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GOVERNMENT OF INDIA
MINISTRY OF WATER RESOURCES,
RIVER DEVELOPMENT & GANGA REJUVENATION
CENTRAL GROUND WATER BOARD

PLAN ON
ARTIFICIAL RECHARGE TO GROUNDWATER AND WATER CONSERVATION IN MUSUNURU MANDAL, KRISHNA DISTRICT, ANDHRA PRADESH STATE

SOUTHERN REGION
HYDERABAD
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PLAN ON
ARTIFICIAL RECHARGE TO GROUNDWATER AND WATER CONSERVATION IN MUSUNURU MANDAL, KRISHNA DISTRICT, ANDHRA PRADESH STATE

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AT A GLANCE

Name of the Mandal	MUSUNURU
District	KRISHNA
State	ANDHRA PRADESH
Total Area sq.km.	208
Area suitable for Artificial Recharge (sq.km.)	206
Latitude and Longitude	16.705220 to 16.9335180 and 80.865560 to 81.048750.
Average Annual Rainfall (mm)	1042
Geology	Sandstone, Khondalite
Average Depth To Water Level (Decadal) (Pre Monsoon)	58.4
Average Depth To Water Level (Decadal) (Post Monsoon)	23.4
Ground Water Resources	
Annual Replenishable Ground Water Resources (MCM/yr)	35.64
Net Annual Ground Water Availability(MCM)/yr	32.08
Net Annual Ground Water Draft(MCM)/yr	44.96
Projected Demand for Domestic and Industrial Use(MCM)/yr	2.46
Stage of Ground Water Development (%)	140
Surface runoff available (MCM)/yr	59.75
Total Storage Created in the Mandal by Various Agencies (MCM)/yr	0.28
Artificial Recharge/Conservation Measures	
Recharge Structures Proposed (No.s)	Percolation Tanks: 0, Check Dams: 145 Farm ponds: 320, Recharge Shafts: 20
Improving Water use Efficiency	Micro Irrigation System -1600 ha
Tentative Total Cost in Lakhs (Rs.)	1873.83
Expected Recharge/Savings (MCM)/yr	8.10

1. INTRODUCTION

Musunuru Mandal is one of over-exploited mandal in krishna district, Andhra Pradesh State, which is economically backward and chronically drought affected. The mandal has 16 inhabited villages and with 16 gram panchayats.

2. LOCATION

The mandal lies between north latitudes 16.705220 to 16.9335180 and between east longitudes 80.865560 to 81.048750. The mandal occupies the northeast part of the Krishna district and is bounded on the north by Chatrai mandal, on the east by West Godawari district, on the south by Bapulapadu mandal and west by Nuziveedu mandal. (Fig.1) The geographical area of the mandal is 208 sq.km.

3. PHYSIOGRAPHY AND DRAINAGE:

The area is drained by streams which are tributaries of Lower Krishna River. The streams are mostly ephemeral in nature. The drainage pattern is dendritic, rectangular to sub rectangular due to the influence of geological structures. (Fig.2)

4. RAINFALL

The average rainfall in the mandal is 1042 mm. The rainfall during the South-west monsoon season i.e., June-September accounts for about 85% of the total rainfall.

5. LAND USE PATTERN

Out of the total geographical area of 208 sq.km, the area covered by forest is 29.67 sq.km and the net area sown is 94.79 sq.km. Barren and uncultivable land is 10.43 sq.km. The land for non agricultural use accounts for 21.27 sq.km.(Fig.3)

6. HYDROGEOLOGY

The area is underlain by Sand stones and Khondalites of Pre Cambrian age (Fig.4). Ground water occurs in weathered and fractured zones under water table and semi-confined conditions. The weathered zone thickness as per the GEC report is 15 m. The weathered zone has been extensively tapped by dug and dug cum bore wells up to 20 m depth, which are mostly dry now. Ground water occurs in the fractured rock formations up to 200 m bgl. However, the potential fractures are encountered between 50-100 m bgl. The cumulative yield varies from 2-5 lps.

7. GROUND WATER LEVEL SCENARIO

The depth to water level during the pre-monsoon and post-monsoon varies from 2 to 20 m. The average depth to water level (decadal) during pre and post monsoon is 58.4 and 23.4 m bgl respectively. The decadal mean water level trend during post monsoon is depicted in the Fig-5.

8. DYNAMIC GROUND WATER RESOURCES

The Ground water availability, Utilization and stage of Development in Musunuru Mandal Krishna District are given in Table-1.

Table-1: Ground water resources of Musunuru mandal, Krishna district.

Annual Replenishable Ground water resources (MCM)	35.64
Net Annual Ground Water Availability(MCM)/yr	32.08
Net Annual Ground Water Draft(MCM)/yr	44.96
Projected Demand for Domestic and Industrial use up to 2025. (MCM)	2.46
Stage of Ground water development (%).	140
Whether notified or not with year of notification.	No

9. NEED FOR ARTIFICIAL RECHARGE AND CONSERVATION METHODS

The ground water withdrawal is more than the recharge with a stage of development above hundred percent. The long term water level trend mostly shows a declining trend and the water levels are very deep ranging up to 60 m. The sustainability of bore wells has become questionable as many bore wells are either drying up or have recorded reduced yields. There is no surface water irrigation facility in the area. All these factors indicate that there is an urgent need for artificial recharge and water conservation in the Mandal.

10. JUSTIFICATION OF THE ARTIFICIAL RECHARGE PROJECT

Musunuru Mandal falls under high stage of ground water development i.e., 140 % and with sufficient amount of uncommitted surface runoff. The area is completely dependent on ground water for domestic, industrial and irrigation purposes. During the monsoons runoff quickly flows out of the area without natural recharge to ground water. It is necessary to apply artificial recharge techniques to allow more and more recharge through check dams, PTs, MPTs, farm ponds, recharge shafts to cope up with the withdrawal pattern and also to improve ground water situation through various interventions including on farm activities and micro irrigation systems (Sprinkler-Drip-HDPE).

11. AVAILABILITY OF SURPLUS, SURFACE WATER FOR ARTIFICIAL RECAHRGE OR CONSERVATION

The runoff was calculated by taking into account of normal rainfall of the mandal and corresponding runoff yield from Strangers table. The existing storage created by various artificial recharge structures constructed by the State Government, if any, was deducted for calculating the runoff yield to recommend new AR structures.

