13.3 Developing Database and GIS (First Phase)

13.3.1 Unifying GIS Coordinate System

There are several data sources which have X, Y coordinate. In one study, UTM is used, in the other study, geographic latitude and longitude is used. But in most of the studies, datum (in UTM case, zone No as well) is not specified on the report. It causes the problems on plotting point on the map. Because for example, the X, Y on Arc 1960 datum is about 250 m away from the X,Y on WGS1984 datum.

When we use those existing X, Y coordinate, we assume the datum by following rule.

- The number assumed from GPS: WGS1984
- The number assumed from the map: Arc1960

Internal Drainage Basin across UTM zone 36 and 37. Because each zone uses different origin of X, Y, it may causes confusion of user who is not familiar with mapping system. So in this study, we use geographic latitude and longitude as grid on the datum Arc 1960, which is standard of Tanzania. All the sources including images will be geo-referenced as geographic lat/lon, Arc1960. GPS is also set for geographic lat/lon, Arc1960 for user not to be confused when using with maps.

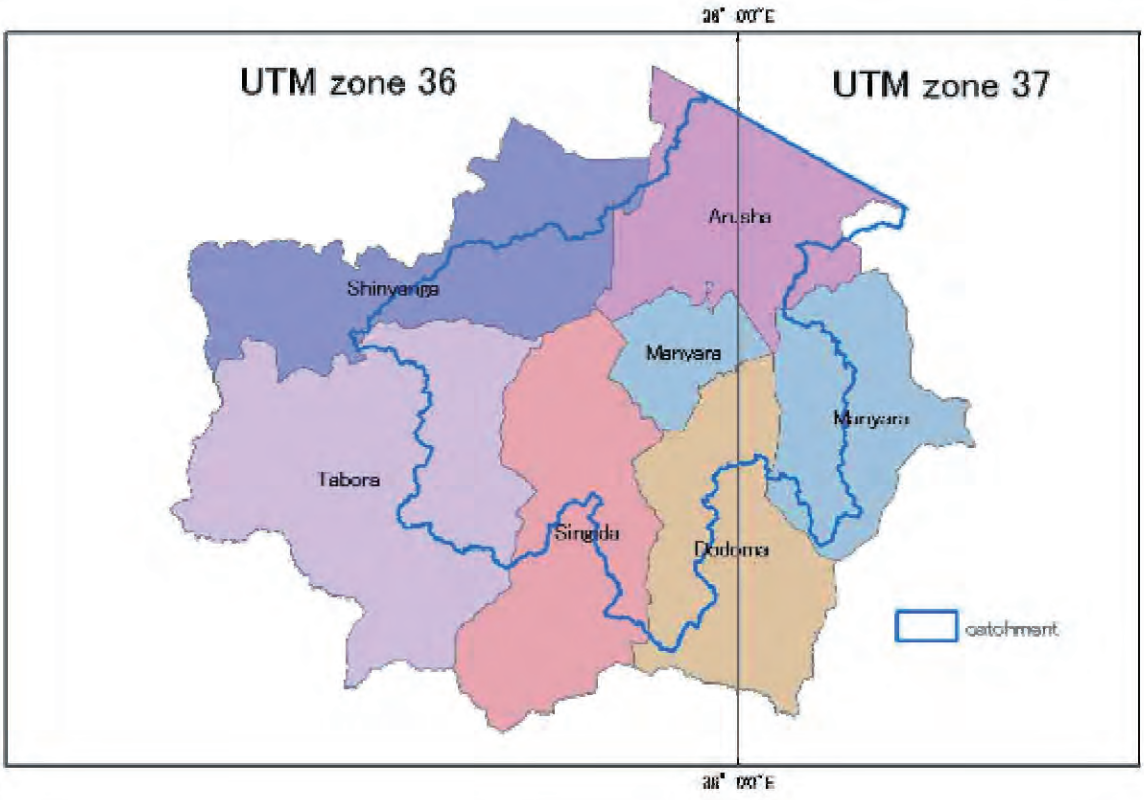

Figure 13-7 UTM zone in Internal Drainage Basin

13.3.2 GIS Components Development

(1) Administrative Boundary

Administrative Boundary has been developed from 1/50,000 topographic maps and EA (Enumeration Area) population research sheets from Census as shown in Figure 13-8.

There are some parts which ward polygons from Census don't much with EA boundaries. In that case, ward polygon is regarded as correct basically because ward polygon is authorized and standardized in Tanzania. But if it makes inconsistency too much in some part, modification of ward polygon is considered. Topographic feature is not considered when digitized.

