



**ENVIRONMENTAL & SOCIAL IMPACT
ASSESSMENT**

PROGRESS REPORT

For: SLALA RUBBER COMPANY.

Prepared By: EARTHTIME INC.

TABLE OF CONTENT

1. INTRODUCTION	14
1.1 THE ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT.....	16
1.2 SCOPE OF WORK.....	16
2 LEGISLATIVE AND INSTITUTIONAL FRAMEWORK	17
2.1 LEGISLATIVE FRAMEWORK	17
2.2 ENVIRONMENTAL QUALITY STANDARDS.....	22
2.3 INSTITUTIONAL FRAMEWORK.....	22
3 DESCRIPTION OF THE ENVIRONMENT	25
3.1 GENERAL SETTING	25
3.2 LOCATION.....	28
3.3 METEOROLOGICAL SETTING	31
3.3.1 <i>Precipitation</i>	31
3.3.2 <i>Temperature</i>	33
3.3.3 <i>Winds</i>	34
3.4 GEOLOGICAL SETTING	36
3.4.1 <i>Stratigraphy</i>	39
3.4.1.1 <i>Plantation Area</i>	39
3.4.1.2 <i>Factory Area</i>	40
3.5 HYDROGEOLOGICAL SETTING.....	41
3.5.1 <i>Water Resources</i>	46
3.5.2 <i>Farmington River</i>	46
3.5.3 <i>Yia, Niafo Creek and Bolo River</i>	48
3.5.4 <i>Groundwater Wells</i>	51
3.6 ECOLOGICAL STATUS.....	53
3.7 SOCIO-ECONOMIC STATUS.....	56
4 DESCRIPTION OF THE PLANTATION AND THE FACTORY	62
4.1 GENERAL DESCRIPTION OF THE FACTORY	62
4.2 GENERAL DESCRIPTION OF THE PLANTATION	63
4.3 INFRASTRUCTURE	65
4.3.1 <i>Workshops and Power Plants</i>	66
4.3.2 <i>Storage Facilities</i>	69
4.3.3 <i>Clinics</i>	73
4.3.4 <i>Laboratory</i>	78
4.3.5 <i>Housing and Offices Complexes</i>	79
4.3.6 <i>Schools</i>	81
4.4 FUEL CONSUMPTION	82
5 PROCESS DESCRIPTION.....	86
5.1 PLANTATION	86

5.1.1	Nursing	86
5.1.2	Tapping.....	87
5.1.3	Coagulation of Latex.....	88
5.1.4	General Maintenance.....	90
5.1.4.1	Weeding and Control of Fungi.....	90
5.1.4.2	Fertilization.....	92
5.1.4.3	Repair and Maintenance of Platforms at Collection Stations	93
5.1.4.4	Removal of Branches and Fallen Trees.....	93
5.1.4.5	Replanting of Old Rubber Trees.....	93
5.1.5	Fire Control	94
5.2	FACTORY	94
5.2.1	Reception and Storage	97
5.2.2	Treatment	98
5.2.3	Slab Cutter (Tanks 1 & 2)	100
5.2.4	Pre-Breaker Feed Tank (3), Pre-Breaker and Transfer Tank (tank 4).....	101
5.2.5	Coarse and Intermediate Pelletiser and Tank 5	101
5.2.6	Fine Pelletisers and Tank 6.....	102
5.2.7	Drying	102
5.2.8	Trolley Filling Station and Wet End Dryer Feeding.....	103
5.2.9	Handling of Biscuits from Trolley to Pressing Station	103
5.2.10	Bale Press Operation and Control.....	105
5.2.11	Trolley Washing Procedure.....	107
5.2.12	Packaging	108
6	ENVIRONMENTAL IMPACT ASSESSMENT AND ANALYSIS	110
6.1	ENVIRONMENTAL IMPACT ASSESSMENT AND ANALYSIS OF THE SRC'S PLANTATION	111
6.1.1	Impact on Soil Quality	112
6.1.2	Impact on Water Resources	117
6.1.2.1	Water Quality and Effluent Discharge Analysis.....	122
6.1.2.1.1	Results and Interpretation	124
6.1.2.1.1.1	Wells	124
	pH	124
	Temperature	126
	Total Dissolved Solids (TDS)	126
6.1.3	Solid Waste Management	129
6.1.4	Impact on Air Quality and Odors Emissions.....	130
6.1.4.1	Dust Emissions	131
6.1.5	Impact on Biodiversity.....	131
6.1.6	Occupational health safety.....	133
6.2	ENVIRONMENTAL IMPACT ASSESSMENT AND ANALYSIS OF SRC'S RUBBER PROCESSING FACILITY.....	136
6.2.1	Impact on Water Resources	138
6.2.1.1	Water Quality and Effluent Discharge Analysis.....	139
6.2.1.1.1	Results and Interpretation	143
6.2.1.1.1.1	Wells (Well f1)	143
	Total Dissolved Solids (TDS)	143
	pH	144
	Turbidity	144