Total Geographical area (Sq.kms)	208
Hilly Area (Sq.kms)	2
Area suitable for Artificial Recharge (sq.km.)	206
Runoff Yield in MCM/yr	59.75
Existing No. of Check Dams	40
Storage created MCM/yr	0.28
Existing No. of Percolation Tanks	0
Storage created MCM/yr	0
Total Existing Storage Created	0.28

12. FEASIBLE ARTIFICIAL RECHARGE STRUCTURES

Since the mandal is categorized as over exploited, there is an immediate need for improving ground water scenario and to ensure sustainability of ground water sources. It is also suggested to create additional storage capacity of surface water bodies which would result in supplementing irrigation thereby reducing the ground water draft. The run off available in the mandal has been assessed as 59.47 MCM/yr, which could be considered for further planning of artificial recharge. However, the number of artificial recharge structures feasible has been recommended in areas, by considering the utilizable yield, number of existing structures, land use, drainage pattern and also where the post monsoon water levels (decadal mean) are more than 5 m bgl., and or decadal trends are either falling or showing insignificant raising trend.

A) Check dams and Percolation Tanks

The area is covered by seasonal nalas – drains, which carry discharge during monsoon period debauched into the water bodies within a short duration. It is proposed to identify such nalas for construction of check dams/Percolation tank with recharge shafts, so as to harness ground water and to increase soil moisture content.

- The site selected for check dam/Percolation Tank should have sufficient thickness of permeable soils or weathered material to facilitate recharge of stored water within a short span of time. The water stored in these structures is mostly confined to the stream course and height is normally less than 2m.

- These are designed based on stream width and excess water is allowed to flow over the crest wall. In order to avoid scouring from excess runoff water cushions are provided on the downstream side. To harness maximum runoff in the stream, a series of such check dams can be constructed to have recharge on a regional scale.

- Considering the annual monsoon rainfall of 1042 mm, sufficient rain water can be harnessed. This will improve ground water regime as well as delaying the instant flow into the main river.

- The flow in these seasonal rivers can be sustained up to about 2 to 3 months after monsoon.

- Recharge trenches can also be constructed along upstream side of the check dam/Percolation Tank in the impoundment area for enhancing the ground water recharge rate.

Thus, a total of **145 Check dams** are recommended.

B). Recharge Shafts

The existing check dams and percolation tanks lose their storage capacity as well as recharge capacity due to siltation. Hence, Recharge shafts are recommended in the existing Check dams and Percolation tanks to enhance the ground water recharge. During the heavy downpours, there will be sufficient accumulation of runoff, which can also effectively be utilized for recharge by constructing recharge shafts. Hence, it is proposed to construct 20 recharge shafts of 165 mm dia with 30 m depth in the existing check dams.

C). Farm Ponds

A farm pond is a large dug out in the earth, usually square or rectangular in shape, which harvests rain water and stores it for future use. It has an inlet to regulate inflow and an outlet to discharge excess water. The pond is surrounded by a small bund, which prevents erosion on the banks of the pond. The size and depth depend on the amount of land available; the type of soil water from the farm pond is conveyed to the fields manually, by pumping, or by both methods.

Advantages of Farm Ponds

- They provide water to start growing crops, without waiting for rain to fall.
- They provide irrigation water during dry spells between rainfalls. This increases the yield, the number of crops in one year, and the diversity of crops that can be grown.
- Bunds can be used to raise vegetables and fruit trees, thus supplying the farm household with an additional source of income and of nutritious food.
- Farmers are able to apply adequate farm inputs and perform farming operations at the appropriate time, thus increasing their productivity and their confidence in farming.
- They check soil erosion and minimize siltation of waterways and reservoirs.
- They supplies water for domestic purposes and livestock.
- They promote fish rearing.
- They recharge the ground water.
- They improve drainage.
- The excavated earth has a very high value and can be used to enrich soil in the fields, levelling land, and constructing farm roads.

As per the Land use classification, majority of the area is covered by the agricultural field. Hence, it is proposed to construct 320 farm ponds in 16 villages of the Mandal @ 20 farm ponds in each village.

D). Micro Irrigation System (Sprinkler /drip/HDPE pipes)

Micro irrigation is defined as the frequent application of small quantities of water directly above and below the soil surface; usually as discrete drops, continuous drops or tiny streams through emitters placed along a water delivery line.

In flood/furrow irrigation method more than 50% of applied water is wasted through seepage to deeper level, localized inundation causes loss through evaporation and it leaches out the nutrients from the plant. While through drip & sprinkler irrigation wastages of irrigational water could be minimized. The studies on different crops, has revealed that irrigation water is saved drastically. The conveyance losses (mainly seepage & evaporation) can be saved up to 25 to 40% through utilization of HDPE pipes. Initially the scheme is proposed to be implemented in worst affected areas showing deepest water levels and significant declining trends. It is proposed to take up micro irrigation system in 1600 ha @ 100 ha per village.

13. TENTATIVE COST ESTIMATES (MUSUNURU MANDAL)

S.No.	Feasible Artificial Recharge & Water Conservation structures/	No. of Structures/ Quantity	Total Volume (MCM)	Tentative unit cost (in Rs lakh)	Total tentative cost (in Rs Lakh)	Expected Annual GW recharge/savings (MCM)
1	Proposed Masonry Check dams Crest Length -10-15 m, Height-1-2 m) (0.007 MCM*4 fillings)	145	4.06	5	725	3.045
2	Recharge shaft in Check dam (50% of the existing Check dams)	20	0.22	0.5	10	0.22
3	Proposed Percolation Tanks (100*100*2.5)* 4 fillings)	0	0	15	0	0
4	Renovation Desilting, Repairs and installation of Recharge Shafts in existing PTS (50% of the existing PTS)	0	0	1	0	0
5	Proposed Farm Pond (6 filling) 5*5*1.5 dimension @ 20 farm ponds per each village	320	0.04608	0.25	80	0.041472
6	Proposed Sprinkler/drip/HDPE pipes for 100 ha in each village	1600	9.6	0.6	960	4.8
7	Proposed Piezometers up to 50 mbgl @ one PZ per Village	16	0	0.6	9.6	0
8 (i)	Total (No. of AR Structures)	501	4.33		824.6	3.306
8 (ii)	Total (ha)	1600			960	4.8
	Total (8(i) + 8 (ii))				**1784.6**	**8.106**
9	Impact Assessment & O & M -5 % of Total cost of the Scheme				**89.23**	
	Grand Total				**1873.83**	

*(Expected annual GW Recharge/Savings MCM - CDS& PTS: 75%, Farm ponds - 90%, Sprinklers-50%, Recharge shafts in existing CDS and PTS-100%)

Note: The type, number and cost of structure may vary according to site, after the ground truth verification.

