CHAPTER - XI
CONCLUSION AND RECOMMENDATION

11.1 Summary and Discussions

Indiscriminate clay mining, unscientific planning and developments, insufficient guidelines and lack of awareness of environmental and socio-economic issues are the major challenges in clay mining and tile/brick industries in Thrissur district. The study reveals that clay mining had changed the surface expressions of the landforms, land use, soil fertility and hydrologic system of the district. Total of 124 clay mining locations are identified and most of them are abandoned and waterlogged. Since clay mining is restricted in the study area, clay based industries are unable to procure sufficient quantity of clay for tile/brick production. A proper environment management plan should be formulated and alternative for clay resource should be developed to minimize the extraction in future. Salient findings emerged through this study are presented here.

❖ Major rock types present in Thrissur district include precambrian crystallines, residual deposit and recent to sub-recent sediments. The oldest and most widespread rocks are the precambrian consists of Charnockite, Hornblende Gneiss, Pink Granite and Syenite and distributed in highland and midland. The residual deposit is the laterite present in midland and recent to sub-recent sediments (coastal sand and alluvium) are present in lowland.

❖ Clay minerals are Hydrous Aluminium Phyllosilicates, with variable amounts of Iron, Magnesium and Alkali metals. Commonly formed in the study area by the breaking down of feldspar in rocks. Clay minerals are divided into four major groups viz. Kaolinite group, Montmorillonite/Smectite group, Illite (Or the Clay-Mica) group and Chlorite Group. Kaolinite is the major mineral found in the alluvial plains of Chalakudy river basin with traces of gibbsite and illite.
The district has a tropical humid climate and average annual rainfall of 3370 mm. The spatial distribution of annual rainfall during 2009 reveals that clay mining affected locations are concentrated in Class I where annual rainfall is between 2500 and 2700 mm. The spatial distribution of annual rainfall during 2010 shows that clay mining affected locations are concentrated in Class III and IV where annual rainfall is between 2900-3100 mm and 3100-3300 mm. The monthly rainfall distribution in 7 stations shows that all stations except Irinjalakuda and Vadakkanchery recorded high rainfall distribution during 2010 than the previous year.

Chalakudypuzha, Karuvannurpuzha and Bharathapuzha are the main river systems in the district. They take their origin from the mountains on the east, and flow westward and discharge into the Arabian Sea. Dendritic drainage pattern and 6th order streams are present in the three major drainage systems of the district. The annual yields of the river basins are Chalakudypuzha (2541 mm³), Karuvannurpuzha (1887 mm³) and Bharathapuzha (6540 mm³) respectively. Clay for making tiles are mainly found in the alluvial plains of these three rivers.

Physiographically the district is divided into three classes viz., highland (>75 m above MSL), the midland (20-75 m) and lowland (<20 m). The clay mining affected area is present in the midland and lowland region of the district. The highland and midland portion of the district are enriched with different species of flora and fauna. Insects and plant species are declining in alarming rate due to indiscriminate clay/sand mining from river basins and other aquatic environment.

The increase in population density is a manifestation of decrease in per capita availability of land over the years. Census, 2011 shows that the total population of Thrissur district is 31,10,327 (Male - 14,74,665 and Female – 16,35,662). In case of population size, Thrissur district is ranked 4th place. The population density in the district increased from 981 to 1026 persons/sq.km and ranked 7th place in the State. Thrissur taluk shows the
highest population and the lowest is in Kodungallur. Out of the 92 panchayaths, 26 panchayaths showed population density less than the average density of 981 persons/sq.km. In addition, total of 26,89,299 people (95.32%) are literates out of 31,10,327 people in the district. Sex-ratio of the district increased to 1109 females from 1092 in 2001 Census. There is negligible decrease in Child sex-ratio i.e., 959 from 960. Urban agglomerations (UAs) of the district are Thrissur (UA) and Chalakudy (UA). The total workers of the district is 9,55,300, which includes main workers and marginal workers (Male - 7,19,253, Female - 2,36,047).