6.2.1.1.2	Surface Water.....	144
	Total Dissolved Solids (TDS).....	145
	pH.....	146
	Turbidity.....	146
	Temperature.....	146
6.2.1.2	Water Consumption.....	147
6.2.1.3	Wastewater Management.....	150
6.2.2	Impact on Air Quality.....	151
6.2.3	Impact on Biodiversity.....	153
6.2.4	Impact on Human Amenity and Health.....	156
6.2.5	Impact on landscape and Visual Amenity.....	157
6.2.6	Noise Emission.....	157
6.2.6.1	Noise Level Monitoring Equipment.....	158
6.2.6.2	Noise Level Monitoring Methodology.....	158
6.2.6.3	Results & Interpretations.....	159
7	SOCIAL IMPACT ASSESSMENT.....	163
7.1	SURVEY METHODOLOGY.....	163
7.2	DESCRIPTION OF SOCIO-ECONOMIC CONDITIONS OF CAMPS RESIDENTS AT SRC.....	167
7.2.1	Community Profile.....	167
7.2.1.1	Camp 1.....	172
7.2.1.2	Camp 2.....	176
7.2.1.3	Camp 3.....	181
7.2.1.4	Camp 4.....	185
7.2.1.5	Camp 5.....	188
7.3	ANALYSIS OF INDIVIDUAL QUESTIONNAIRES.....	192
7.3.1	Housing Conditions as Expressed by Surveyed Individuals.....	196
7.3.2	Health Care Infrastructure.....	199
7.3.3	Educational Infrastructure.....	200
7.3.4	Training.....	203
7.3.5	Migration.....	203
7.3.6	Employment.....	204
7.3.7	Road Infrastructure.....	205
7.3.8	Attitude of Surveyed Residents towards Salala Rubber Company.....	206
7.3.8.1	Environment, Health and Safety.....	206
7.3.8.2	Community Services.....	207
7.3.8.3	Land use resources & Archeological Resources.....	208
7.3.9	Expectations.....	209
8	ENVIRONMENTAL & SOCIAL MANAGEMENT PLAN.....	211
8.1	OBJECTIVES OF THE ENVIRONMENTAL MANAGEMENT PLAN.....	211
8.2	MITIGATION MEASURES.....	213
8.3	SIGNIFICANCE OF MITIGATION MEASURES.....	213
8.4	DESCRIPTION OF MITIGATION MEASURES.....	214
8.4.1	Mitigation Measures for the Plantation.....	215
8.4.1.1	Mitigating Impacts on Soil Quality and Soil Preservation Practices.....	215
8.4.1.2	Mitigating Impacts on Water Resources.....	217
8.4.1.3	Mitigating Impacts of Air Emissions and Odors.....	218

