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Mapping of Granite Quarries in Kerala, India: A critical mapping initiative

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1 Introduction

The transformation of granite stone, from a protective wall or a primitive weapon of prehistoric human being to commercial granite, (Phanerocrystalline, compact, hard and polishable, decorative building rock) a mining product have at least 7000 years of history as a resource used by man. Granite mining extract the common property of the present and future generations of not just man, but other organisms as well, while helping the building up of human civilisations. Across the countries, there exists wide variation in the manner in which granite quarrying in conducted. In developed countries it has evolved into a formal enterprise using techniques like GIS, remote sensing, 3D visual impact assessment etc. to foresee the impacts (Ramos & Panagopoulos, 2004). The data regarding the projects is made available for public review. On the other hand, the small-scale mining sectors of most developing countries are still in its infancy in terms of formalization, use of advanced technology, prior assessment of environmental impact, professional management and public review process.

In Kerala, the southern west state of India which harbour 18 % of the Western Ghats Taluk with high endemic and biodiversity rich regions, the information we have on the granite quarries is the low resolution maps with point representation of mining site in some districts of Kerala prepared by mining and geology Dept of Kerala and published as Mineral information system through its official website (http://dmg.kerala.gov.in). As observed by the FIMI report (1994), there is a big information gap at the national or state level, in the collection of spatial and temporal information on small scale mechanised and non- mechanized quarries. However, developments in Geographic information technology (GIT) which combines GIS, Remote Sensing and GPS has created new avenues in mapping and spatial decision making. After the advent of FOSSGIS and Web GIS, GIT has simplified the process of data availability in public sector, analytical capability and peoples' participation in mapping and spatial decision making (Alex & Sajeev 2015).

The present study attempted to map the distribution of granite quarries in Kerala using the open access satellite data during period 2014 - 2015 from WebGIS sources like Google Earth, Google Map and Bing Map. Manual visual interpretation, area estimation and analysis were done using QGIS. Primary proximity analysis of the quarries was also done using available valuable secondary geographic data. The methodology adopted for the work is critical mapping which explicitly addresses the various sets of decisions taken during the mapping process as a function of existing power relations embedded in knowledge (Crampton, 2010). Rather than a standalone map of granite quarries, our interest was to see the distribution of quarries in relation to major

landscape features.

2 Methods

The GPS coordinate, area and elevation of the some quarries were recorded using Garmin Oregon 650 GPS. The GPX layer file format in GPS was converted to Keyhole Markup Language (KML) file format and Shape file (.shp) format for further analysis which are the common file format in Google earth and GIS software respectively. The pattern and visual specification of the quarry was verified using these KML file in Google earth software using recently available (2014 – 2015) google satellite image of the site and its historical image. Further verification was done by google map and Bing map using QGIS - Open layer plug-in. Using these visual specifications we manually interpreted and vectorised all quarries in Kerala as polygon shape file layer and verified with detailed field visit of selected granite quarries. Each quarries in a district were named with unique id in DTVQN system in which D indicate district code, T for Taluk code, V for village code and then QN indicate Quarry number.

Using the GIS layers like elevation layer (USGS,2004), drainage network (SOI,1972), earthquake epicentre (Rajendran, et.al. 2009), lineament (KSDMPP, 2010) and environmental sensitive area (WGEEP Report, 2009 & HLWG Report, 2012) the GIS analysis like intersection, Interpolation, Proximity analysis were done and quantified. QGIS 2.8 and Arc GIS 9.3 software were used for this.