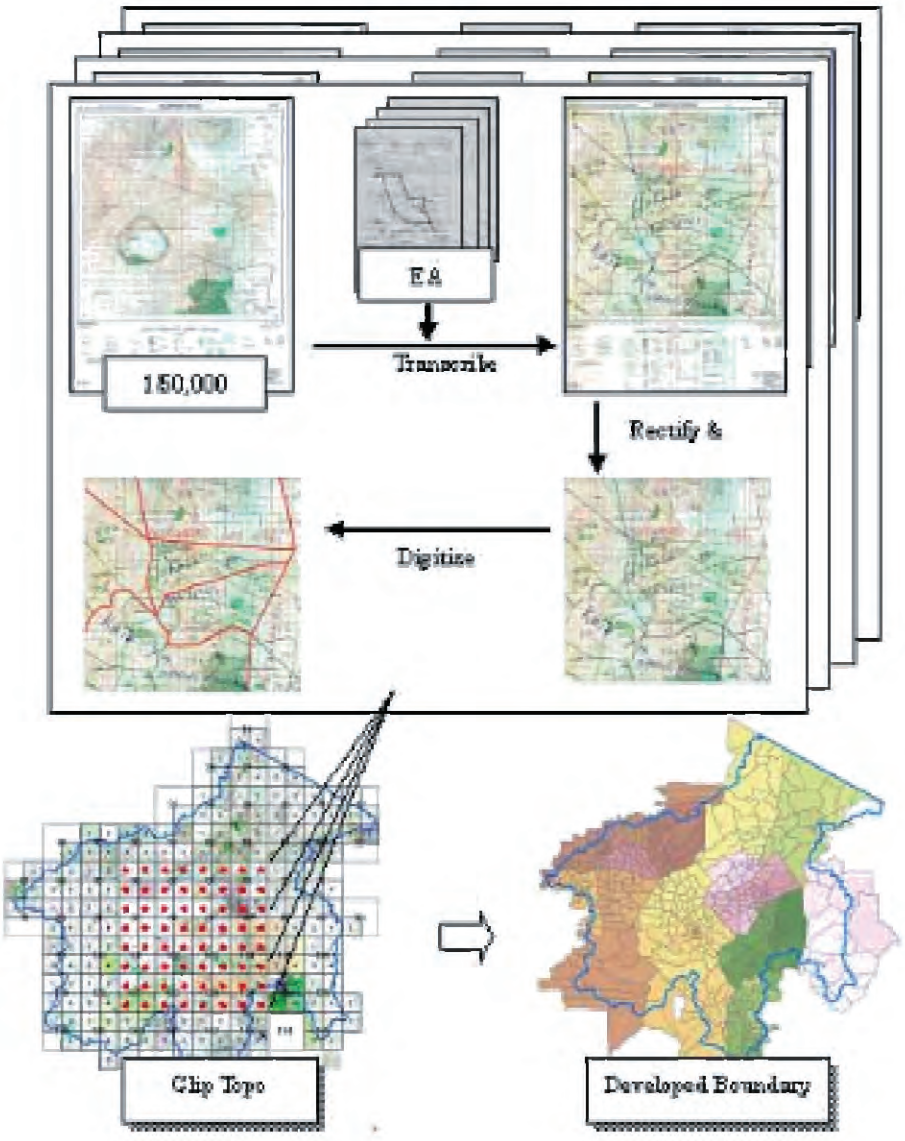

Figure 13-8 Developing Administrative Boundary

(2) Geological Feature

Geological feature GIS data has been developed from geological maps. Geological maps have been rectified with geographic lat/lon coordinate on Arc1960 datum and then clipped.