8.4.1.3.1	Dust Emissions	218
8.4.1.4	Mitigating Impacts on Ecosystem and Biodiversity	218
8.4.1.5	Mitigating Impacts on Human Health and Occupational Safety	219
8.4.2	Mitigation Measures for the Rubber Processing Facility / SRC's Rubber Factory.....	225
8.4.2.1	Water Pollution Control	226
8.4.2.2	Air Pollution Control	227
8.4.2.3	Preserving Biodiversity	229
8.4.2.4	Occupational Safety	229
8.5	SOCIAL MANAGEMENT PLAN	229
8.5.1	Community Development Program	230
8.5.1.1	Objectives	231
8.5.1.2	Scope of the Program.....	231
8.5.1.3	Potential Areas for Social Development	232
8.5.1.4	Construction/upgrade of Healthcare Facilities	232
8.5.1.5	Construction and Upgrading of Existing Educational Infrastructure.....	233
8.5.1.6	Provision of Electricity	234
8.5.1.7	Potable Water Supply	234
8.5.1.8	Vocational training and local employment.....	235
8.5.1.9	Empowering Women and Supporting Auxiliary Business	235
8.5.1.10	Organization and Resources.....	236
8.5.1.11	Constructing & Rehabilitating new Household Units	236
8.5.1.12	Waste Management	236
8.5.1.13	Road Infrastructure.....	238
8.5.1.14	Timeframe	238
9	ENVIRONMENTAL & SOCIAL MONITORING PLAN.....	239
9.1	COMPLIANCE MONITORING	239
9.2	IMPACT DETECTION MONITORING.....	240
9.2.1	Water Monitoring	243
9.2.2	Effluent Monitoring	244
9.2.3	Air Quality Monitoring	244
9.2.4	Noise Level Monitoring.....	246
9.2.5	Safety	247
9.3	RECORD KEEPING	250
9.4	CAPACITY BUILDING.....	250
9.4.1	Specialized Training Workshops	250
10	CONCLUSIONS AND RECOMMENDATIONS	251
	REFERENCES	252