3 Results

3.1 Distribution of granite quarries in Kerala

We detected 5924 quarries within an area range 0.02 to 64.04 h in the state of Kerala. The total area of quarries is 7157.6 h whereas the average quarry area is 1.20 h with a standard deviation of 2.57. Sector wise analysis shows that Central Kerala had the highest number and area of quarries, where there are 2438 quarries with a total area 3610.4h. North Kerala had 1969 (1871.97 h) quarries and south Kerala has 1517 (1675.21 h) quarries. District wise data of quarries shows that Palakkad district have the highest number of quarries with 867 quarries in covering an area of 1165.93 h. Ernakulam district have the highest total area of quarries with 774 quarries covering an area of 1261.13 h (Table 1).Thrissur district have the largest granite quarry in Kerala in Kongadu panchayat of Thalappilly Taluk, Perimbilavu, extending to 64.04 h. Area class wise analysis of granite quarries of Kerala shows that majority (50.6 %) of granite Quarries in Kerala are in the 0.02 – 0.5 h class. 35.7 % of quarries falls within the area class 0.5 – 2 h. There are 73 granite quarries in Kerala with an area above 10 h which cover a total area of 1308.2 h. There are 10 quarries in Central Kerala, 3 quarries in north Kerala and 6 quarries in south Kerala having an area greater than 20 h. There are no granite quarries in Alappuzha district.

Table 1.Distribution of granite quarries in Kerala during 2014 - 2015

Sectors	District	No.	Area (h)			
			Total	Range	Mean	SD
Northern Kerala	Kasaragod	315	142.82	0.06 - 5.31	0.45	0.49
	Kannur	327	277.90	0.05 - 10.83	0.85	1.26
	Kozhikode	509	514.17	0.05 - 15.12	1.01	1.58
	Wayanad	161	149.57	0.07 - 30.83	0.93	2.61
	Malappuram	657	787.51	0.05 - 38.95	1.20	2.53
	Total	**1969**	**1871.97**	**0.05 - 38.95**	**0.95**	**1.92**
Central Kerala	Palakkad	867	1165.93	0.02 - 35.98	1.34	2.19
	Thrissur	469	924.77	0.07 - 64.04	1.97	3.95
	Ernakulam	774	1261.13	0.05 - 46.95	1.63	3.57
	Idukki	328	258.59	0.03 - 17.52	0.79	1.57
	Total	**2438**	**3610.42**	**0.02 - 64.04**	**1.48**	**3.04**
Southern Kerala	Alappuzha			-		
	Kottayam	499	368.95	0.03 - 8.32	0.74	1.08
	Pathanamthitta	352	420.99	0.02 - 20.92	1.20	2.55
	Kollam	305	317.87	0.04 - 28.3	1.04	2.42
	Thiruvananthapuram	361	567.40	0.02 - 31.33	1.57	3.41
	Total	**1517**	**1675.21**	**0.02 - 31.33**	**1.1**	**2.44**
Grand Total		**5924**	**7157.60**	**0.02 - 64.04**	**1.20**	**2.57**

3.2 Granite quarries and the Drainage system

There are 44 river basins in Kerala. As per the national norms Kerala have only four medium rivers they are Chaliyar, Bharatha puzha, Periyar and Pamba. Of these, Periyar is the longest river and Bharatha puzha the largest. The distribution of granite quarries in the major river basins of Kerala is given in the Table 2. The Baharathapuzha river basin has the largest number of quarries (940, area: 1286.86 h), followed by Muvattupuzha river basin (627, area: 1094.99 h).

Proximity of quarries to the drainage network was computed from first and second order drainage networks vectorised from SOI toposheet. It was found that 96 % of granite quarries in the Kerala are within 500m buffer distance from the drainage network. There are 2553 (1840.9 h) granite quarries within 100 m buffer range of drainage and 4072 (5312.4 h) granite quarries with in 200 m buffer distance (Table 3).

Table 2 : Distribution of granite quarries in major river basins of Kerala

SL No.	River Basin	Length of the River (Km)	Number of Quarries	Quarry Area (Ha)	Quarry Area Range (Ha)	Quarry Area in Average (Ha)	Standard Deviation of Quarry Area
1	Periyar	224	562	673.12	0.04 - 46.95	1.2	3.09
2	Bharathapuzha	209	940	1286.86	0.02 - 35.98	1.37	2.18
3	Pamba	176	106	139.55	0.03 - 20.92	1.32	3
4	Chalakudi	169	90	153	0.08 - 46.95	1.7	5.07
5	Chaliyar	169	465	638.12	0.06 - 38.95	1.37	2.93
6	Kadalundy	130	362	364.68	0.05 - 12.38	1.01	1.68
7	Achankovil	128	95	126.02	0.04 - 15.79	1.33	2.75
8	Kallada	121	185	167.65	0.04 - 15.79	0.91	1.83
9	Muvattupuzha	121	627	1094.99	0.04 - 37.45	1.75	3.33
10	Valapattanam	110	129	128.18	0.11 - 7.98	0.99	1.37
11	Chandragiri	105	104	41.85	0.06 - 2.31	0.4	0.35
12	Manimala	90	217	221.36	0.04 - 15.5	1.02	1.78
13	Kuppam	88	41	33.64	0.06 - 10.83	0.82	1.77
14	Vamanapuram	88	131	241.48	0.02 - 31.33	1.84	4.21
15	Minachil	78	321	249.04	0.03 - 8.32	0.78	1.06