14. TIME SCHEDULE

Steps	Quarters							
	1st	2nd	3rd	4th	5th	6th	7th	8th
Identification of line department/implementing agency and preparation of DPR								
Approval of Scheme and releases of sanction of funds								
Implementation of ARS								

Phase = one quarter or 3 months or equivalent to financial quarter

A). Operation and Maintenance

In all projects impact assessment has to be carried out to ensure that project is economically viable, socially equitable and environmentally sustainable by inter-related socio-economic, cultural and human-health impacts, both beneficial and adverse. Accordingly it is proposed to have impact assessment as well as operation & Maintenance at the rate of 5% of the total cost of the project for 5 years from the completion of artificial recharge project.

B). Expected Benefits

The benefits of the project are:

1. The implementation of the project would result in additional recharge/Ground water savings to the tune of 8.10 MCM.
2. Ground water recharge will help in arresting the rapid decline in ground water resources and will also ensure improvement in quality of ground water by dilution.
3. Proposed structures and measures will also enhance the ground water potential and would ensure sustainability of ground water resources. It is estimated that the stage of ground water development may likely to be reduced from the present 140% to 111% (29%)
4. It will also help in controlling soil erosion.

Acknowledgements

The data received from the Director Ground Water Department Andhra Pradesh in respect of the basic inputs is duly acknowledged. The information on existing Artificial Recharge Structures have been taken from the EMUSTER, Department of Rural Development, Government of AP.

EXISTING ARTIFICIAL RECHARGE STRUCTURES
MUSUNURU MANDAL, KRISHNA DISTRICT, AP

S.no	Gram Panchayat	Habitation	Structure Type	Longitude	Latitude	Scheme
1	Akkireddigudem	Akkireddigudem	Check Dam	80.9001	16.8682	NREGS
2	Akkireddigudem	Akkireddigudem	Check Dam	80.8983	16.8734	NREGS
3	Akkireddigudem	Akkireddigudem	Check Dam	80.8954	16.8769	NREGS
4	Ramanakkapeta	Ramanakkapeta	Check Dam	80.8873	16.8854	NREGS
5	Ramanakkapeta	Ramanakkapeta	Check Dam	80.8763	16.9083	NREGS
6	Surepalle	Gollagudem	Check Dam	80.8863	16.9078	NREGS
7	Surepalle	Gollagudem	Check Dam	80.8813	16.9055	NREGS
8	Surepalle	Gollagudem	Check Dam	80.8794	16.9093	NREGS
9	Surepalle	Surepalle	Check Dam	80.8965	16.9094	NREGS
10	Chintalavalli	Chintalavalli	Check Dam	80.9186	16.8370	NREGS
11	Chintalavalli	Gogulampadu	Check Dam	80.9315	16.8563	NREGS
12	Chintalavalli	Gogulampadu	Check Dam	80.9325	16.8521	NREGS
13	Gullapudi	Gullapudi	Check Dam	80.9498	16.8989	NREGS
14	Katrenipadu	Harischandapuram	Check Dam	80.9241	16.7868	NREGS
15	Katrenipadu	Harischandapuram	Check Dam	80.9349	16.7909	NREGS
16	Katrenipadu	Katrenipadu	Check Dam	80.9530	16.7903	NREGS
17	Katrenipadu	Katrenipadu	Check Dam	80.9512	16.7780	NREGS
18	Katrenipadu	Katrenipadu	Check Dam	80.9518	16.7803	NREGS
19	Katrenipadu	Katrenipadu	Check Dam	80.9479	16.7850	NREGS
20	Chekkapalli	Chakkapalle	Check Dam	80.9198	16.8646	NREGS
21	Lopudi	Lopudi	Check Dam	80.9536	16.9265	NREGS
22	Lopudi	Lopudi	Check Dam	80.9440	16.9049	NREGS
23	Lopudi	Lopudi	Check Dam	80.9480	16.9055	NREGS
24	Lopudi	Lopudi	Check Dam	80.9428	16.9103	NREGS
25	Lopudi	Lopudi	Check Dam	80.9330	16.9158	NREGS
26	Lopudi	Lopudi	Check Dam	80.9534	16.9056	NREGS
27	Korlagunta	Korlagunta	Check Dam	80.8919	16.8057	NREGS
28	Korlagunta	Korlagunta	Check Dam	80.8920	16.8032	NREGS

29	Korlagunta	Korlagunta	Check Dam	80.8917	16.7948	NREGS
30	Korlagunta	SimhadriApparaopeta	Check Dam	80.8986	16.8263	NREGS
31	Korlagunta	SimhadriApparaopeta	Check Dam	80.8947	16.8240	NREGS
32	Korlagunta	SimhadriApparaopeta	Check Dam	80.8928	16.8262	NREGS
33	Korlagunta	SimhadriApparaopeta	Check Dam	80.8906	16.8208	NREGS
34	Ramanakkapeta	Ramanakkapeta	Check Wall	80.8882	16.8805	NREGS
35	Ramanakkapeta	Ramanakkapeta	Check Wall	80.8544	16.8923	NREGS
36	Ramanakkapeta	Ramanakkapeta	Check Wall	80.8679	16.8979	NREGS
37	Ramanakkapeta	Ramanakkapeta	Check Wall	80.8647	16.9046	NREGS
38	Katrenipadu	Harischandapuram	Check Wall	80.9331	16.8003	NREGS
39	Katrenipadu	Katrenipadu	Check Wall	80.9531	16.8019	NREGS
40	Lopudi	Lopudi	Check Wall	80.9377	16.9093	NREGS

PROPOSED ARTIFICIAL RECHARGE STRUCTURES
MUSUNURU MANDAL, KRISHNA DISTRICT, AP.