Thrissur district is leading in its production of clay bricks and tiles for construction. The paddy fields possess heavy and good quality clay which is mined extensively to meet the requirement of the tile/brick industries. Alluvial clay is mainly concentrated in the paddy fields of midland and lowlands of Vadakkanachery, Karuvannur and Chalakudy river basins. The average depth of availability of good quality clay is 0.60–4m below ground level (bgl) and present in yellow to reddish brown colour. For brick making, average quality clay is required whereas for tile making good quality clay is needed. The deep clay mining in the paddy fields deteriorates the fertility of the soil and groundwater quality. The clay mining affected places are under severe threat of soil erosion and land degradation. Total of 124 clay mining affected locations are identified using Cartosat satellite data (2010) from and 39 Panchayaths, Thrissur Corporation and Chalakudy Municipality. Most of the clay mining sites are abandoned and waterlogged now. Waterlogged clay mining pits are being used for pisciculture in Puthukkad, Kallur, Marathakkara and floriculture (lotus cultivation) in Vainthalappadam. The waterlogged clay mining pits are being used for sand mining after pumping out water. Sand mining enhances the level of suspended solids, in the overlying water column, which leads to higher turbidity levels in the adjacent wells. A severe ecological implication of sand mining is the
destruction of sand layer lying below the clay bed that serves as a potential aquifer of the area.

- The temporal changes in geomorphology are identified from Cartosat-1 PAN data (2010), SOI toposheet (1966) coupled with field data and secondary data. The impacts due to clay mining in landform are assessed and in geomorphology (1966), 19 units have been delineated from the topographical data. Major classes identified in the district are coastal plain (12.06%), mud flat (coastal plain) (7.25%), alluvial plain (10.40%), lower plateau (lateritic) – dissected (17.17%), piedmont zone (20.54%) and denudo-structural hill (24.30%). In case of geomorphology (2010), 21 units has been delineated from Cartosat satellite images. Land mining area and waterlogged clay mining pits are the current landform changes identified due to anthropogenic process. Land mining area was identified in transition zones of alluvial plain and lower plateau (lateritic). Overburden dump of clay deposits are another landform change noticed in clay mining area as well as tile/brick industrial area.

- The temporal changes in land use/land cover during 1966, 2005, and 2010 shows that land use pattern of Thrissur district has been changing rapidly. Traditional paddy areas are either given for clay mining area or diverted for tree crops and settlement purpose. Total of 4.06 sq.km (0.13%) area left as fallow land during 2010. The paddy cultivation is found decreasing in the district due to socio-economic problems like shortage of labours, low price for produce and out-migration. The land under mixed crops being converted to rubber plantations and settlements. Total of 15.26 sq.km (0.50%) area in the paddy field of the district is affected due to open cast clay mining. The abandoned clay mining pits are found as waterlogged area and fallow land.

- The annual groundwater recharge of Thrissur district was 774.99 MCM and was maximum in Kodakara block, which possess maximum waterlogged clay mining pits. Net annual groundwater availability of the
district was 702.75 MCM. The existing gross groundwater draft for all users of the district was 326.44 MCM and stage of groundwater development was 46.45%.

- The assessment of groundwater fluctuation of 27 water sampling stations in pre-monsoon and monsoon seasons during 2010 shows that change is found maximum in clay mining area rather than non-clay mining area. The spatial distribution of groundwater fluctuation is also support the findings. Among the 19 water sampling stations, 11 locations in the clay mining area are possessing deep waterlogged clay mining pits, depth ranges between 2 and 4.5 m. In non-clay mining area, groundwater fluctuation is maximum in Pullu (+2.30 m) and minimum in Meloor (+2 m). In clay mining area, groundwater fluctuation is maximum in Trikkur (+6.70 m) and minimum in Nellayi (+2.29 m). The deep excavation and pumping out of water from the clay mining pit may cause the lowering of water table.

- The water quality analysis reveals that all samples showed seasonal variations and changes were high during monsoon season than pre-monsoon, the quality of water is affected in sampling stations near to clay mining locations than the non-clay mining stations. The well water samples proximity to clay mining area showed low pH, high electrical conductivity and high TDS. The waterlogged clay mining pit showed quality difference of acidity, high conductivity and high TDS due to clay mining in paddy field, transportation of mined clay and its processing and improper solid waste disposal. In paddy fields where sand mining took place which is a continuation of clay mining, the water appeared as turbid since the water bearing strata is disturbed. Turbidity is noticed in wells of Cheruval, Puthukkad, Alagappa Nagar, Thalore, Nellayi and Mulangu. In non-clay mining area, EC and TDS were high in Edathirinji and Alappad. The two locations are from coastal area and saline intrusion is high to the nearby waterbodies.
Biological assay of water samples from clay mining area, waterlogged clay mining pit and non-clay mining area shows the presence of coliform bacteria during both seasons indicate groundwater is polluted. The sources of microbials in the well samples include the practice of land disposal of sewage effluents, sludge’s and solid wastes, septic tank effluents, urban runoff as well as agricultural mining and industrial practice. In waterlogged clay mining area, the high bacterial contamination is due to clay mining, sand mining activities, municipal waste dumping, misuse by workers in tile/brick clay mining field etc. Hence, the use of boiled water is recommended for drinking and cooking from domestic wells.