Table 3.Proximity of granite quarries to drainage network

Sectors	Districts	Drainage Buffer(m)					
		0 - 100		0 - 200		0 - 500	
		No.	Area	No.	Area	No.	Area
Northern kerala	Kasaragod	140	40.20	247	114.91	314	142.44
	Kannur	189	107.27	263	236.34	313	269.51
	Kozhikode	219	183.93	321	349.03	472	467.09
	Wayanad	94	45.51	135	133.35	160	148.79
	Malappuram	316	265.70	474	647.89	647	781.52
	Total	**958**	**642.61**	**1440**	**1481.52**	**1906**	**1809.35**
Central kerala	Palakkad	218	161.25	409	641.27	785	1085.01
	Thrissur	154	179.00	252	582.44	411	829.28
	Ernakulam	231	211.76	375	789.74	621	1138.38
	Idukki	209	115.40	391	360.84	479	468.56
	Total	**812**	**667.41**	**1427**	**2374.29**	**2296**	**3521.23**
Southern kerala	Alappuzha	-	-	-	-	-	-
	Kottayam	297	153.15	430	341.75	505	383.31
	Pathanamthitta	175	146.94	261	368.82	345	415.28
	Kollam	162	79.56	253	291.25	305	317.86
	Thiruvananthapuram	173	151.24	261	454.81	339	556.72
	Total	**807**	**530.89**	**1205**	**1456.63**	**1494**	**1673.17**
Grand Total		2557	1840.90	4072	5312.44	5696	7003.75

3.3 Proximity of Granite quarries to Earthquake Epicentres and Lineaments

Correlation between earthquakes and lineaments have established for Kerala (Raj et al. 2001). Increase in the seismicity rate in the region in recent years is explained as due to increased anthropogenic activities, which includes changes in hydrological pathways as a consequence of rapid landscape changes (Rajendran et al. 2009).The stresses corresponding to both removal of overburden and groundwater withdrawal in the mining operation may trigger slips along faults causing large rock bursts which is defined as mining-induced seismic event in adverse condition nearby mining area (Guha 2000, Gibowicz et.al., 1981;Larsson, 2004). There are about 115 earth quake with a magnitude range 0.8 – 5 ML reported in Kerala during 1986 - 2013. The proximity of granite quarries to epicentres of these earthquakes and lineaments is given in Table 4 .It was found that there are 354 (612h) quarries with in 1 km buffer of major and minor lineaments in Kerala. There are 78 granite quarries with in 1 km proximity of the epicentres of recorded earthquakes in Kerala (Appendix :1).

3.4 Proximity of the quarries to the protected forests and Reserve forests

The proximity of granite quarries to the protected and reserved forests is given in Table 5. There are 79quarries with a total area 85.83h within the 500 m protected forests and there are 1378 quarries within 1 km of the reserved forests. Quarries close to the forests are more prevalent in central Kerala

3.5 Granite Quarries and Environmental Sensitive areas

Recently two reports were published which identified the Ecologically sensitive zones in the Western Ghats. The first was the Western Ghats Ecology Expert Panel