S.No.	Mandal	Lattiutude	Longitude	Structure type
1	Musunuru	16.7129	80.9628	Checkdam
2	Musunuru	16.7686	81.0207	Checkdam
3	Musunuru	16.7647	80.9869	Checkdam
4	Musunuru	16.7680	80.9779	Checkdam
5	Musunuru	16.7437	80.9892	Checkdam
6	Musunuru	16.7553	80.9789	Checkdam
7	Musunuru	16.7480	80.9769	Checkdam
8	Musunuru	16.7550	80.9728	Checkdam
9	Musunuru	16.7470	80.9735	Checkdam
10	Musunuru	16.7440	80.9710	Checkdam
11	Musunuru	16.7397	80.9675	Checkdam
12	Musunuru	16.7367	80.9735	Checkdam
13	Musunuru	16.7400	80.9762	Checkdam
14	Musunuru	16.7411	80.9878	Checkdam
15	Musunuru	16.7343	80.9847	Checkdam
16	Musunuru	16.7291	80.9744	Checkdam
17	Musunuru	16.7299	80.9792	Checkdam
18	Musunuru	16.7282	80.9599	Checkdam
19	Musunuru	16.7272	80.9527	Checkdam
20	Musunuru	16.7206	80.9527	Checkdam
21	Musunuru	16.7242	80.9747	Checkdam
22	Musunuru	16.7110	80.9682	Checkdam
23	Musunuru	16.7327	80.9975	Checkdam
24	Musunuru	16.7285	80.9966	Checkdam
25	Musunuru	16.7603	81.0226	Checkdam
26	Musunuru	16.7571	80.9638	Checkdam
27	Musunuru	16.7709	80.9494	Checkdam
28	Musunuru	16.7752	81.0454	Checkdam
29	Musunuru	16.7630	80.9795	Checkdam
30	Musunuru	16.7478	81.0147	Checkdam
31	Musunuru	16.7283	81.0059	Checkdam
32	Musunuru	16.8291	80.9768	Checkdam
33	Musunuru	16.8297	80.9894	Checkdam
34	Musunuru	16.8228	80.9833	Checkdam

35	Musunuru	16.8221	80.9816	Checkdam
36	Musunuru	16.8122	80.9778	Checkdam
37	Musunuru	16.8091	80.9719	Checkdam
38	Musunuru	16.7938	80.9718	Checkdam
39	Musunuru	16.7939	80.9789	Checkdam
40	Musunuru	16.8075	80.9830	Checkdam
41	Musunuru	16.8106	80.9840	Checkdam
42	Musunuru	16.8262	80.9968	Checkdam
43	Musunuru	16.8252	80.9806	Checkdam
44	Musunuru	16.8327	80.9679	Checkdam
45	Musunuru	16.7735	80.9996	Checkdam
46	Musunuru	16.7722	80.9842	Checkdam
47	Musunuru	16.8105	81.0202	Checkdam
48	Musunuru	16.8175	81.0163	Checkdam
49	Musunuru	16.7928	81.0260	Checkdam
50	Musunuru	16.8967	80.9564	Checkdam
51	Musunuru	16.8874	80.9491	Checkdam
52	Musunuru	16.8978	80.9618	Checkdam
53	Musunuru	16.8865	80.9672	Checkdam
54	Musunuru	16.8619	80.9711	Checkdam
55	Musunuru	16.8591	80.9749	Checkdam
56	Musunuru	16.8584	80.9830	Checkdam
57	Musunuru	16.8504	80.9355	Checkdam
58	Musunuru	16.8667	80.9601	Checkdam
59	Musunuru	16.8656	80.9635	Checkdam
60	Musunuru	16.8556	80.9888	Checkdam
61	Musunuru	16.8518	80.9877	Checkdam
62	Musunuru	16.8592	80.9693	Checkdam
63	Musunuru	16.8529	80.9543	Checkdam
64	Musunuru	16.8590	80.9512	Checkdam
65	Musunuru	16.8616	80.9481	Checkdam
66	Musunuru	16.9247	80.9570	Checkdam
67	Musunuru	16.9251	80.9658	Checkdam
68	Musunuru	16.8930	80.9813	Checkdam
69	Musunuru	16.8769	80.9861	Checkdam
70	Musunuru	16.8856	80.9487	Checkdam
71	Musunuru	16.8989	80.9437	Checkdam

72	Musunuru	16.9001	80.9360	Checkdam
73	Musunuru	16.9041	80.9378	Checkdam
74	Musunuru	16.8613	80.9460	Checkdam
75	Musunuru	16.8582	80.9462	Checkdam
76	Musunuru	16.8544	80.9360	Checkdam
77	Musunuru	16.9096	80.9690	Checkdam
78	Musunuru	16.9096	80.9755	Checkdam
79	Musunuru	16.9129	80.9589	Checkdam
80	Musunuru	16.9049	80.9584	Checkdam
81	Musunuru	16.9037	80.9488	Checkdam
82	Musunuru	16.8934	80.9554	Checkdam
83	Musunuru	16.7977	80.9341	Checkdam
84	Musunuru	16.8432	80.9622	Checkdam
85	Musunuru	16.8444	80.9524	Checkdam
86	Musunuru	16.8448	80.9481	Checkdam
87	Musunuru	16.8333	80.9578	Checkdam
88	Musunuru	16.8309	80.9531	Checkdam
89	Musunuru	16.8156	80.9403	Checkdam
90	Musunuru	16.8204	80.9641	Checkdam
91	Musunuru	16.8035	80.9641	Checkdam
92	Musunuru	16.8011	80.9565	Checkdam
93	Musunuru	16.7996	80.9496	Checkdam
94	Musunuru	16.8031	80.9366	Checkdam
95	Musunuru	16.8024	80.9296	Checkdam
96	Musunuru	16.8076	80.9195	Checkdam
97	Musunuru	16.8260	80.9277	Checkdam
98	Musunuru	16.8287	80.9136	Checkdam
99	Musunuru	16.8066	80.9168	Checkdam
100	Musunuru	16.7998	80.9191	Checkdam
101	Musunuru	16.7928	80.9435	Checkdam
102	Musunuru	16.7910	80.9474	Checkdam
103	Musunuru	16.7916	80.9550	Checkdam
104	Musunuru	16.7978	80.9577	Checkdam
105	Musunuru	16.8347	80.9546	Checkdam
106	Musunuru	16.7827	80.9435	Checkdam
107	Musunuru	16.7879	80.9343	Checkdam
108	Musunuru	16.7856	80.9593	Checkdam