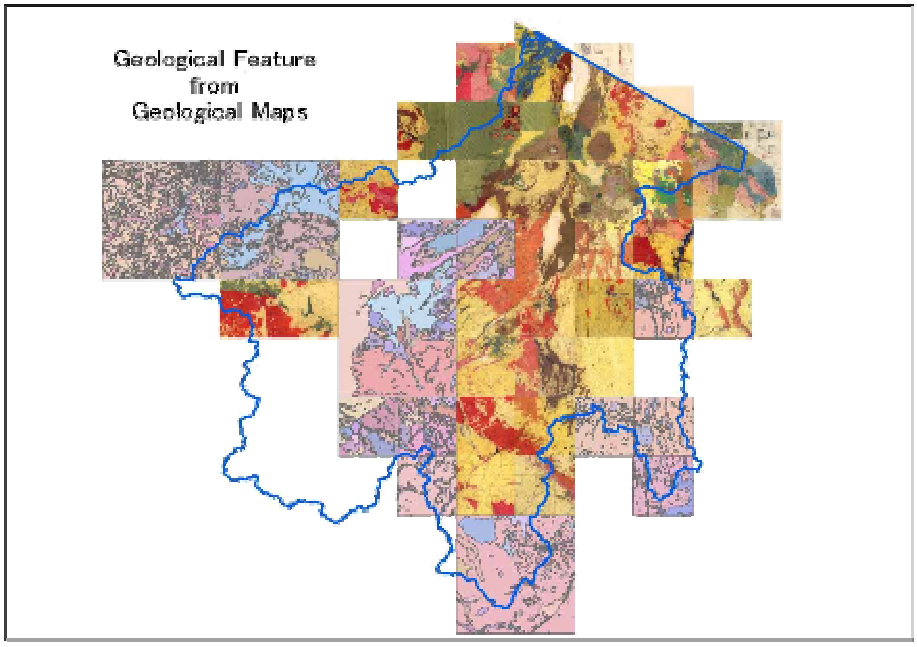

Figure 13-9 Developed Geological Feature from Geological Maps

Because each geological map had been developed by different people and organization on different period, the classification and legend of them are different from each other. So the simplified and unified legend has been developed by analyzing all the maps (Table 13-12).

The joint parts between some maps don't match each other as well. But the purpose of this study is developing hydro-geological map, not geological map itself, digitalized feature has been developed on each sheet individually without joining them between maps.

Table 13-12 Geological Feature Legend

Type	Geological Name	Period	
1	Recent and Pleistocene; sand, gravel, soil, limestone, tuff		
2	Scoria		
3	Volcanics; basalt, andesite, trachyte, tuff		
4	Younger Extrusives; basalt, nephelinite, phonolite, trachyte	-Pleistocene	
5	Oldonyo Sambu: olivine basalt, lava, tuff, agglomerate	Pliocene - Lower Pleistocene	0.3 Ma
6	Oldoinyo Lengai; nephelinite, phonolite, tuff		
7	Older Extrusives; basalt, andesite, tuffs	Pliocene	
8	Oldoinyo Dili; Trachytic tuff, carbonatite, fenite	Pre-Neogene	
9	Bukoban; mudstone, sandstone, quartzite, shale	Proterozoic	Pre-Cambrian
10	Bubu Cataclastites; Mylonite, milonitic schist, gneiss	Archean	Pre-Cambrian
11	Usagaran; quartzite, gneiss, amphibolite, marble	Archean	Pre-Cambrian
12	Kavirondian; quatzite, phillite	Archean	Pre-Cambrian
13	Nyanzian; banded limestone, meta-volcanics, chlorite schist, pseudo-porphyry	Archean	Pre-Cambrian
14	Dodoman; schist, gneiss, quartzite,amphibolite, hornblende gneiss, acid gneiss, migmatite	Archean	Pre-Cambrian
15	Intrusive rocks; Granite	Archean	Pre-Cambrian
16	Post orogenic granitic rocks	Archean	Pre-Cambrian
17	Late orogenic granitic rocks	Archean	Pre-Cambrian
18	Synorogenic granitic rosks	Archean	Pre-Cambrian
19	Gabbro		

(3) Main Road and Railway

Main road and railway GIS data has been developed from 1/250,000 topographic maps. 1/250,000 topographic maps have been rectified with UTM coordinate on Arc1960 (some of them are Arc1950) datum first, and then converted to geographic lat/lon on Arc1960.