LIST OF FIGURES

FIGURE 3-1: LIBERIA BORDERED BY IVORY COAST, GUINEA AND SIERRA LEONE.....	27
FIGURE 3-2: VEGETATION COVER IN LIBERIA (1973).....	28
FIGURE 3-3: LOCATION MAP OF THE STUDY AREA SHOWING THE LOCATION OF THE FACTORY AS WELL AS THE PLANTATION. MAPS WITH BETTER RESOLUTIONS ARE AVAILABLE IN APPENDIX	30
FIGURE 3-4: AVERAGE ANNUAL PRECIPITATION BETWEEN 1961 AND 1980 (LIBERIAN HYDROLOGICAL SERVICE, 1981).....	32
FIGURE 3-5: AVERAGE MONTHLY PRECIPITATION FROM YEAR 1961 TILL 1980 (LIBERIAN HYDROLOGICAL SERVICE, 1981).	33
FIGURE 3-6: MONTHLY TEMPERATURE VARIATION (LIBERIAN HYDROLOGICAL SERVICE, 1981).....	33
FIGURE 3-7: GEOLOGICAL PROVINCES OF LIBERIA (TYSDAL AND THORMAN, 1983).....	37
FIGURE 3-8: GEOLOGICAL MAP OBTAINED FROM GEOLOGICAL QUADRANGLE OF MONROVIA (C. H. THORMAN, 1977). MAPS WITH BETTER RESOLUTIONS ARE AVAILABLE IN APPENDIX	38
FIGURE 3-9: FARMINGTON / DU RIVER BASIN (MODIFIED FROM LIBERIA HYDROLOGICAL SERVICE, 1983).	48
FIGURE 3-10: HYDROLOGICAL MAP OF THE STUDY AREA. MAPS WITH BETTER RESOLUTIONS ARE AVAILABLE IN APPENDIX	50
FIGURE 3-11: LOCATION OF WELLS WITHIN THE PLANTATION. MAPS WITH BETTER RESOLUTIONS ARE AVAILABLE IN APPENDIX	52
FIGURE 3-12: WELLS COVERED WITH CEMENT.	53
FIGURE 4-1: VIEWS SRC FACTORY'S WORKSHOP.	67
FIGURE 4-2: POWER PLANT WITHIN SRC'S FACTORY.	67
FIGURE 4-3: FUEL STORAGE TANKS. (A) TANK # 1 WITH CAPACITY 2600 GALS; (B) TANK # WITH CAPACITY OF 2750; (C) TANK # 3 WITH STORAGE CAPACITY OF 3250 GALS; (D) TANK # 4 WITH STORAGE CAPACITY OF 5100 GALS; (E) TANK # 5 WITH STORAGE CAPACITY OF 5400 GALS; (F) TANK # 6 CURRENTLY NOT USED.	70
FIGURE 4-4: SHORT TERM STORAGE TANKS. (A) LOCATED WITH THE PROCESSING PLANT FOR THE DRYER AND (B) LOCATED WITHIN THE POWER PLANT FOR THE GENERATORS.	70
FIGURE 4-5: WAREHOUSE LOCATED WITHIN THE FACTORY'S AND USED FOR STORAGE OF SPARE PARTS, AND OTHER TECHNICAL INSTRUMENTS.	71
FIGURE 4-6: (A) & (B) BUNKERS FILLED WITH RAW RUBBER BEFORE BEING PROCESSED; (C) RAW RUBBER IN BUNKER WITH SYRUP LEACHATE; (D) BUNKER PARTIALLY EMPTY.....	72
FIGURE 4-7: (A) EXTERIOR VIEW OF PLANTATION'S CLINIC; (B) THE ONLY SOURCE OF ELECTRICITY FOR THE CLINIC A GASOLINE GENERATOR.	74
FIGURE 4-8: PROPOSED CLINIC MODIFICATIONS.....	77
FIGURE 4-9: (A) AVERAGE FUEL CONSUMPTION OF GENERATORS, 2001-2008. (B) AVERAGE FUEL CONSUMPTION OF DRYER, 2001-2008. SOURCE: SRC, 2008.	83
FIGURE 4-10: (A) AVERAGE TOTAL FUEL USE ON A MONTHLY BASIS, 2001-2008; (B) AVERAGE TOTAL FUEL USE ON A YEARLY BASIS, 2001-2008.....	84
FIGURE 5-1: NURSERIES AT SRC'S PLANTATION.....	87
FIGURE 5-2: (A-C) CEMENT BOXES IN WHICH LATEX IS PLACED FOR COAGULATION AFTER ADDING FORMIC ACID; NOTE THE SMALL CUP IN THE WORKER'S HAND IN FIGURE C WHICH IS USED TO ADD THE FORMIC ACID TO THE RUBBER. (D) FORMIC ACID BOTTLE.	89
FIGURE 5-3: (A-B) COAGULATED LATEX PLACED ON WOODEN PLATFORM. NOTE THE LEACHATE IN FIGURE A. THESE TABLES ARE MADE BAMBOO THAT ARE REPLACED AT LEAST ONCE A YEAR WHILE PLATFORM SUPPORTS ARE TREE SECTIONS THAT ARE REPLACED AS NEEDED.....	89
FIGURE 5-4: WEIGHING THE COAGULUM BEFORE BEING SENT TO THE FACTORY.....	90
FIGURE 5-5: WORKERS EQUIPPED WITH SPRAYING TOOLS. NOTE THE LACK OF USE OF SAFETY TOOLS AND OUTFITS.	92
FIGURE 5-6: WET END PROCESS SCHEMATIC DIAGRAM. (SOURCE: SRC, 2008).....	95