Table 4. Proximity of granite quarries to lineaments and earthquake epicentres

Sectors	Districts	Distance from Lineament		Distance from Epicentre	
		0 – 1km		0 – 1 km	
		No.	Area	No.	Area
Northern Kerala	Kasaragod	29	10.82	-	-
	Kannur	15	15.81	-	-
	Kozhikode	22	18.87	-	-
	Wayanad	11	7.83	-	-
	Malappuram	57	149.79	5	2.58
	Total	**134**	**203.12**	**5**	**2.58**
Central Kerala	Palakkad	86	110.09	17	22.20
	Thrissur	20	67.48	20	91.76
	Ernakulam	39	162.99	5	2.84
	Idukki	23	15.11	2	1.16
	Total	**168**	**355.67**	**44**	**117.96**
Southern Kerala	Alappuzha	-	-	-	-
	Kottayam	13	3.79	14	4.91
	Pathanamthitta	22	29.67	-	-
	Kollam	11	14.6	-	-
	Thiruvananthapuram	6	5.64	15	16.23
	Total	**52**	**53.7**	**29**	**21.14**
Grand Total		**354**	**612.49**	**78**	**141.68**

Table 5. Proximity of granite quarries to protected forests and reserved forests.

Sectors	Districts	Distance from the PF		Distance from the RF	
		0 - 1km		0 - 1km	
		No.	Area	No.	Area
Northern kerala	Kasaragod	-	-	41	14.35
	Kannur	-	-	37	38.11
	Kozhikode	-	-	129	104.61
	Wayanad	13	7.38	68	44.59
	Malappuram	-	-	40	41.51
	Total	**13**	**7.38**	**315**	**243.17**
Central kerala	Palakkad	15	32	264	355.13
	Thrissur	6	17.13	339	585.35
	Ernakulam	2	1.28	157	236.87
	Idukki	42	27.51	200	127.57
	Total	**65**	**77.92**	**960**	**1304.92**
Southern kerala	Alappuzha			-	-
	Kottayam	-	-	4	1
	Pathanamthitta	-	-	49	154.69
	Kollam	-	-	31	34.27
	Thiruvananthapuram	1	0.53	19	1262
	Total	**1**	**0.53**	**103**	**1451.96**
Grand Total		**79**	**85.83**	**1378**	**3000.05**

(WGEEP) report which identified three zones of ecologically sensitive areas (ESZ 1, 2 & 3) and the second was the High Level Working Group (HLWG) report which identified single class of ecologically sensitive area. The WGEEP recommended not to grant permission for quarrying in ESZ 1 & 2 and to phase out the current quarrying activity within a period of 5 years. It recommended quarrying in ESZ 3 under strict regulation and social auditing. The HLWG categorized quarrying as a red category industry and banned it in the ecologically sensitive areas identified by them. We checked the status of quarrying activity in each of the above said zones.

The number and area of quarries in each of the ecologically sensitive zone/areas is given in Table 6. We found that there are 1486 granite quarries in ESZ 1, 169 in ESZ 2 and 1667 quarries in ESZ 3 identified by WGEEP. In the Ecologically Sensitive Area identified by HLWG, there are 655 granite quarries (Appendix :2).

Table 6: Number and area of granite quarries in the ESZ and ESA areas.

Sectors	Districts	WGEEP Report						HLWG Report	
		ESZ - 1		ESZ -2		ESZ -3		ESA	
		No.	Area	No.	Area	No.	Area	No.	Area
Northern Kerala	Kasaragod	-	-	-	-	175	84.43	-	-
	Kannur	149	126.11	-	-	1	0.33	11	8.32
	Kozhikode	1	0.39	-	-	88	78.65	56	44.32
	Wayanad	156	147.20	-	-	-	-	28	20.97
	Malappuram	9	4.26	-	-	450	622.45	44	20.51
	Total	**315**	**277.96**	**-**	**-**	**714**	**785.86**	**139**	**94.12**
Central Kerala	Palakkad	290	336.37	-	-	221	264.32	134	209.41
	Thrissur	154	280.46	106	279.38	206	308.92	64	108.84
	Ernakulam	9	57.05	-	-	2	7.15	5	4.92
	Idukki	307	247.52	-	-	-	-	244	151.39
	Total	**760**	**921.40**	**106**	**279.38**	**429**	**580.39**	**447**	**474.56**
Southern Kerala	Alappuzha	-	-	-	-	-	-	-	-
	Kottayam	11	15.99	60	47.45	229	157.1	24	23.44
	Pathanamthitta	167	204.57	3	17.13	82	96.09	20	52.80
	Kollam	93	92.73	-	-	210	257.41	13	15.03
	Thiruvananthapuram	140	186.42	-	-	13	7.72	12	8.56
	Total	**411**	**499.71**	**63**	**64.58**	**534**	**518.32**	**69**	**99.83**
Grand Total		**1486**	**1699.07**	**169**	**343.97**	**1677**	**1884.57**	**655**	**668.51**