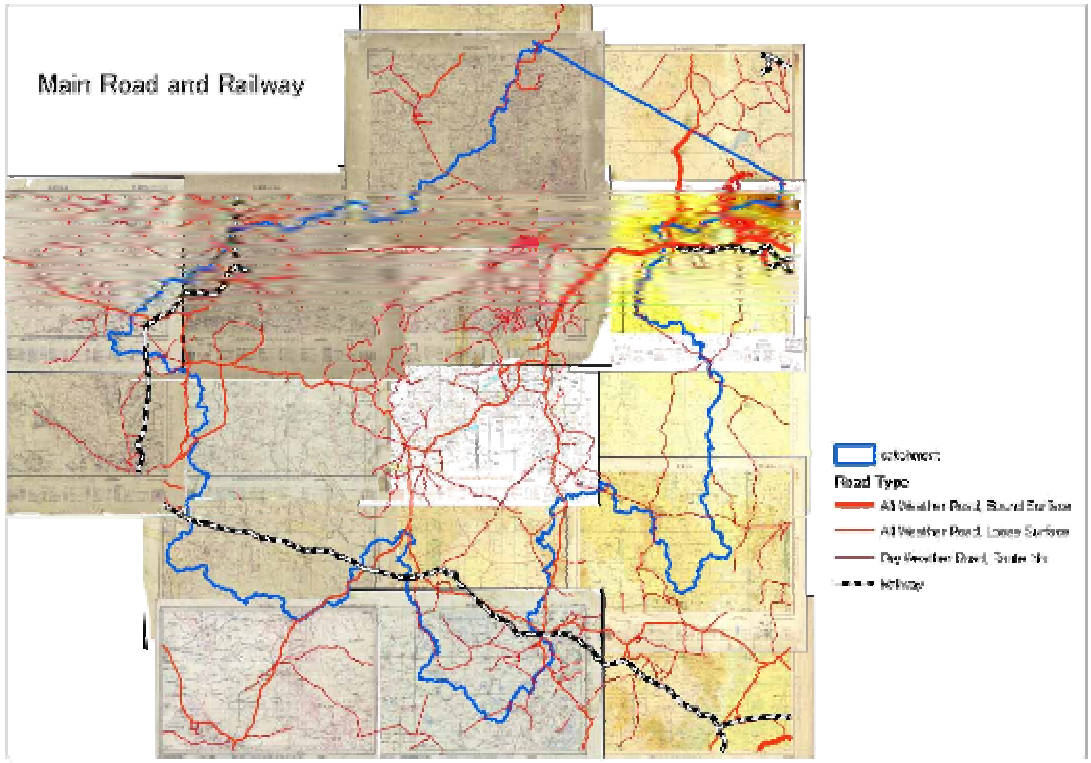

Figure 13-10 Developed Main Road and Railway GIS Data from 1/250,000 Topographic Maps

There are mainly two types of legend for 17 maps. Three kinds of road have been developed after analyzing legends of maps (Table 13-13).

Table 13-13 Categorized Road Type

Code	Type1	Type2
1	All Weather Road	Bound Surface
2	All Weather Road	Loose Surface
3	Dry Weather Road	Route No

There are some parts in which the road cannot be joined between maps. There are also isolated main road (main road is not supposed to be isolated). This is assumed due to the different period which the maps had been developed. If the gaps are small, they have been modified. But it is difficult to judge which is correct in some part. In that case, 1/50,000 topographic maps are used as reference.

(4) Law Regulated Area (Forest Reserve)

Law regulated area (forest reserve) GIS data has been developed from administrative maps. Administrative maps have been rectified with UTM coordinate on Arc1960 datum first, and then converted to geographic lat/lon on Arc1960 datum except Dodoma administrative map. Dodoma administrative map has been rectified with geographic lat/lon on Arc1960 datum

Numerical value of grid on Shinyanga administrative map seems to be wrong and not consistency with other maps. It was not simple shift error or difference of false easting, northing. So LANDSAT ETM+ panchromatic ortho-image had been used to rectify this map.

Boundary of those administrative maps and Ward polygon from Census don't match each other. Ward polygon from Census originated from 1/50,000 topographic map and seem to be more reliable compared to 1/500,000 administrative maps, forest reserve boundary have been developed to match with the boundary of Ward polygon.

Forest reserve area couldn't be divided into more detail parts. So the only one code has been set for each polygon currently.

