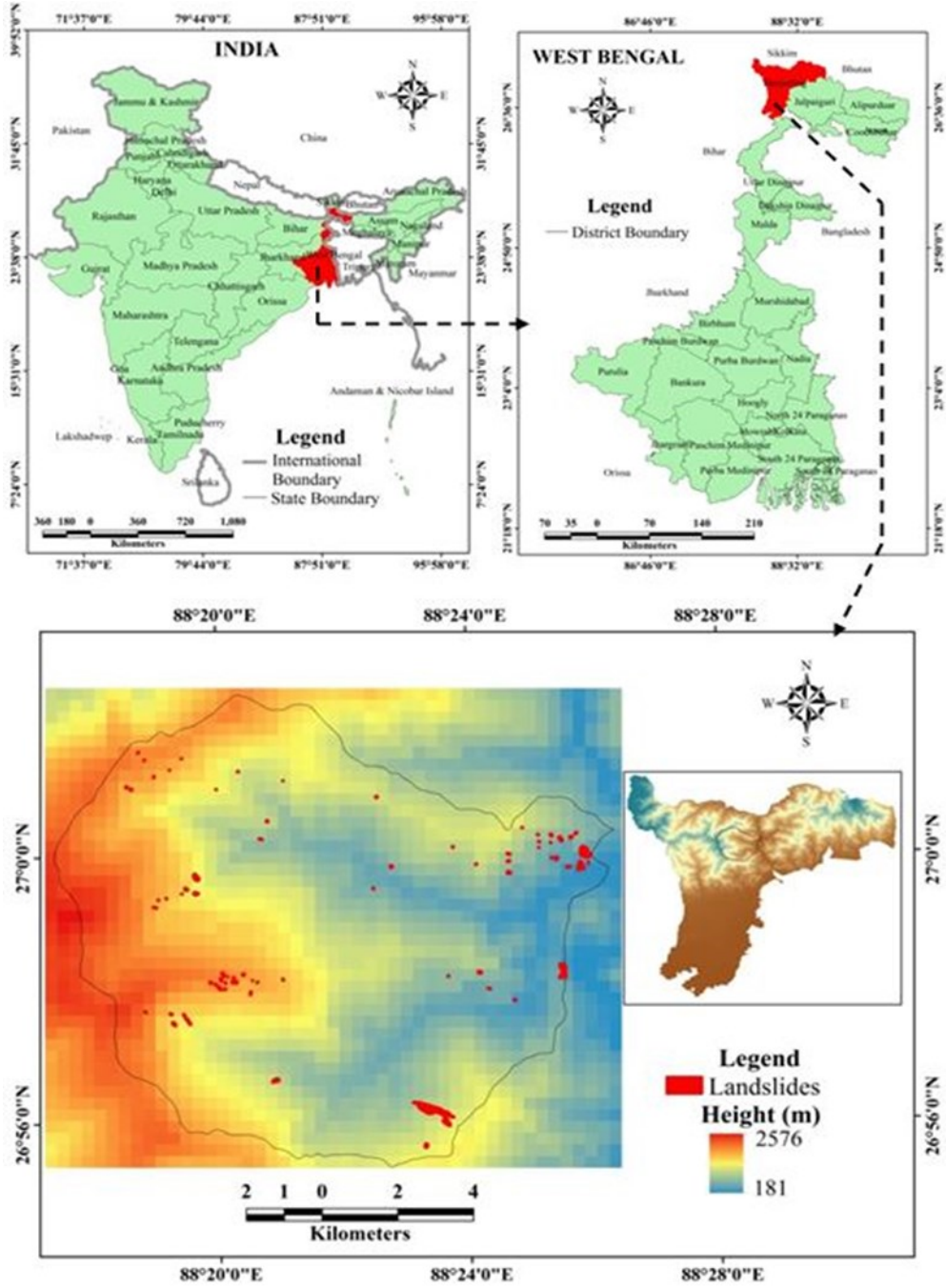

Fig. 1. Study Area

Table 1. Landslides of the Rayeng Basin

Location	Rock type	Structural factors	Slope in degree	Drainage factors	Remarks regarding Landslides
(A) C.D Block Rangli Ragliot:					
1. Pubong khasmahal	Damuda group, ; Rangit pebble slate	Foliation, schistosity	20-30	High to very high drainage density	severely vulnerable
2. Rangli Rangliot Tea garden.	Paro subgroup	Mega fold, warps of forth &fifth generation	15-25	Same	severely vulnerable
3. Pumong Tea garden.	Rangit Pebble, Slate	Cleavage, fracture	>25	Same	severely vulnerable
4.Reshop Bazer	Paro subgroup		15-20	Same	vulnerable
5.Labda .Khasmahal	Paro subgroup	Linenation ,puccer	20-30	Same	vulnerable
6.Mangpu Cinchona plantation	Graphite ,chist,Gneiss	striping	20-25	Same	severely vulnerable
7.Rong Chong khasmahal	Gorubathan formation; Feldspathic Greywacke marble	Cleavage, fracture	15-30	Same	vulnerable
(B) C.D Block Kurseong:				Same	
1.Chattak pur Forest	Darjeeling Gneiss	Linenation ,puccer	15-20	Same	vulnerable
2.Upper Mamring .Khasmahal	Darjeeling Gneiss	Stripping,	15-20	Same	risky
3..,LowerMamring Khasmahal	Paro subgroup	Linenation ,puccer	15-20	Same	vulnerable
4.Toryak Khasmahal	Paro subgroup	Linenation ,puccer	15-20	Same	vulnerable
5..Sittong Khasmahal	Lingtse, Granite ,Gneiss	Cleavage, fracture	15-18	Same	vulnerable
6.Barasit Tong Khasmahal	Gorubathan formation; Feldspathic Greywacke marble	Cleavage, fracture, striping	20-25	Same	vulnerable
7.Mangpu Cinchona Plantation	Graphite schist, Gneiss	Cleavage, fracture	15-30	Same	vulnerable
8.Selpu Khasmahal	Lingtse, Granite ,Gneiss	Cleavage, fracture	15-20	Same	vulnerable
9 Rolak Khasmahal	Gorubathan formation; Feldspathic Greywacke marble	Cleavage, fracture	15-20	Same	vulnerable