3.6 Impacts

The type and nature of environmental and socio-economic impact of granite quarries is compiled in appendix 3. It has been observed that in the effort to make quick money most of the long term ecological and socio-economic impact of granite quarries has been undermined (Sunitha et al., 2010).

4 Conclusion

This work presents the raw information on granite quarries of Kerala. Relying on remotely sensed data, it was impossible to ascertain whether a particular quarry is functional or not. The data generated needs to be updated with inputs on a variety of parameters related to each of the coded quarries. It is envisaged to do this on a participatory mode by hosting the map and attribute table in the public domain in the internet accessible to the general public. Thus the next phase of the work is to host the data, convey the information to the general public with the link to be accessed for adding information. A truly participatory data collection and mapping process is envisaged and the work presented here is the skeletal structure. With stiff resistance emerging in many parts of Kerala against granite quarrying, it is expected that the general public would have a large amount of information to provide on each of the quarries. A peoples' narrative on the granite quarrying which irrecoverably deformed the topography of Kerala in a short span of time would be valuable addition to the history of environmental movement in Kerala.

References

[1] Alex C. J., & Sajeev T. V., Experiments in critical mapping data, Scale, functionalities . Proceedings of 27th Kerala Science congress 27 – 29 January 2015, Alappuzha (2104 - 2115)

[2] Crampton, J. W. (2010). Mapping. *A critical introduction to cartography and GIS. Malden: Blackwell.*

[3] FIMI - Federation of Indian Minerals Industries. (1994). Granite Industry: Potent Export Potential. Facts For You, volume 16, November

[4] Gadgil, M. (2014). Western Ghats Ecology Expert Panel. Economic & Political Weekly, 49(18), 39

[5] Gibowicz, S. J., Droste, Z., Guterch, B., & Hordejuk, J. (1981). The Belchatow, Poland, earthquakes of 1979 and 1980 induced by surface mining. *Engineering Geology*, 17(4), 257-271.

[6] Guha, S. K. (2000). Mining Induced Seismicity. In *Induced Earthquakes* (pp. 159-215). Springer Netherlands.

[7] Kasturirangan, K., Babu, C. R., Mauskar, J. M., Chopra, K., Kishwan, J., Shanar, D., ... & Chandrasekharan, I. (2013). Report of the high level working group on Western Ghats. *submitted to the Ministry of Environment and Forests, Government of India*.

[8] Kerala State Disaster Management Plan Profile (2010). Kerala State Disaster Management Authority,20-24pp.

[9] Larsson, K. (2004). Seismicity in mines a review.Technical Report Department of Civil and Environmental Engineering Division of Rock Mechanics

[10] Ningappa, C., Sannappa, J., Chandrashekara, M. S., & Paramesh, L. (2009). Studies on radon/thoron and their decay products in granite quarries around Bangalore city, *India. Indian Journal of Physics*, 83(8), 1201-1207.

[11] Panel, W. G. E. E., & Gadgil Commission. (2011). Report of the Western Ghats Ecology Expert Panel. *The Ministry of Environment and Forests, Government of India, New Delhi*.

[12] Praseeda Kumari, M. (2015). Study on the environmental impact of mining in Mukundapuram area of Trissur District, Kerala State using remote sensing and GIS.

[13] Raj, K. G., Paul, M. A., Hegde, V. S., & Nijagunappa, R. (2001). Lineaments and seismicity of Kerala—A remote sensing based analysis. *Journal of the Indian Society of Remote Sensing*, 29(4), 203-211.

[14] Rajendran, C. P., John, B., Sreekumari, K., & Rajendran, K. (2009). Reassessing the earthquake hazard in Kerala based on the historical and current seismicity. *Journal of the Geological Society of India*, 73(6), 785-802.