109	Musunuru	16.7863	80.9574	Checkdam
110	Musunuru	16.7869	80.9541	Checkdam
111	Musunuru	16.8432	80.9676	Checkdam
112	Musunuru	16.8423	80.9712	Checkdam
113	Musunuru	16.7799	80.9584	Checkdam
114	Musunuru	16.7818	80.9622	Checkdam
115	Musunuru	16.7829	80.9463	Checkdam
116	Musunuru	16.8248	80.9484	Checkdam
117	Musunuru	16.8951	80.9155	Checkdam
118	Musunuru	16.8963	80.8984	Checkdam
119	Musunuru	16.8817	80.9155	Checkdam
120	Musunuru	16.8549	80.9145	Checkdam
121	Musunuru	16.8584	80.9131	Checkdam
122	Musunuru	16.8881	80.9204	Checkdam
123	Musunuru	16.8825	80.9262	Checkdam
124	Musunuru	16.8980	80.9195	Checkdam
125	Musunuru	16.9062	80.9053	Checkdam
126	Musunuru	16.9136	80.8975	Checkdam
127	Musunuru	16.9205	80.8963	Checkdam
128	Musunuru	16.9108	80.8829	Checkdam
129	Musunuru	16.9103	80.8747	Checkdam
130	Musunuru	16.8777	80.9276	Checkdam
131	Musunuru	16.8949	80.9094	Checkdam
132	Musunuru	16.9016	80.8988	Checkdam
133	Musunuru	16.9038	80.8883	Checkdam
134	Musunuru	16.8971	80.8745	Checkdam
135	Musunuru	16.9207	80.8780	Checkdam
136	Musunuru	16.9188	80.8854	Checkdam
137	Musunuru	16.9210	80.9113	Checkdam
138	Musunuru	16.9164	80.8872	Checkdam
139	Musunuru	16.8918	80.8834	Checkdam
140	Musunuru	16.8885	80.8807	Checkdam
141	Musunuru	16.9036	80.9105	Checkdam
142	Musunuru	16.8601	80.9312	Checkdam
143	Musunuru	16.8556	80.9297	Checkdam
144	Musunuru	16.8866	80.9020	Checkdam
145	Musunuru	16.9048	80.9262	Checkdam

Fig.1

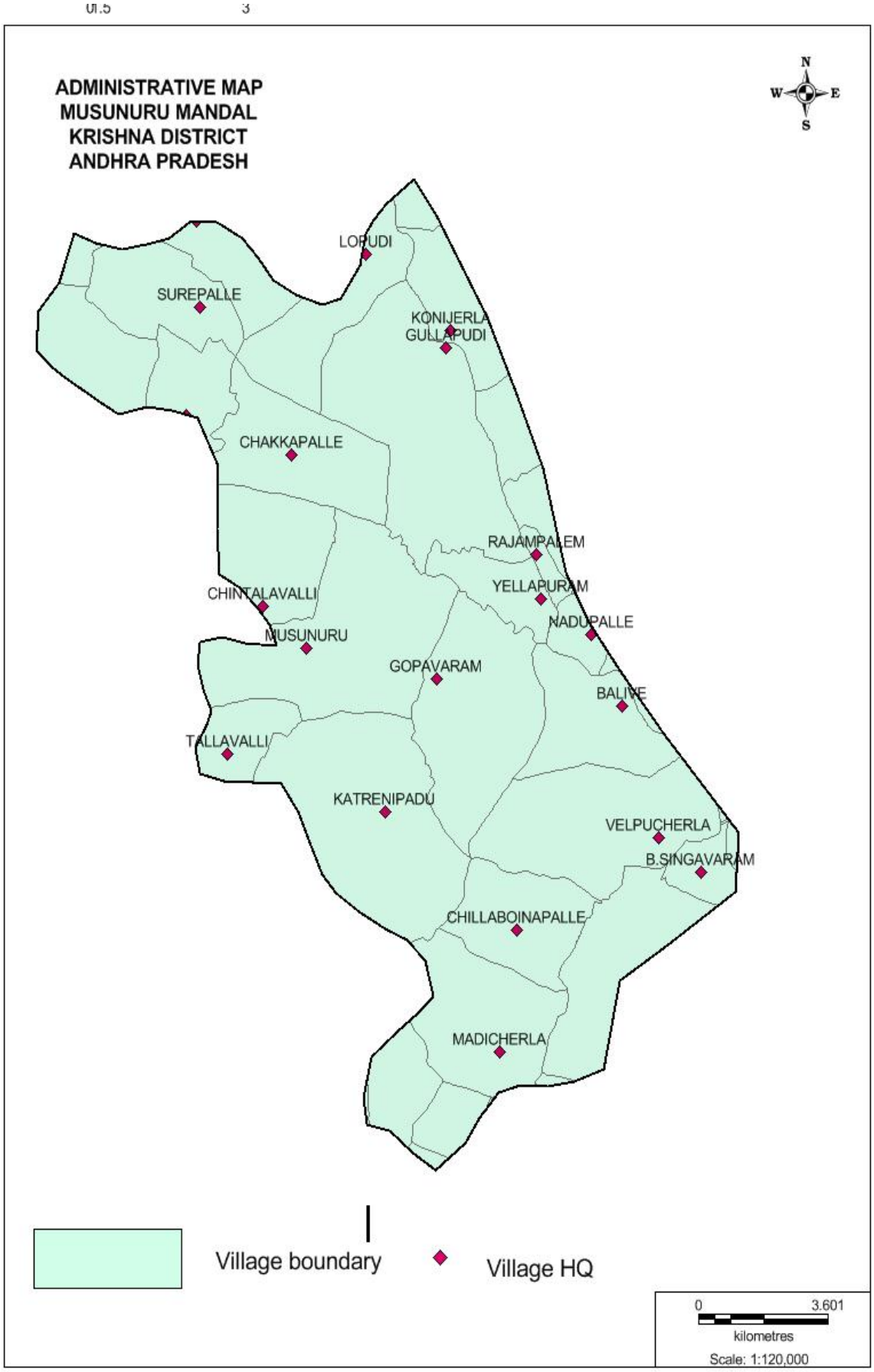

ADMINISTRATIVE MAP
MUSUNURU MANDAL
KRISHNA DISTRICT
ANDHRA PRADESH
N
W
E
S
LOPUDI
SUREPALLE
KONIJERLA
GULLAPUDI
CHAKKAPALLE
RAJAMPALEM
YELLAPURAM
CHINTALAVALLI
NADUPALLE
MUSUNURU
GOPAVARAM
BALIVE
TALLAVALLI
KATRENIPADU
VELPUCHERLA
B.SINGAVARAM
CHILLABOINAPALLE
MADICHERLA
Village boundary
Village HQ
0
3.601
kilometres
Scale: 1:120,000