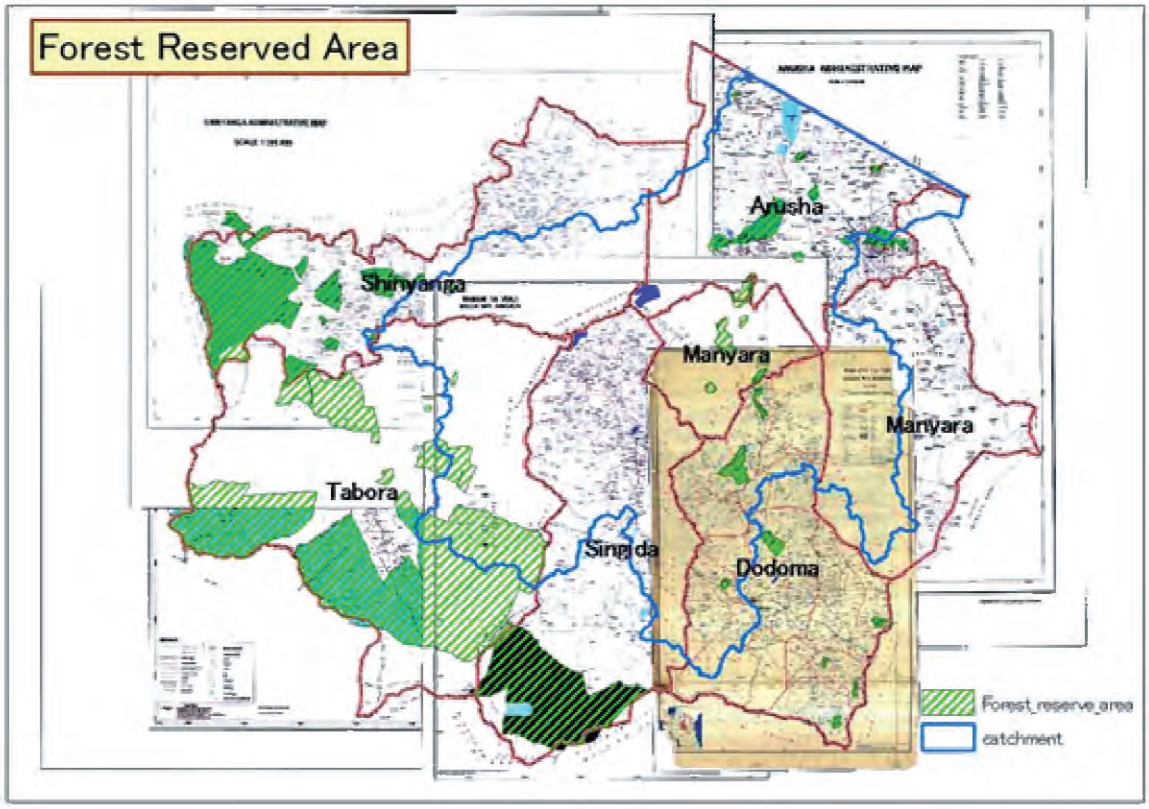

Figure 13-11 Developed Forest Reserved Area from Administrative Maps

13.3.3 Database Components Development

(1) Village List & Enumeration Area List

Village List has been developed from 2002 Population and Housing Census for Database/GIS. Enumeration Area List has been developed from 2002 Population and Housing Census as well.

Table 13-14 2002 Population and Housing Census (Population by Village)

Population by Village, 5 Year Age Group and Sex: Tanzania, 2002

Region: 1 Dodoma

District: 1 Kondoa

Village / Strret Pop. Category	Code	Sex	Total	0-4	5 - 9	10 - 14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+	Median
Dodoma Region	1	Total	1,692,025	278,158	255,413	217,055	174,116	146,062	125,510	108,328	80,943	68,344	50,281	44,032	32,573	33,542	77,668	17.7
		Male	818,782	138,493	128,494	110,397	87,499	64,058	56,526	50,386	38,717	32,963	23,838	20,456	15,254	15,131	36,570	16.8
		Female	873,243	139,665	126,919	106,658	86,617	82,004	68,984	57,942	42,226	35,381	26,443	23,576	17,319	18,411	41,098	18.7
Kondoa District	1	Total	428,090	72,584	69,376	60,989	42,756	30,990	27,860	24,213	19,596	16,298	12,758	11,119	8,344	9,727	21,480	16.3
		Male	212,497	36,712	35,698	31,778	23,364	13,483	12,190	11,381	9,396	7,938	5,948	5,127	3,981	4,569	10,932	15.4
		Female	215,593	35,872	33,678	29,211	19,392	17,507	15,670	12,832	10,200	8,360	6,810	5,992	4,363	5,158	10,548	17.3
	11	Bumbuta - Rural Ward																
Total Ward		Total	14,056	2,478	2,214	2,024	1,418	1,169	974	782	625	522	371	321	277	327	554	16.1
		Male	7,240	1,239	1,158	1,075	867	485	480	407	324	246	159	140	142	183	335	15.9
		Female	6,816	1,239	1,056	949	551	684	494	375	301	276	212	181	135	144	219	16.5
Total, Rural Area		Total	14,056	2,478	2,214	2,024	1,418	1,169	974	782	625	522	371	321	277	327	554	16.1
		Male	7,240	1,239	1,158	1,075	867	485	480	407	324	246	159	140	142	183	335	15.9
		Female	6,816	1,239	1,056	949	551	684	494	375	301	276	212	181	135	144	219	16.5
Bumbuta	1	Total	2,893	499	473	464	304	226	169	143	106	104	77	66	53	85	124	15.2
		Male	1,440	261	240	235	184	85	74	69	55	40	34	26	23	47	67	14.7
		Female	1,453	238	233	229	120	141	95	74	51	64	43	40	30	38	57	16.1
Mahongo	2	Total	1,130	204	200	176	108	70	77	66	44	41	34	28	15	23	44	14.6
		Male	562	94	104	98	70	29	30	30	25	19	13	11	6	9	24	14.2
		Female	568	110	96	78	38	41	47	36	19	22	21	17	9	14	20	15
Kisaka	3	Total	1,137	170	171	190	127	90	66	65	58	46	41	22	15	31	45	16.5
		Male	562	81	81	99	74	38	29	30	33	23	13	10	11	14	26	16.4
		Female	575	89	90	91	53	52	37	35	25	23	28	12	4	17	19	16.7
Chubi	4	Total	1,054	176	168	150	93	88	83	59	41	37	30	42	32	26	29	16.8
		Male	539	82	88	77	56	39	40	24	23	15	18	21	19	16	21	17
		Female	515	94	80	73	37	49	43	35	18	22	12	21	13	10	8	16.4
Itaswi	5	Total	4,156	780	638	525	385	400	315	235	217	142	110	78	90	76	165	16.8
		Male	2,183	394	334	286	230	166	165	137	110	79	56	34	46	47	99	16.7
		Female	1,973	386	304	239	155	234	150	98	107	63	54	44	44	29	66	16.9
Mauno	6	Total	3,686	649	564	519	401	295	264	214	159	152	79	85	72	86	147	16.4
		Male	1,954	327	311	280	253	128	142	117	78	70	25	38	37	50	98	16.2
		Female	1,732	322	253	239	148	167	122	97	81	82	54	47	35	36	49	16.8