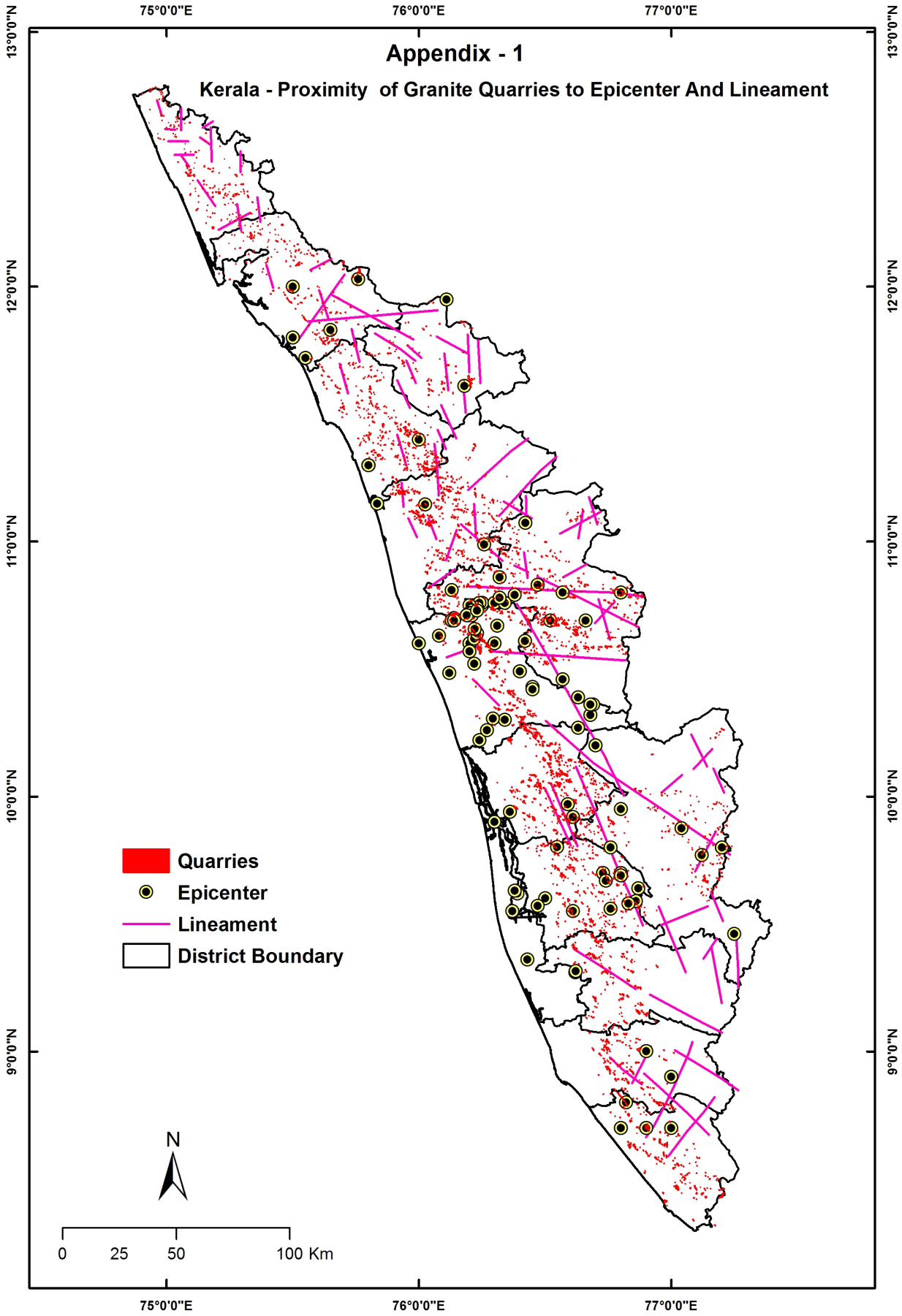
[15] Ramos, B., & Panagopoulos, T. (2004, June). The use of GIS in visual landscape management and visual impact assessment of a quarry in Portugal. *In International Conference on Environmental and Mineral Processing* (Vol. 1, pp. 73-78).