Fig.2

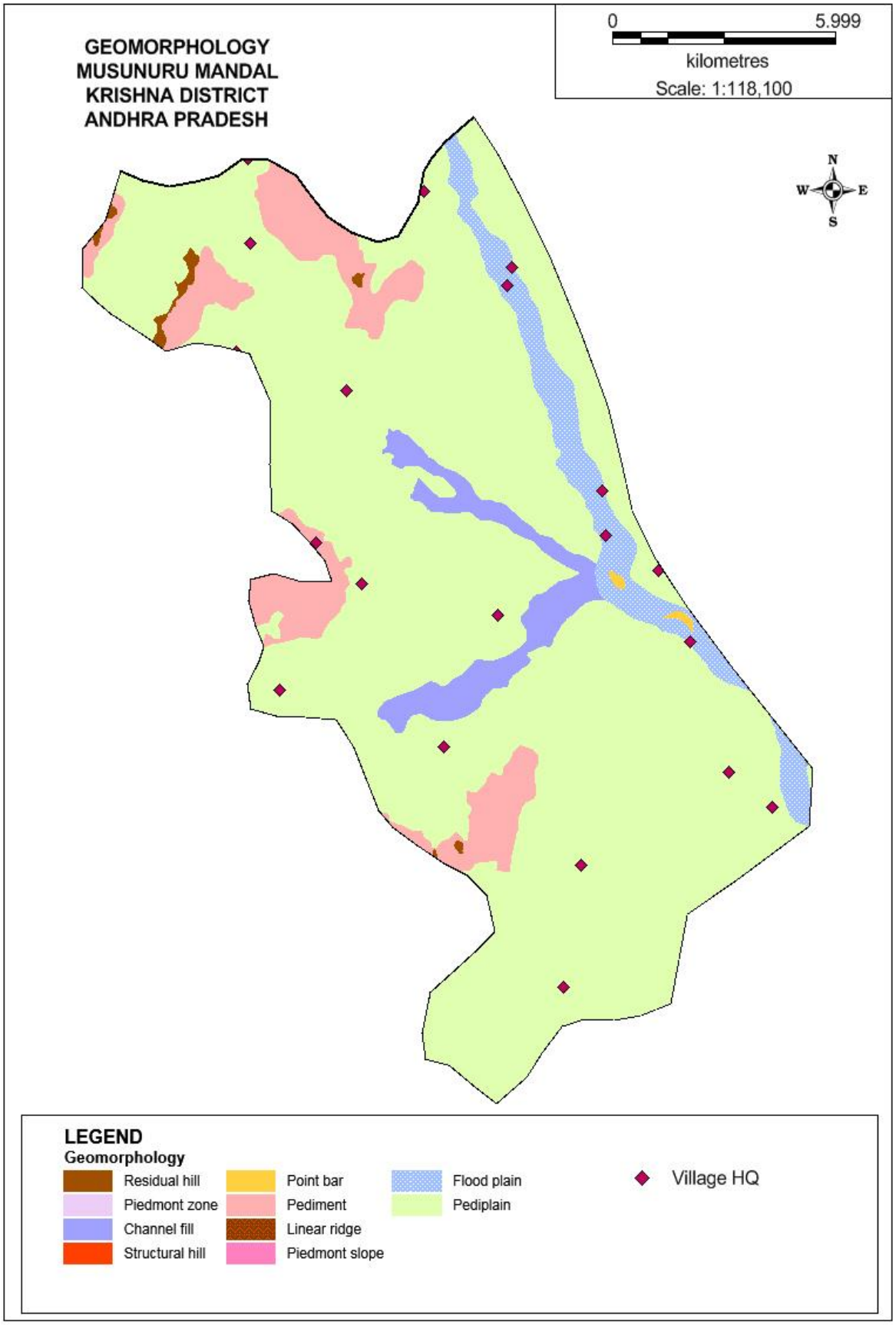

GEOMORPHOLOGY
MUSUNURU MANDAL
KRISHNA DISTRICT
ANDHRA PRADESH
0
5.999
kilometres
Scale: 1:118,100
N
W
E
S
LEGEND
Geomorphology
Residual hill
Piedmont zone
Channel fill
Structural hill
Point bar
Pediment
Linear ridge
Piedmont slope
Flood plain
Pediplain
Village HQ