10.Lonku Khasmahal	Gorubathan formation; Feldspathic Greywacke marble	Cleavage, fracture	15-20	Same	vulnerable
C.D Blok Kalimpong-				Same	
1,Riyong Foret	Reyang formation ;quartz key beds	Cleavage, fracture	20-30	Same	
2.Turzam Forest	Gorubathan formation; Feldspathic Greywacke marble	Cleavage, fracture	20-30	Same	
3.Rambi Bazar	Reyang formation ;quartz key beds	Foliation, schistosity	20-25	Same	
4.D.I.F.,Riayang Railway Station,	Reyang formation ;quartz key beds	Linenation ,puccer	15-20	Same	
5.Birik Forest	Reyang formation ;quartz key beds	Faulting	20-25	Same	
6.Suntalay Khasmahal	Reyang formation ;quartz key beds	Faulting	20-25	Same	

Causes of Landslides in Rayeng Basin

On account of its own geologic, geomorphic, and climatic and pedogenic characteristics, there are specific causes behind the occurrences of landslides in the Rayeng Basin. Slides and subsidence are the most striking types of landslides frequently take place. Slides are frequently occurred in the monsoon season owing to slope failure. Subsidence occurs in consequence of removal of basal support both for excessive rainfall and anthropogenic causes. On the basis of thorough study the below mentioned factors may be considered as causative one for landslides incidence in the basin:

1. Tectonic activity: According to final report published by Prof. Mamta Desai, Project Coordinator, Department of Ecology & Environment, Netaji Institute for Asian Studies, the trends of rising of young mountains is the basic reasons for frequent landslide hazards in the Himalayan region. Intensive study of longitudinal profiles of Rayeng River conveys that the basin is passing through very active tectonic activities. In the Rayeng Basin tectonic disturbances are also responsible for landslides happenings.