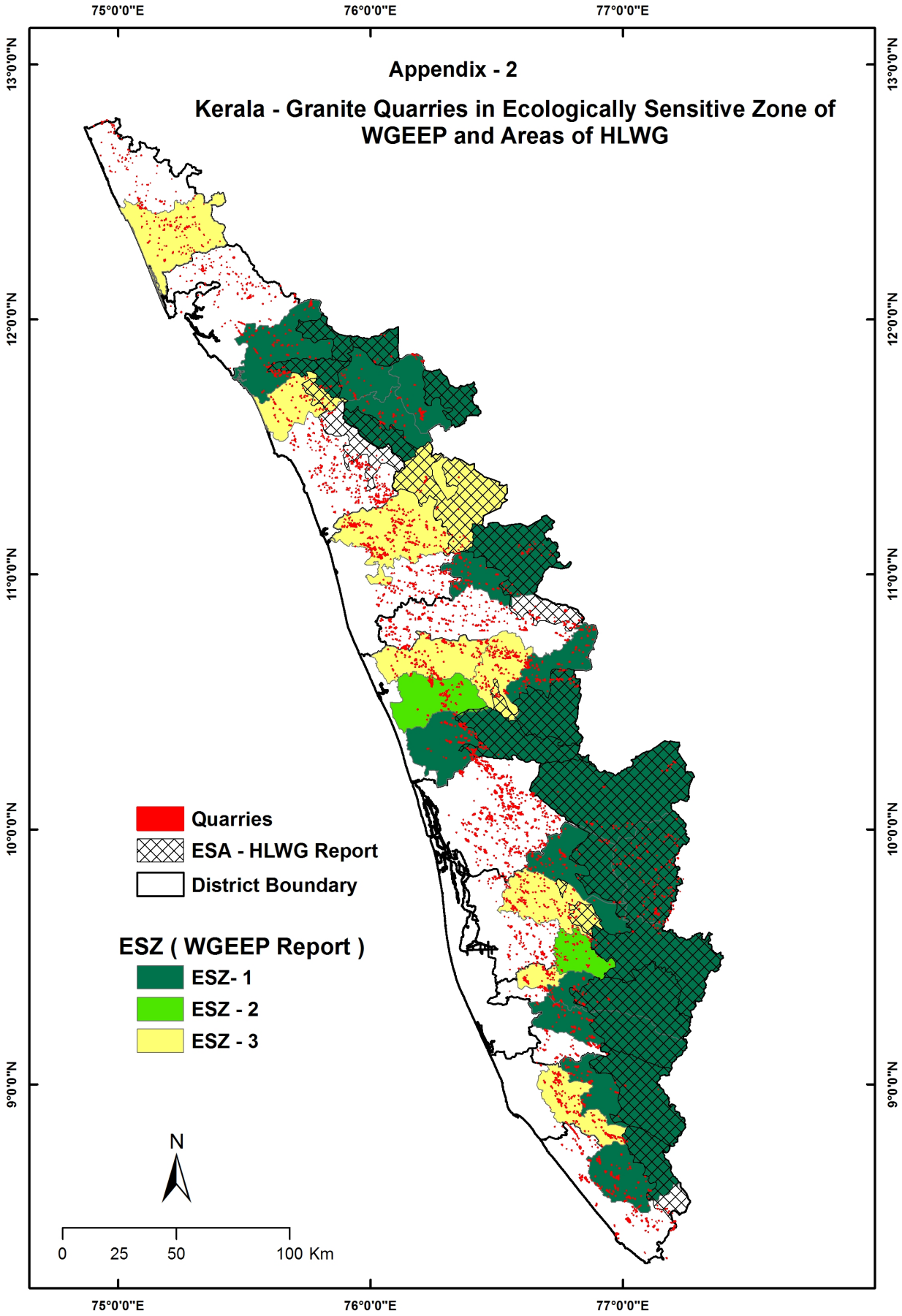
[16] Sajinkumar, K. S., Sankar, G., Rani, V. R., & Sundarajan, P. (2014). Effect of quarrying on the slope stability in Banasuramala: an offshoot valley of Western Ghats, Kerala, India. *Environmental Earth Sciences*, 72(7), 2333-2344.