Fig.3

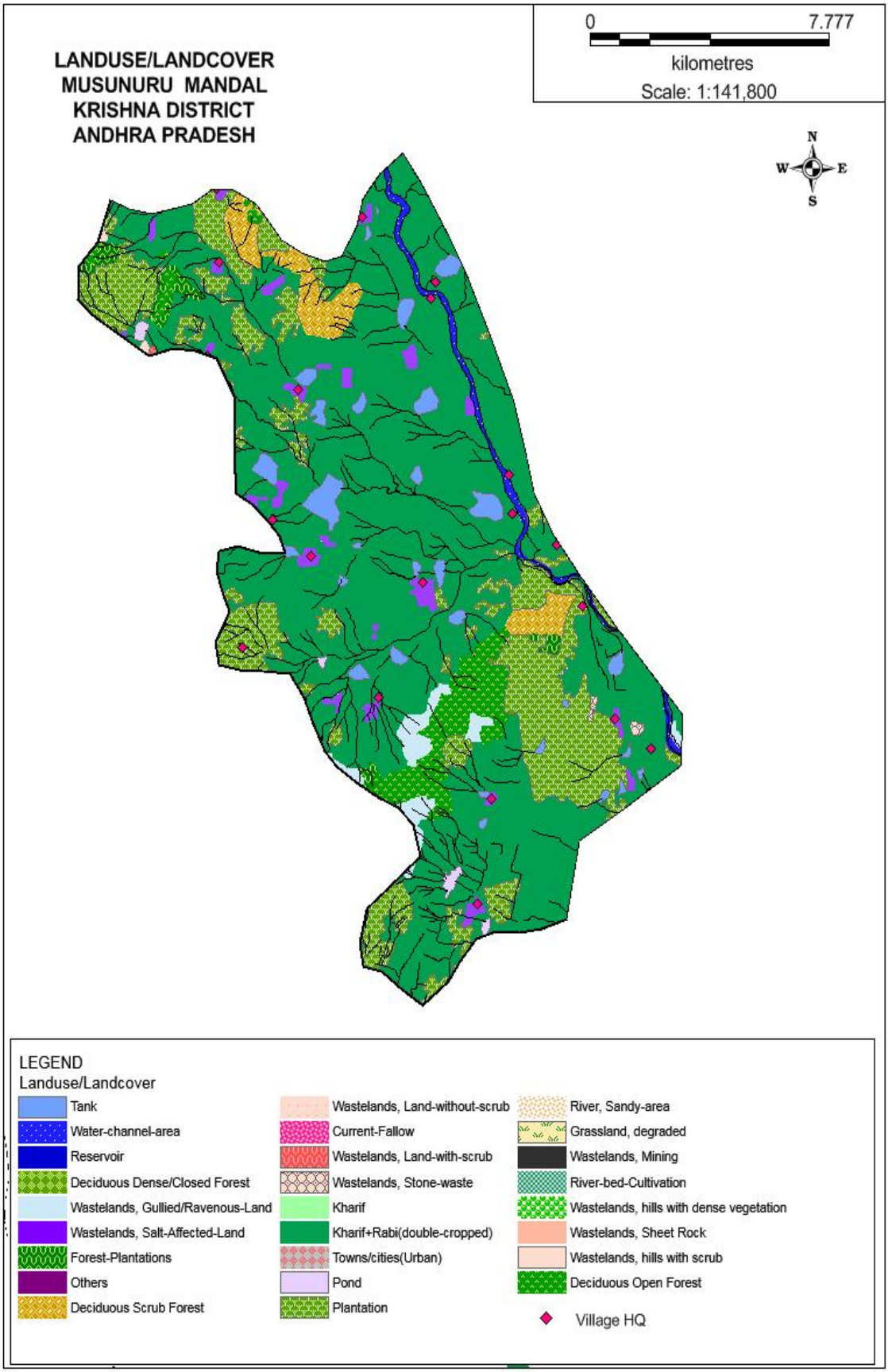

LANDUSE/LANDCOVER
MUSUNURU MANDAL
KRISHNA DISTRICT
ANDHRA PRADESH
0
7.777
kilometres
Scale: 1:141,800
N
W
E
S
LEGEND
Landuse/Landcover
Tank
Water-channel-area
Reservoir
Deciduous Dense/Closed Forest
Wastelands, Gullied/Ravenous-Land
Wastelands, Salt-Affected-Land
Forest-Plantations
Others
Deciduous Scrub Forest
Wastelands, Land-without-scrub
Current-Fallow
Wastelands, Land-with-scrub
Wastelands, Stone-waste
Kharif
Kharif+Rabi(double-cropped)
Towns/cities(Urban)
Pond
Plantation
River, Sandy-area
Grassland, degraded
Wastelands, Mining
River-bed-Cultivation
Wastelands, hills with dense vegetation
Wastelands, Sheet Rock
Wastelands, hills with scrub
Deciduous Open Forest
Village HQ