FIGURE 5-7: DRY PROCESS SCHEMATIC DIAGRAM. SOURCE: SRC, 2008.	96
FIGURE 5-8: SRC'S WEIGHBRIDGE LOCATED AT THE FACTORY'S SITE.....	98
FIGURE 5-9: COLLECTION OF COAGULUM. NOTE THAT BASIC OCCUPATIONAL SAFETY EQUIPMENT SUCH AS MASKS ARE NOT USED BY THE WORKERS.	99
FIGURE 5-10: DRIED RUBBER BISCUIT EMERGING FROM THE DRYER.	104
FIGURE 5-11: DRIED RUBBER BISCUITS BEING UNLOADED FROM THE DRYER'S TROLLEY. NOTE THE LACK OF USE OF SAFETY EQUIPMENT BY WORKERS.	104
FIGURE 5-12: INTERNAL TEMPERATURE OF BISCUITS BEING MEASURED.	105
FIGURE 5-13: PRESSING MACHINES AT SRC'S FACTORY.	107
FIGURE 6-1: NITROGEN CYCLE (PIDWIRNY, 2006).	116
FIGURE 6-2: <i>IN-SITU</i> ANALYSIS ACTIVITIES AT THE PLANTATION'S WELLS AND OTHER WATER BODIES. (E) <i>IN-SITU</i> ANALYSES AT THE KPORLARYAH STREAM WITHIN THE PLANTATION; (F) <i>IN-SITU</i> ANALYSES AT THE BOLO RIVER ON THE OUTSKIRTS OF THE PLANTATION.	123
FIGURE 6-3: VARIATION OF PH AT THE TESTED WELLS WITHIN THE PLANTATION.....	125
FIGURE 6-4: PH SCALE INDICATOR.	125
FIGURE 6-5: VARIATION OF WATER TEMPERATURE FOR WELLS TESTED AT THE PLANTATION.	126
FIGURE 6-6: VARIATION OF TDS VALUES (MG/L) FOR WELLS WITHIN THE PLANTATION.....	127
FIGURE 6-7: TDS SCALE IN PARTS PER MILLION (PPM).	127
FIGURE 6-8: (A-C) WORKERS ON PLANTATION POORLY EQUIPPED WITH PERSONAL PROTECTIVE EQUIPMENT; (D) A CONTAINER OF FORMIC ACID PLACED NEAR A COAGULATION LOCATION WITH NO LABELING OR APPROPRIATE STORAGE.	135
FIGURE 6-9: ENVIRONMENTAL IMPACTS GENERATED BY A TYPICAL RUBBER DRYING/STABILIZING FACILITY	137
FIGURE 6-10: RUBBER PRODUCTION PROCESS AND THE RELATED INPUTS AND OUTPUTS.	138
FIGURE 6-11: SAMPLING LOCATIONS AT SRC'S FACTORY'S SITE.	140
FIGURE 6-12: <i>IN-SITU</i> ANALYSIS ACTIVITIES AT THE FACTORY'S SITE.....	141
FIGURE 6-13: (A) EFFLUENT POND AT SRC'S FACTORY; (B) OUTLET FROM EFFLUENT POND; (C) EFFLUENT DRAINAGE LEADING TO THE YEA CREEK.....	143
FIGURE 6-14: COMPARISON OF WATER QUALITY BETWEEN THE INTAKE POINT (YEA CREEK), EFFLUENT POND AND OUTLET POINT (YEA CREEK).	145
FIGURE 6-15: NOISE LEVEL AT VARIOUS LOCATIONS AT SRC.	161
FIGURE 6-16: FIGURE ADOPTED FROM HANDBOOK OF NOISE CONTROL, C. M. HARRIS, EDITOR, MCGRAW-HILL BOOK Co., 1979, AND FICAN 1992.	162
FIGURE 7-1: LOCATION MAP OF THE CAMPS AND THE PLANTATION.....	170
FIGURE 7-2: NUMBER OF HOUSEHOLDS PER CAMP.	170
FIGURE 7-3: POPULATION DISTRIBUTION IN EACH CAMP.....	171
FIGURE 7-4: NUMBER OF FAMILIES IN EACH CAMP.	171
FIGURE 7-5: NUMBER OF SHOPS PER CAMP.	172
FIGURE 7-6: NUMBER OF WORKERS BY GENDER.	172
FIGURE 7-7: PERCENTAGE OF MALES TO FEMALES IN CAMP 1.	175
FIGURE 7-8: TOILET FACILITY WITHIN CAMP 1.....	175
FIGURE 7-9: SELLING SPOT WITHIN CAMP 1.	176
FIGURE 7-10: PERCENTAGE OF MALE TO FEMALE IN CAMP 2.	177
FIGURE 7-11: PERCENTAGE OF POPULATION BY AGE IN CAMP 2.	177
FIGURE 7-12: A TWO-BEDROOM HOUSE IN CAMP 2.	178
FIGURE 7-13: BASIC RENOVATION FOR ONE OF THE HOUSES IN CAMP 2.	178