2. Geology of the basin: There are various rocks present in the Rayeng Basin. Remarkable are Darjeeling gneiss, Paro-gneiss, Lingtse granite gneiss, feldspathic greywacke marble, phyllites and quartzites of the Paro sub-group and the Reyang group. The Lingtse granite gneiss are sturdily foliated and sheared, viewing very high rate of weathering at major part of the basin. The Paro-gneiss is strong and coarse grained than the Darjeeling gneiss of higher metamorphic grade. The quartzites are stronger than the other rocks in the area. However, all the rocks are folded, faulted, and sheared to varying degrees, and they have been subjected to high levels of weathering along the drainage

channels (Sarkar and Kanungo, 2004). Phyllite turns into slippery for the period of monsoon. As a result the areas consist of phyllite are more susceptible to landslides. The Daling group of rocks is seen to be affected easily by landslides. Recurrent landslides occur in the areas comprise of Darjeeling gneiss and Daling group of meta-sediments and low occurrences in high grade schist. The utmost failures are taken place in areas consists of granite followed by Dalings. Foliation is one of the important attributes of some metamorphic rocks in their tendency to split into thin laminae or sheets caused by parallel arrangement of platy, layered or planar minerals. Lineaments are also responsible for landslides in the basin.

3. Soil of the basin: Darjeeling gneiss, schist and Phyllite are the parent materials of the soils of the Rayeng Basin. Intensity of soil erosion in the basin has been accelerated recently. Deposition of soil is only observed at the confluence of Rayeng River. Skeletal soil of the basin is susceptible to landslide.

4. Rainfall: Huge quantity rainfalls entertain by Darjeeling district. Majority of these rainfalls take place from the months of June to October. It is at the present well known that rainfall does produce landslides in some cases. For the duration of continual intense rainfall, the weathering process go faster, reducing schist and mudstones into silts and fine sands, and consequent failure of these fine materials activate landslides.

5. Land use pattern: The land use pattern is one of the vital factors determining the stability condition in respect of landslide. The land use map of Rayeng Basiri conveys that, there is tea plantation (Rangli Rangliot Tea garden), cinchona plantation (Mangpu plantation) and other agricultural activities are existed in the basin. Not only that channel diversion and constructional activities are performed along rivers and even clearing the forests which are responsible for reducing shearing strength. Thus possibility of landslides increases in the basin.

6. Anthropogenic activities: Encroachment of settlements on the vulnerable slope is one of the important causative factors of frequent landslide hazards in the basin. Construction of buildings with inappropriate planning besides the roads and on the steeper terrain increases the load on the already despoiled slopes. Construction of bridges over Rambi river, artificial channel diversion of Rayeng river, construction of hydel project in the Tista River near the confluence of Raying river are also responsible for landslide occurrences in basin area.

Fig. 2. Landslide (a) Due to Excessive Rainfall at Rambi Bazar (b) Due to Removal of Vegetal Cover at Labda Khasmahal and (c) Beside the Bank of Rayeng Near Confluence

Table 2. Rating Scheme for Susceptibility Index Value

Contributing Factors	Description	Category/ Magnitude	Rating
Lithology	Rock	Quartzite	1.8
		Phyllite	1.3
		Schist/ slate	0.5
		Gneiss	0.5
		Lingtse Granite	1.0
Structure	Lineament		1.65
	Fracture		2.30
	Joint		1.65
	Cleavage		2.0
Slope	Moderate slope	< 16˚	0.5
	Moderately steep slope	16˚ - 23˚	1.0
	Steep slope	23˚ - 30˚	1.5
	Very steep slope	> 30˚	1.6
Relative Relief	Moderate	< 220 m	0.5
	Moderately high	220 – 380 m	0.7
	High	380 – 540 m	0.8
	Very high	> 540 m	1.0
Land use and land cover	Dense forest cover		0.2
	Deforested area		1.8
	Plantation		0.7
	Construction		1.5
	Grazing land		1.00
Drainage Density	Low	< 2 km/sq. km	0.2
	Medium	2 – 4 km/sq.km	0.4
	High	> 4km/sq.km	1.0