The socio-economic survey conducted in 283 tile/brick industries during 2007 point out that 214 are large scale and 69 are small scale industries. Majority of the industries were exporting their products to neighbouring states and 76% of turnover is from Tamil Nadu. The survey reveals that majority of the industries were concentrated in Nenmanikkara, Puthur, Parappukkara, Vallachira, Puthukad, Trikkur, Alagappa Nagar, Kadukutty, Mala and Cherpu panchayaths. The development profiles of Tile industries from 1950 to 2006 shows that total 276 industries started in the district and newly started industries were 217 during the period of 1980-2000. Only 24 industries were started after the year 2000, which is very low comparing with earlier statistics. Around 5480 employees (Male - 1880 and Female - 3600) are depending tile/brick industries for their livelihood. Major products were roofing, ceiling, decorative, ridges and flooring tiles. Since clay mining is restricted from the paddy fields, tile/brick industries are procuring clay from neighbouring states and meet the demand. Around 73 tile factories in Thrissur district were laid off due to the scarcity of clay in the district.

The soil characteristics of the district reveal that four distinct types of soil can be observed such as Forest soil, Laterite soil, Alluvial soil and Coastal
alluvium. In a broad sense, National Bureau of Soil Science & Land use Planning and Soil Survey Organization derived 16 soil mapping units in the district. Soil profile study conducted in 12 selective locations of the paddy fields. It reveals that all locations possess alluvial soil, texture varies from fine, fine loamy, coarse loamy and very fine. The depth is shallow (25-50 cm), moderately deep (50-100 cm), deep (100-150 cm) and very deep (> 150 cm). Good quality clay is present in Thrissur, Mannuthi, Ollur, Cherpu, Kodakara, Irinjalakuda, Chalakudy and Koratti whereas moderate quality in Kunnamkulam, Vadakkanchery and Kaniyarkod. Poor quality clay is present in Vadanapalli, Tripayar and Chavakad.

- In the analysis part, area and production of various crops prepared by Department of Economics and Statistics, Govt. of Kerala during 2004-11 has studied. Double crop (paddy), pulses, sugar cane, pepper, ginger, turmeric, banana, tuber, pineapple, tapioca and vegetables are the seasonal crops cultivated in the district. The area and production of paddy shows a decreasing trend during 2004-08 and in 2009-11. The area and production is found increased in 2011-12 (21,172 H and 62,316 T) due to the implementation of food security schemes and better irrigation facilities. The analysis shows that the area and production of seasonal crops was maximum during 2004-05 (49,429 H/1,57,195 T) and minimum during 2010-11 (30,148 H/1,23,429 T). Total of 15 types of tree crops present in the district, Coconut is dominant in mixed crop followed by mango and jack tree. The other tree crops present in the district are arecanut, tamarind, cloves, nutmeg, cinnamon, palmyrah, vanilla, papaya, drumstick and betel leaves. The area is maximum during 2005-06 (1,56,610 H) and minimum during 2010-11 (1,07,195 H). The production was maximum during 2005-06 (1,13,527 T) and minimum during 2009-10 (43,803 T). The plantation crops statistics reveals that area of rubber increased to 15,420 H during 2010-11 from 14,057 H during 2004-05.
The land use change analysis shows that increase in population density is the influencing factor in land use change. Major changes are noticed in Agriculture and Built-up land. The paddy cultivation in the district is decreasing due to use of fallow land for clay mining and conversion to other crops and settlement. Banana and Tapioca are the seasonal crops found increased in the paddy field of the district. The Horticultural plantation is changing to Agro-Horticulture (Coconut, Pineapple etc.), Agriculture plantation (Rubber) and settlement. The Forest plantation is found changed to Agriculture plantation (Rubber) and Agro-Horticultural plantation during 2010. The Waterbodies increased after the built of Chimoni reservoir at Echippara across Chimoni river. The landfill area are seems to be increased in industries and mining area shows the increase in tile/brick clay mining and quarry mining in the district. The increase in conversion of Agriculture land to Built up land will lead to warming of the region and lowering of groundwater level. The change in forest plantation will also lead to climate change of the region.