[17] Sunitha, N., Nandini, N and Paramesh Naik (2010).Economic environment and health status of stone quarry workers. The Socioscan; Vol. 2(3&4): 27-33.

[18] Survey Of India Toposheet (1972), Government of India.

[19] USGS (2004) Shuttle Radar Topography Mission, 1 Arc Second scene


Appendix - 1
Kerala - Proximity of Granite Quarries to Epicenter And Lineament
75°0'0"E
76°0'0"E
77°0'0"E
13°0'0"N
12°0'0"N
11°0'0"N
10°0'0"N
9°0'0"N
Quarries
Epicenter
Lineament
District Boundary
N
0
25
50
100 Km


Appendix - 2
Kerala - Granite Quarries in Ecologically Sensitive Zone of WGEEP and Areas of HLWG
75°0'0"E
76°0'0"E
77°0'0"E
13°0'0"N
12°0'0"N
11°0'0"N
10°0'0"N
9°0'0"N
Quarries
ESA - HLWG Report
District Boundary
ESZ (WGEEP Report)
ESZ- 1
ESZ - 2
ESZ - 3
N
0
25
50
100 Km

Appendix: 3

Table 7. Type and nature of environmental and socio economic impact of granite quarries (Sajin Kumar et al. 2011, Ningappa et al 2009, Praseeda 2015)

Environmental attributes	Causative activities	Type of effects	Nature of effects
Air quality	Soil excavation, drilling, blasting, crushing, loading, transportation and debris dumping	Dust emission, shattering of rock particulates, dust deposition on canopy cover, inhalation of fine particulates, Higher concentration of radon and thorium	Extremely adverse
Noise level	Soil excavation, drilling, blasting, crushing, loading, transportation and debris dumping	Significant to extreme and continuous grinding sound, discrete machinery noise, impulse noise of moderate level and intermittent traffic noise	Extremely adverse
Landscape changes	Soil excavation, quarrying and debris dumping in wetland	Disfiguration of hillock, change in natural setting, a major long-term implication, Wetland destrucion	Significantly adverse
Soil	Soil excavation, quarrying and debris dumping, Dust emission	Loss of top soil, nutrient depletion and change in soil character	Moderately adverse
Land use	Soil excavation, quarrying and debris dumping	Change from sustainable to unsustainable use	Appreciably adverse
Groundwater	Soil excavation and labour camp, Blasting, large quarry pit	Reduced infiltration , Water table Sinking, contamination, increased water use, Probable improvement in recharge	Moderately adverse Minimally beneficial
Surface water	Soil excavation, quarrying and debris dumping, large quarry pit	Increased runoff and turbidity in water during rainy season, Obstruct the flow, Contamination	Appreciably adverse
Flora	Soil excavation, debris dumping and labour camp	Loss of natural vegetation, loss of biodiversity	Appreciably adverse
Fauna	Soil excavation, drilling, blasting, transportation and labour camp	Disturbance to terrestrial fauna, loss of faunal diversity	Minimally adverse
Employment	Soil excavation, drilling, loading, transportation, crusher and debris dumping	Increased direct and indirect employment opportunities	Moderately beneficial
Income	Quarrying, transportation, manual crushing, labour camp	Increased income to the quarry and crusher operator. Enhanced income generating activities in nearby localities	Moderately beneficial Minimally beneficial
Amenities	Transportation	Excessive use of road	Appreciably adverse
Aesthetics	Soil excavation, quarrying, crushing, transportation and debris dumping	Change in natural setting, dustyappearance and haphazard placement of material	Appreciably adverse
Tranquillity	Blasting, crushing and transportation	Loss of calmness, prevalence of uneasiness	Moderately adverse
Health and Safety	Soil excavation, drilling, blasting, crushing, loading, transportation, debris dumping, storage of explosives and labour camp	Possibility of respiratory diseases, hearing impairment, chances of injuries to workers and accidents due to machineries and fly rocks on blasting	Appreciably adverse