Table 3. Terrain Factors and Their Respective Weight Value

Factor	Weight value
Slope	30
Lithology	25
Land use	15
Relative relief	10
Drainage Density	15
Landform	5
Total	100

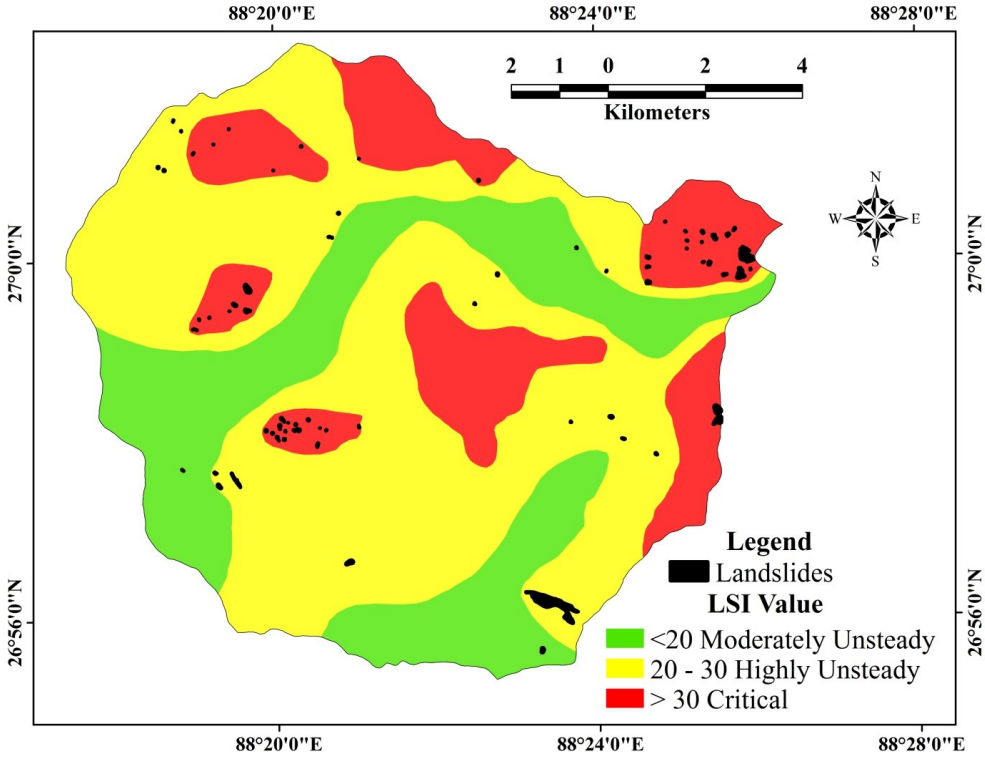

Fig. 3. Landslide Susceptibility Zones

Determination of Various Landslides Susceptibility Zones in Rayeng Basin

The term zonation applies in a general sense to categories the land surface into areas and arranges these according to degree of actual or potential of some phenomena of occurrences (Varnes, 1984). Terminologically, landslide susceptibility zonation means to categorize the land surface into areas and to arrange them according to the degree of vulnerability of different causative factors landslides susceptibility zonation is categorization of certain area according to propensity of landslides occurrences. Geological survey of India has made several efforts to prepare landslide zonation map, in the Himalayan region. For zonation of landslide susceptibility of certain area geologists of the Geological Survey of India, have considered several geological, geomorphological and anthropogenic factors. Landslide zonation of the Himalayan region has been prepared by a number of researchers from the Geological Survey of India and other institutions (Mehrotra et al., 1996, Krishna et al., 2004; Bhandari, 2004, Bera, 2005; Basu and Bera, 2007; De, 2007) based on the preparation of different thematic maps showing data concerning the following controlling factors: 'Drainage', 'Slope', 'Lithology', 'Landform', 'Land use' and 'Landslide incidence' (Basu, De and Bera, 2009). In accordance with the Geological Survey of India scientific hazard zone mapping involves a comprehensive estimation and analysis of the precedent happenings of landslides in terms of their location, degree and occurrence with respect to a variety of geo-environmental factors that control landslides and mass movements. The