The clay mining impacts identified in the natural drainage system are drainage chocking, waterlogged area and stream course change. The natural streams are found removed during the unscientific clay mining from the paddy field. Drainage chocking is present in abandoned clay mining sites of Chiranellur, Cheraparambu, Pazhai, Madavakkara, Manali, Ettumunna, Trikkur, Arattupuzha, Kundazhi and Pichampallikonam.

The artificial water bodies generated due to deep clay mining in paddy fields for clay resource are delineated under waterlogged area due to clay mining. This class is mainly found in Kecheri, Tharakkal ambalam, Marathakkara, Nenmanikkara, Parappukkara and Chalakudy. Stream course change is present in Cheruval where the course of Keli thodu was modified as a result of clay mining and a stream got widened to regulate the flow. The existing stream course was removed during clay mining.
Status of clay mining and virgin area map is prepared by extracting paddy fields, conversions and mining details from land use map (2010), land mining area from geomorphology (2010), clay mining status prepared by Mining and Geology Department (2005) and field work. Various units delineated in the clay bearing formation of the study area are virgin area (346.21 Km²), virgin reclaimed (63.87 Km²), virgin not suitable (78.30 Km²), excavated-waterlogged (14 Km²), excavated-wasteland (1.97 Km²) and miscellaneous (2528 Km²).

Suitable area for clay mining is derived through overlay analysis in GIS platform. The parameters selected for the study are status of clay mining, virgin location, comparatively deeper groundwater level, tile/brick industry location, soil (type, texture, depth, quality) and proper transportation facility. Total 4.36 sq.km area in 20 locations are suggested for sustainable clay mining in the district.

11.2 Recommendations

The following recommendations are put forward for sustainable mining, reuse of degraded land and conservation of clay resource in the district.

11.2.1 Land use

1. Paddy fields of the district where two crops of rice is cultivating should be carried out through food security schemes implemented by the Government.

2. The increase in built up land by changing the agriculture land and forest plantation to other agriculture plantation will also lead to climate change of the region and lowering of groundwater level.

3. Forested upland areas have an essential role in sustaining and protecting water resources and also maintaining the quality of water yield. Thus, emphasis should be given to enrichment planting.
especially in degraded upland areas. The shrubby indigenous species is suitable in upstream area for preventing the soil erosion (Muraleedharan, 2007).

4. Clay/sand mining will drastically affect the existing land use and the mined areas will be difficult to rehabilitate. So Land use norms are to be strictly followed to avoid unscientific land use and land fills.

5. Vegetables and seasonal crops can be practiced in refilled clay mining pits where paddy is not cost effective.

6. A watershed management approach focusing various aspects of forestry, agriculture, hydrology, ecology, soils and climatology to find ways of conserving and using land resources shall be adopted. Conservation of paddy fields in the downstream area should get a top priority.

11.2.2 Hydrology

1. Paddy fields are the sources of groundwater, prohibit mining below the level of water table depth reference of adjacent areas.

2. The waterlogged abandoned clay mining pit in the paddy fields will serve as ground water recharge system.

3. The existing abandoned waterlogged area should be kept unpolluted to avoid contamination in adjacent wells.

11.2.3 Utilization of Waterlogged Clay Mining Pits

1. The waterlogged clay mining pits can be utilized for pisciculture like in other locations of Puthukkad, Kallur and Muthrathikkara.

2. Other uses of waterlogged clay mining pits are for irrigation, water sports (picnic or camping locations), floriculture, etc.
11.2.4 Environmental Impact

1. The environmental problems related to mining needs proper accounting. Clay mining should be allowed only after conducting Environmental Impact Assessment (EIA) study in the proposed sites.

2. A proper environment management plan should be formulated for managing the already degraded zones.

11.2.5 Sustainable Clay Mining

1. Regulate random mining and allow only location-specific extraction of the clay resource under well conceived guidelines (Padmalal et al., 2004).

2. During transportation of clay, measures should be taken to cover the load since it creates atmospheric pollution.

11.2.6 Alternative to Clay Resource

1. Use of reservoir silt as an alternative to tile/brick clay to meet the demand of clay based industry.

2. Utilization of fly ash bricks produced from thermal power plants as an alternative to clay bricks in an experiment basis (Singh and Jagmohan, 2006).

3. Create awareness among the public to substitute laterite blocks or alternatives to clay bricks for construction.
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