Table 13-15 Developed Village List from 2002 Population and Housing Census

pV_Code	R_Code	Region	D_Code	District	W_Code	Ward	W_Type	V_Code	Village	Pop	0_4	5_9	10_14	15_19	20_24	25_29	30_34	35_39	40_44	45_49	50_54	55_59	60_64	65	MeadAge
010101101	01	Dodoma	01	Kondoa	011	Bumbuta	Rural	01	Bumbuta	2893	499	473	464	304	226	169	143	106	104	77	66	53	85	124	15.20
010101102	01	Dodoma	01	Kondoa	011	Bumbuta	Rural	02	Mahongo	1130	204	200	176	108	70	77	66	44	41	34	28	15	23	44	14.60
010101103	01	Dodoma	01	Kondoa	011	Bumbuta	Rural	03	Kisaka	1137	170	171	190	127	90	66	65	58	46	41	22	15	31	45	16.50
010101104	01	Dodoma	01	Kondoa	011	Bumbuta	Rural	04	Chubi	1054	176	168	150	93	88	83	59	41	37	30	42	32	26	29	16.80
010101105	01	Dodoma	01	Kondoa	011	Bumbuta	Rural	05	Itaswi	4156	780	638	525	385	400	315	235	217	142	110	78	90	76	165	16.80
010101106	01	Dodoma	01	Kondoa	011	Bumbuta	Rural	06	Mauno	3686	649	564	519	401	295	264	214	159	152	79	85	72	86	147	16.40
010102101	01	Dodoma	01	Kondoa	021	Pahi	Rural	01	Pahi	5874	917	978	905	775	368	318	274	240	222	156	157	104	139	321	15.90
010102102	01	Dodoma	01	Kondoa	021	Pahi	Rural	02	Potea	2151	423	373	336	207	127	129	130	91	58	34	59	42	50	92	14.20
010102103	01	Dodoma	01	Kondoa	021	Pahi	Rural	03	Salare	1475	261	224	221	144	100	94	77	72	46	46	33	25	41	91	16.10
010102104	01	Dodoma	01	Kondoa	021	Pahi	Rural	04	Kiteo	3038	582	458	462	254	218	172	174	132	106	82	74	56	65	203	15.30
010102105	01	Dodoma	01	Kondoa	021	Pahi	Rural	05	Kinyasi – Majengo	1932	310	337	286	192	130	122	82	79	71	62	42	43	45	131	15.90
010102106	01	Dodoma	01	Kondoa	021	Pahi	Rural	06	Kinyasi Kati	3641	625	634	581	351	231	194	196	159	150	104	98	74	81	163	14.80
010102107	01	Dodoma	01	Kondoa	021	Pahi	Rural	07	Ikengwa	1980	383	357	284	204	125	129	122	91	58	60	49	29	35	54	14.40
010103101	01	Dodoma	01	Kondoa	031	Busi	Rural	01	Busi	4712	892	790	644	422	339	355	265	221	207	121	122	62	109	163	15.40
010103102	01	Dodoma	01	Kondoa	031	Busi	Rural	02	Sambwa	3036	543	535	453	282	198	185	163	141	98	99	76	57	69	137	14.90
010103103	01	Dodoma	01	Kondoa	031	Busi	Rural	03	Keikei	3438	681	598	472	269	290	271	191	148	117	99	80	46	57	119	14.70
010103104	01	Dodoma	01	Kondoa	031	Busi	Rural	04	Idindiri	2531	497	404	394	212	195	162	148	121	100	69	42	35	43	109	14.60
010103105	01	Dodoma	01	Kondoa	031	Busi	Rural	05	Ihari	2037	426	333	270	185	149	147	107	90	81	64	33	27	50	75	14.80
010104101	01	Dodoma	01	Kondoa	041	Haubi	Rural	01	Haubi	8756	1490	1467	1375	949	549	438	408	387	331	245	209	169	227	512	15.20
010104102	01	Dodoma	01	Kondoa	041	Haubi	Rural	02	Mafai	2366	457	471	372	247	135	140	139	99	87	44	50	23	34	68	13.40
010104103	01	Dodoma	01	Kondoa	041	Haubi	Rural	03	Ntomoko	1739	367	344	262	157	90	101	87	61	61	44	40	24	28	73	13.00
010105101	01	Dodoma	01	Kondoa	051	Kalamba	Rural	01	Baura	1483	226	283	236	142	63	52	74	53	48	35	48	35	43	145	14.90
010105102	01	Dodoma	01	Kondoa	051	Kalamba	Rural	02	Kalamba	5356	909	1012	920	585	251	246	258	193	217	164	140	88	121	252	14.10
010105103	01	Dodoma	01	Kondoa	051	Kalamba	Rural	03	Hebi	2866	541	543	438	275	221	180	123	111	99	77	60	38	59	101	14.00