FIGURE 7-14: ONE OF THE HOUSES WITH BROKEN WALL WITHIN CAMP 2.	179
FIGURE 7-15: TOILET AND BATHING FACILITIES WITHIN CAMP 2.	180
FIGURE 7-16: PERCENTAGE OF MALE TO FEMALE IN CAMP 3.	182
FIGURE 7-17: SAMPLE VIEW OF HOUSEHOLD CONDITION IN CAMP 3.	182
FIGURE 7-18: NOTE THE ADDED SECTION TO THE HOUSE THAT IS MADE OF MUD AND STICKS. THIS SECTION SERVES AS A KITCHEN FOR THE HOUSEHOLD RESIDENTS.	183
FIGURE 7-19: A WELL IN CAMP 3 WITH CEMENT COVER.	184
FIGURE 7-20: PERCENTAGE OF MALE TO FEMALE IN CAMP 4.	186
FIGURE 7-21: PERCENTAGE OF POPULATION BY AGE IN CAMP 4.	186
FIGURE 7-22: (A) WELL 11 LOCATED CLOSE TO THE SCHOOL; (B) WELL #12 LOCATED WITHIN THE CAMP.	187
FIGURE 7-23: PERCENTAGE OF MALE TO FEMALE IN CAMP 5.	189
FIGURE 7-24: PERCENTAGE OF POPULATION BY AGE IN CAMP 5.	189
FIGURE 7-25: TOILET AND BATHING FACILITIES WITHIN CAMP 5.	190
FIGURE 7-26: WELL WITH CEMENT COVER IN CAMP 5.	191
FIGURE 7-27: PERCENTAGE MALE TO FEMALE OF THE SURVEYED POPULATION	193
FIGURE 7-28: AGE OF SURVEYED POPULATION	194
FIGURE 7-29: EDUCATION LEVEL OF THE SURVEYED POPULATION	194
FIGURE 7-30: MARITAL STATUS OF THE SURVEYED POPULATION	195
FIGURE 7-31: EMPLOYMENT OF THE SURVEYED POPULATION	195
FIGURE 7-32: PERCENTAGE OF SURVEYED POPULATION WORKING AT SRC	196
FIGURE 7-33: DOES ONE OF THE HOUSEHOLD MEMBERS OWN THE HOUSE YOU LIVE IN?	196
FIGURE 7-34: PERCENTAGE OF SURVEYED POPULATION LIVING IN THE SAME HOUSEHOLD	197
FIGURE 7-35: COMMUNITY PROFILE AS RATED BY INDIVIDUALS.	198
FIGURE 7-36: (A-B) DIFFERENT VIEWS OF SCHOOL'S CONDITION IN CAMP 3.	202
FIGURE 7-37: (A-B) CHEMICALS AND TOOLS STORED IN ONE OF THE ROOMS WITHIN THE SCHOOL OF CAMP 3.	203
FIGURE 7-38: NUMBER OF WORKING HOURS AT SRC	205
FIGURE 7-39: ROAD CONDITIONS IN THE CAMPS.	206
FIGURE 7-40: ATTITUDE TOWARDS SRC (ENVIRONMENT, HEALTH AND SAFETY).	207
FIGURE 7-41: ATTITUDE TOWARDS SRC (COMMUNITY SERVICES).	208
FIGURE 7-42: ATTITUDE TOWARDS SRC (LAND USE & ARCHEOLOGICAL RESOURCES)	209
FIGURE 8-1: APPROPRIATE PROTECTIVE CLOTHING TO WEAR DURING AGROCHEMICAL DISPENSING (ILO)	222