factors that involve slope instability are various and their interface processes multifaceted depending on terrain set up and climatic characteristics. The most imperative terrain evaluation factor in hazard zone mapping is the recording of the landslides that take place in the area. The spatial distribution of old and currently active landslides when compared with diverse terrain factors out in the open their importance as a contributing sliding factor.

Table 4 Landslide Susceptibility Index Value (LSI)

Zone	LSI- Value	Remarks
Moderate	<20	Moderately unsteady
High	20-30	Highly unsteady
Very high	>30	Critical

Landslide Susceptibility Index (LSI)

To calculate the susceptibility value index following rating scheme has taken into consideration (Table 2 and Table 3). Evaluating landslide susceptibility values, a Landslide Susceptibility Index (LSI) is computed for all categories of each factor with a correlation of landslide percentage per km^2 of that category. On the basis of landslide susceptibility index value, entire basin has been divided into three landslide susceptibility zones (Table 4 & Fig. 3).

1. **Critical zone:** This is extremely unsteady zones where landslides are probable to happen in vision of the outstanding contributing factors present. This area is more or less stained to such a state that it is virtually not possible to go forward economically and socially tolerable counteractive measures, which can definitely check repetition of hazard. The area has to be totally avoided for settlement or other developmental purposes and rather put down for revival of natural vegetation and realization of natural stability in track of time in the course of the geomorphic processes dynamic in the area.
2. **Highly unsteady zone:** This zone is also landslides prone and is having similar topographic situation as like as critical zone. These places require insistent thought in the outline of litigator measures akin to renewal of natural shrubbery, reforestation , drainage adjustment and constraint of tilting activity and contour bonding to make sure accurate drainage etc. if not immediate action plans are implemented this zone will shortly depreciate to the critical category.
3. **Moderately unsteady zone:** This zone is unwavering in the present condition, however, upcoming land use activity is to be well planned so as to preserve its current position. On the other hand if natural drainage is distressed or slope changed artificially, landslides could be happened.

Mitigation Measures

Landslide is a natural occurrence in mountainous area having feeble geologic structure. As it is a geomorphic process thus it is inevitable. But strength and devastative nature of this occurrence accelerate by human interference, which is hazardous for the

mountain dwellers. Thus for the sake of human beings overwhelming nature of landslide is to be minimized. Several geomorphologists recommended many procedures to alleviate these phenomena. On the basis of field observation and previous geomorphic study by various eminent geomorphologists following measures may be suggested:

1. Ahead of the construction of roads, buildings, hydel projects, geological and geotechnical studies to be done in detail. The areas having weak rocks such as schist, slate, mudstone, phyllite should be avoided for heavy construction.
2. Steep slope and recognized landslide prone areas must be restricted for tea plantation, cinchona plantation and growth of settlement.
3. Unscientific channel diversion must be prohibited.
4. Heavy vehicles should not be allowed in the roads to avoid the high vibration which increases the shearing stress.
5. Construction of surface drains to collect surface runoffs at different elevations and plugging of cracks and crevices to prevent runoffs to seep into the ground, construction of filters and drains behind the concrete and gabion walls to safe passage of the surface runoffs.
6. Soil erosion must be prevented by take on soil conservation method.
7. To stabilize the slope of the Rayeng Basin, vegetal cover must be reinstated. But on the very steep slope where vegetation may accelerate the rate of landslide planting of trees not to be appreciated. In this context illegal clearance must be prevented.