010105104	01	Dodoma	01	Kondoa	051	Kalamba	Rural	04	Loo	3022	477	498	477	299	167	173	130	128	106	117	91	73	89	197	16.00
010106101	01	Dodoma	01	Kondoa	061	Kwadelo	Rural	01	Kwadelo	4037	803	700	624	406	260	253	223	161	143	111	73	62	88	130	14.10
010106102	01	Dodoma	01	Kondoa	061	Kwadelo	Rural	02	Kirere Chang'ombe	858	155	138	115	103	69	51	40	37	30	19	23	18	11	49	16.00
010106103	01	Dodoma	01	Kondoa	061	Kwadelo	Rural	03	Makirinya	3958	789	704	581	383	277	255	205	174	120	85	88	72	68	157	14.20
010107101	01	Dodoma	01	Kondoa	071	Mondo	Rural	01	Mondo	5544	778	858	755	725	372	339	277	255	193	161	176	105	177	373	17.60
010107102	01	Dodoma	01	Kondoa	071	Mondo	Rural	02	Pongai	1449	231	218	180	156	108	109	78	73	57	44	40	28	37	90	18.10
010107103	01	Dodoma	01	Kondoa	071	Mondo	Rural	03	Waida	2424	369	391	380	264	152	144	135	92	94	84	64	39	65	151	16.40
010108101	01	Dodoma	01	Kondoa	081	Dalai	Rural	01	Dalai	2501	428	393	363	239	182	136	154	96	95	71	62	53	68	161	16.40
010108102	01	Dodoma	01	Kondoa	081	Dalai	Rural	02	Tandala	4853	889	813	716	480	308	295	270	217	210	129	117	71	107	231	15.10
010108103	01	Dodoma	01	Kondoa	081	Dalai	Rural	03	Mtakuja	2370	451	405	330	224	190	153	122	93	87	58	57	47	54	99	15.00
010108104	01	Dodoma	01	Kondoa	081	Dalai	Rural	04	Piho	568	96	105	69	55	39	27	29	32	21	18	16	6	16	39	16.30
010108105	01	Dodoma	01	Kondoa	081	Dalai	Rural	05	Kelema Maziwani	2796	401	431	417	308	226	187	137	123	106	83	74	70	84	149	17.40
010109101	01	Dodoma	01	Kondoa	091	Jangalo	Rural	01	Mlongia	3401	594	588	451	346	269	227	196	138	127	96	98	67	58	146	16.00
010109102	01	Dodoma	01	Kondoa	091	Jangalo	Rural	02	Itolwa	6994	1367	1212	891	617	580	510	443	291	289	165	185	102	136	206	16.60
010109103	01	Dodoma	01	Kondoa	091	Jangalo	Rural	03	Jangalo	3249	629	575	473	297	231	204	151	128	126	74	83	62	81	135	14.40
010109104	01	Dodoma	01	Kondoa	091	Jangalo	Rural	04	Jinjo	1705	276	283	269	169	111	113	100	55	58	60	48	26	34	103	15.70
010109105	01	Dodoma	01	Kondoa	091	Jangalo	Rural	05	Churuku	3321	617	550	551	336	218	188	142	134	135	112	84	54	59	141	14.50
010109106	01	Dodoma	01	Kondoa	091	Jangalo	Rural	06	Kinkima	2722	500	451	413	256	216	169	137	92	101	76	75	52	66	118	15.00
010110101	01	Dodoma	01	Kondoa	101	Mrijo	Rural	01	Nkulari	1306	252	229	174	142	81	96	77	38	51	34	43	9	40	40	14.90
010110102	01	Dodoma	01	Kondoa	101	Mrijo	Rural	02	Mrijo Chini	3256	544	465	413	326	289	248	224	156	128	102	88	52	65	156	18.20
010110103	01	Dodoma	01	Kondoa	101	Mrijo	Rural	03	Mrijo Juu	2252	398	362	316	255	162	150	114	97	83	65	49	42	46	113	16.00
010110104	01	Dodoma	01	Kondoa	101	Mrijo	Rural	04	Magasa	1400	264	245	162	115	125	117	88	57	56	39	38	22	17	55	16.30
010110105	01	Dodoma	01	Kondoa	101	Mrijo	Rural	05	Ususumya	1641	313	248	229	167	172	147	98	54	59	30	30	35	27	32	15.90
010110106	01	Dodoma	01	Kondoa	101	Mrijo	Rural	06	Songambele	925	185	127	127	81	77	73	64	45	36	29	18	17	17	29	16.50
010110107	01	Dodoma	01	Kondoa	101	Mrijo	Rural	07	Msaada	2133	416	355	263	201	171	162	141	94	102	59	46	30	39	54	15.80