Fig.4

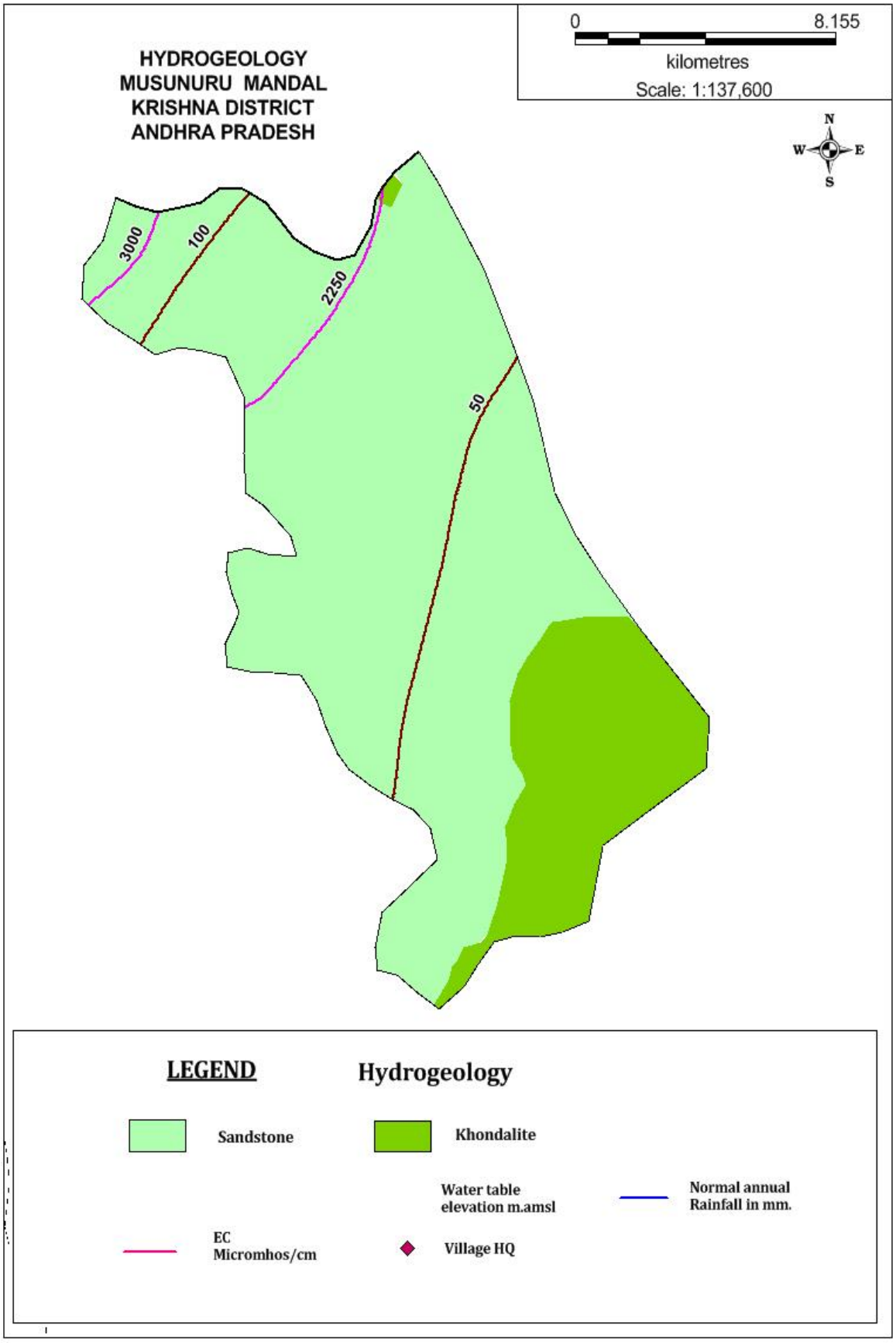
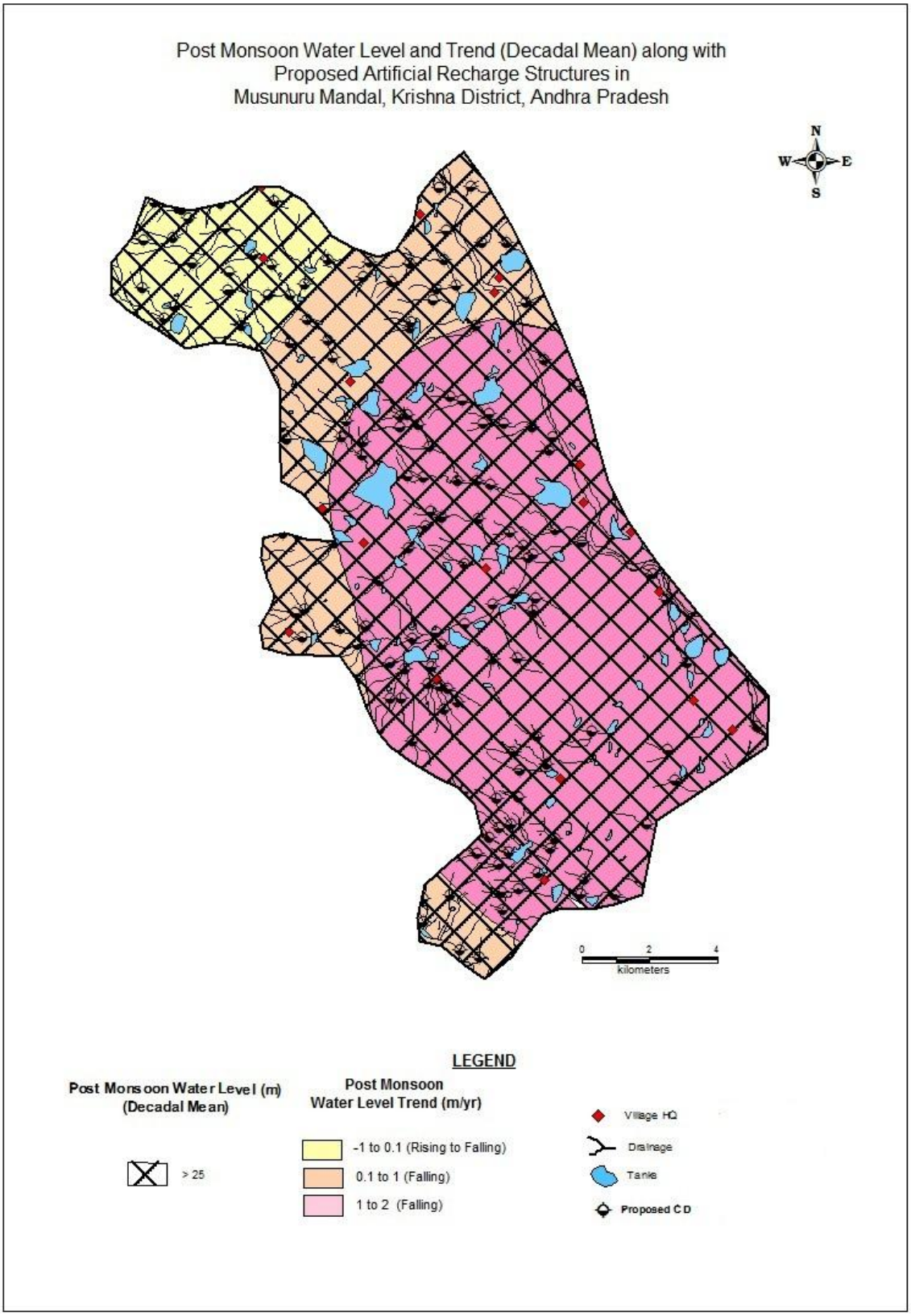

HYDROGEOLOGY
MUSUNURU MANDAL
KRISHNA DISTRICT
ANDHRA PRADESH
0
8.155
kilometres
Scale: 1:137,600
N
W
E
S
3000
100
2250
50
LEGEND
Hydrogeology
Sandstone
Khondalite
Water table elevation m.amsl
Normal annual Rainfall in mm.
EC Micromhos/cm
Village HQ

Fig.5


Post Monsoon Water Level and Trend (Decadal Mean) along with
Proposed Artificial Recharge Structures in
Musunuru Mandal, Krishna District, Andhra Pradesh
N
W
E
S
0
2
4
kilometers
LEGEND
Post Monsoon Water Level (m)
(Decadal Mean)
> 25
Post Monsoon
Water Level Trend (m/yr)
-1 to 0.1 (Rising to Falling)
0.1 to 1 (Falling)
1 to 2 (Falling)
Village HQ
Drainage
Tanks
Proposed C D