Conclusion

From the overall study it can be stated that landslide is the most vital factor for the degradation of Rayeng Basin. In addition, distinguished section of the basin is being suffered from the critical problem of landslides. Both physical and anthropogenic activities are responsible for landslides occurrence in this basin.

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News and Notes

The Indian Geographical Society

Department of Geography, University of Madras, Chennai - 600 005

GENERAL BODY MEETING

Minutes of the General Body Meeting of the Indian Geographical Society (IGS) for the Year 2010 - 2011 held on October 23rd 2010 at the AVB Matriculation Schools, Coimbatore - 641 020

Members Present:

1. Mr. K. Devarajan, *President*
2. Dr. T. Vasantha Kumaran, *General Secretary*
3. Dr. C. Palanivelu
4. Dr. K. Kumaraswamy
5. Dr. P. Elangovan
6. Dr. S.R. Nagarathinam
7. Dr. R. Jaganathan
8. Dr. G. Bhaskaran
9. Dr. V. Madha Suresh
10. Mr. T. Srinivasan
11. Mr. N. Subramanian
12. Mr. R. Parthasarathy
13. Mr. I.C. Kamaraj
14. Mr. R. Gopal
15. Mr. V.R. Murugesan
16. Mr. C. Subramanian
17. Dr. N. Anbazhahan
18. Dr. S. Jayachandran
19. Mr. S.N. Nappoly

Resolutions:

1. Discussed about the dereliction of the duty of the General Secretary and recorded that the members must be informed of all the events at the earliest.
2. Resolved to hold annual conference of the Society at the Bharathidasan University, Tiruchirapalli and to hold School Teachers Workshop at the Bharathidasan University.
3. Discussed the conduct of the "Talent Test" for College students and the modalities of the conduct.
4. Discussed the modes of increasing subscribers/members and resolved to work towards the objective. Creating Campus fund was also discussed and resolved to mobilize institutional members on large scale.
5. Resolved to postpone the awards for the Year and discuss them later.
6. Unanimously elected the following Office Bearers for the Years 2010 - 2011 and 2011 - 2012.

The Present Executive Council thank the

Members of Previous Executive Council of the Indian Geographical Society

President:	Mr. K. Devarajan
Vice Presidents:	Dr. K. Ravindra Reddy Dr. C.T. Pawar Dr. H.N. Mishra Mr. N. Subramanian
General Secretary:	Dr. T. Vasanthakumaran
Assistant Secretaries:	Dr. P. Ilangovan Dr. V. Madha Suresh Dr. J. Uma
Treasurer:	Dr. R. Bhavani
Assistant Treasurer:	Ms. N. Annammadevi
Members of the Council:	Ms. Sheela Gnanasironmani Dr. A. Ganesh Dr. Anita Maria Anandhi Dr. P.H. Anand Dr. N. Nagabhushanam Dr. P.S. Tiwari
Member Nominated to the Executive Committee from the Council:	Dr. P.S. Tiwari
Editor:	Dr. S. Subbiah

New Executive Council of the Indian Geographical Society

President:	Dr. K. Devarajan
Vice Presidents:	Dr. P. Ilangovan Dr. B. HemaMalini Dr. H.N. Misra Dr. R.B. Singh Dr. R. Vaidyanadhan
General Secretary:	Dr. R. Jaganathan
Joint Secretaries:	Dr. R. Bhavani Dr. R. Shyamala Dr. J. Uma Dr. R. Jegankumar
Treasurer:	Dr. V. Madha Suresh
Council Members:	Ms. R. Valli Dr. S.R. Nagarathinam Dr. S. Balaselvakumar Dr. P.H. Anand Mr. G. Jagadeesan Dr. N. Subramanian Mr. C. Subramaniam
Member Nominated to the Executive Committee from the Council:	Dr. S.R. Nagarathinam
Editor:	Prof. K. Kumaraswamy

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I, K. Kumaraswamy, hereby declare that the particulars given above are true to the best of my knowledge and belief.

Dr. K. Kumaraswamy
Editor, The Indian Geographical Journal