(2) Coding Rule

Designing table specification is following policies below.

- Each table has primary key (able to specify certain record by unique code)
- Data type for "code" field is Text (more extensible and flexible than Number)
  e.g.) In case Division Code "0101" need to be segmentalized => "0101-1"
- Length for "code" is aligned (easy to distinguish and sort, friendly when programming)
  e.g.) Dodoma Region Code "1" => 01
- Parent table and Child table have 1 : N (many) relationship

Table 13-16 shows administrative code format and example. "V_ Code" represent "Village Code". "pV_ Code" represent "primary Village Code". Other administrative unit codes, such as Region, Ward, Village, and EA represent as described for Village as well.

Developed Village List (Table 13-15) and Enumeration Area List are compliant with these policies and rules. Entity Relationship Diagram (Figure 13-11) is compliant with these policies and rules as well.

Having unique code in each table is also important for GIS. Figure 13-12 shows image for no relationship and attribute table in GIS.

Table 13-16 Administrative Code Format and Example

primary code	Format	code	R_Code	D_Code	W_Code	V_Code*	EA_Code
		e.g.	01	01	011	01	011
pR_Code	[R_Code]		01				
pD_Code	[R_Code] & [D_Code]			0101			
pW_Code	[R_Code] & [D_Code] & [W_Code]				0101011		
pV_Code	[R_Code] & [D_Code] & [W_Code] & [V_Code]					010101101	
pEA_Code	[R_Code] & [D_Code] & [W_Code] & [EA_Code]						0101011011

*[V_Code] = Left([EA_Code],2) except for Urban Area

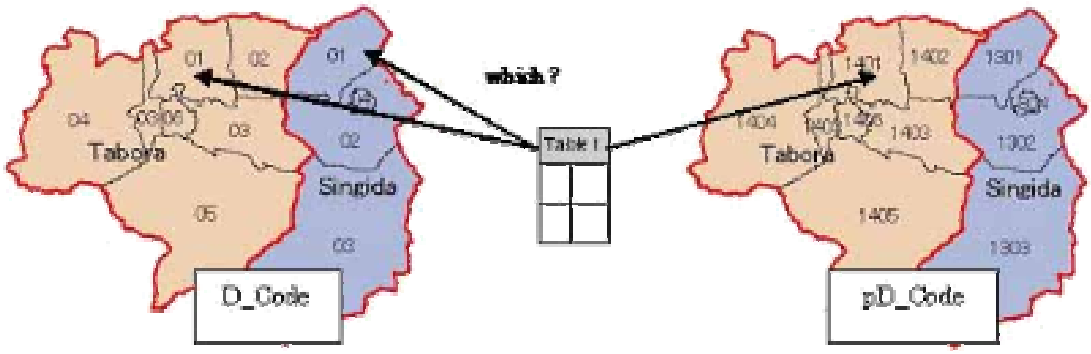

Figure 13-12 No Relationship and Attribute Table in GIS