LIST OF TABLES

TABLE 2-1: CATEGORIES OF LEGISLATIONS IN LIBERIA.	20
TABLE 2-2: INTERNATIONAL ENVIRONMENTAL CONVENTIONS SIGNED/RATIFIED BY THE GOVERNMENT OF LIBERIA.	20
TABLE 2-3: RELEVANT ENVIRONMENTAL LEGISLATIONS.	21
TABLE 3-1: MAJOR RIVERS IN LIBERIA. (LIBERIA HYDROLOGICAL SERVICES, 1988)	26
TABLE 3-2: AVERAGE ANNUAL RAINFALL (1961-1980) (LIBERIAN HYDROLOGICAL SERVICE, 1981).	35
TABLE 3-3: HYDROSTRATIGRAPHIC TABLE OF THE AREA SHOWN IN THE GEOLOGICAL MAP.	42
TABLE 3-4: OVERVIEW OF WATER WELLS WITHIN THE PLANTATION AND THE FACTORY.....	44
TABLE 3-5: LIST OF CLASSIFIED TRIBUTARIES (LIBERIAN HYDROLOGICAL SURVEY, 1983).....	47
TABLE 3-6: PREDOMINANT MATURE FOREST TREE SPECIES.	54
TABLE 3-7: EXPECTED FAUNA PRESENT IN THE AREA.	55
TABLE 3-8: DISTRIBUTION OF SRC'S EMPLOYEES.	58
TABLE 4-1: WET RUBBER PURCHASES IN TONS/YEAR. NOTE THAT 2003 IS CONSIDERED ONLY AS 9 MONTHS AND A HALF OR REAL OPERATION	62
TABLE 4-2: SRC'S FACTORY OUTPUT PRODUCTION (TONS/YEAR). SOURCE: SRC RECORDS. NOTE THAT 2003 IS CONSIDERED ONLY AS 9 MONTHS AND A HALF OR REAL OPERATION	63
TABLE 4-3: DISTRIBUTION OF THE SURFACE PER CLONE IN MATURE AREA. SOURCE: SRC.	63
TABLE 4-4: DISTRIBUTION OF THE SURFACE PER CLONE. SOURCE: SRC, 2008.	64
TABLE 4-5: PRODUCTION OF WET RUBBER FOR YEAR 2005, 2006, 2007 AND 2008. SOURCE: SRC, 2008.	64
TABLE 4-6: ESTIMATED PRODUCTION OVERVIEW PER MONTH FOR 2008. SOURCE: SRC, 2008.	65
TABLE 4-7: SRC'S EXTENSION AND REPLANTING PROGRAM 2008-2015. SOURCE: SRC, 2008.	65
TABLE 4-8: DISTRIBUTION OF SRC'S MAIN INFRASTRUCTURES.	65
TABLE 4-9: TYPE AND NUMBER OF STRUCTURES OF SRC.	66
TABLE 4-10: LIST OF MOBILE EQUIPMENT AT SRC.	68
TABLE 4-11: DESCRIPTION OF THE SRC'S GENERATORS OPERATION PATTERNS.	69
TABLE 4-12: STORAGE FACILITIES AT SRC.	72
TABLE 4-13: NUMBER OF CASES TREATED AT SRC'S CLINIC.....	75
TABLE 4-14: TYPES AND QUANTITY OF CHEMICALS USED BY SRC.	78
TABLE 4-15: TYPES AND QUANTITIES OF OTHER MATERIALS USED AT SRC.....	79
TABLE 4-16: NUMBER OF HOUSES PER CAMP.....	80
TABLE 4-17: NUMBER OF WELLS IN EACH CAMP.	81
TABLE 4-18: TYPES AND QUANTITIES OF PETROLEUM USED AT THE FACILITY.	85
TABLE 5-1: OVERVIEW OF USED HERBICIDES, FERTILIZERS AND PESTICIDES AT SRC'S PLANTATION (SRC, 2008).....	91
TABLE 5-2: FERTILIZER APPLICATION SCHEDULE FOR 2008. SOURCE: SRC, 2008.	92
TABLE 5-3: SPECIFICATIONS FOR PLASTIC PACKAGING MATERIALS. SOURCE: SRC, 2007.....	108
TABLE 6-1: MATURE AREA: DISTRIBUTION OF THE SURFACE PER CLONE. SOURCE: SRC.....	112
TABLE 6-2: IMMATURE AREA: DISTRIBUTION OF THE SURFACE PER CLONE.	112
TABLE 6-3: LIST OF CHEMICALS USED AT THE PLANTATION	114
TABLE 6-4: APPLICATION RATES OF BIOCIDES AND FERTILIZERS	114
TABLE 6-5: FACTORS INDICATION GREATEST LIKELIHOOD OF GROUNDWATER CONTAMINATION BY PESTICIDES.....	120

TABLE 6-6: PESTICIDES SUSCEPTIBLE TO LEACHATE TO GROUNDWATER (TRAUTMAN, N. ET AL, UNKNOWN DATE, HTTP://PMEP.CCE.CORNELL.EDU/FACTS-SLIDES-SELF/FACTS/PEST-GR-GUD-GRW89.HTML)	120
TABLE 6-7: IN-SITU WATER ANALYSES FOR BOTH THE FACTORY AND THE PLANTATION.	128
TABLE 6-8: DIFFERENT TYPES OF SOLID WASTES PRODUCED AT THE PLANTATION, THEIR DISPOSAL METHODS AND THE RELATIVE ENVIRONMENTAL IMPACTS	129
TABLE 6-9: LIST OF THE SOME OF THE AGROCHEMICALS USED AT THE PLANTATION HAVING AN ADVERSE IMPACT ON BIODIVERSITY	132
TABLE 6-10: LIST OF AQUATIC ORGANISMS AFFECTED BY MANCOZEB POLLUTION COUPLED WITH THE NOTED EFFECT (PAN PESTICIDE DATABASE, 2008)	132
TABLE 6-11: SUMMARY OF THE DIFFERENT TYPES OF CHEMICALS USED AT THE PLANTATION AND THE RELATED HEALTH IMPACTS	133
TABLE 6-12: LIST OF PHYSICAL INJURIES	135
TABLE 6-13: PROPERTIES OF THE EFFLUENT GENERATED DURING TSR PRODUCTION IN COMPARISON TO THE WORLD BANK STANDARDS	148
TABLE 14: LIST OF POLLUTANTS GENERATED AS A RESULT OF FUEL COMBUSTION AND THE RELATED HEALTH IMPACT (COOPER ET.AL, 2002; USEPA,2008)	152
TABLE 15: LIST OF WATER POLLUTION PROBLEMS INDUCED BY WRC OPERATION AND THE RELATED IMPACTS	155
TABLE 16: LIST OF AIR POLLUTANTS PRODUCED BY WRC FACILITY AND THE RELATED IMPACTS (COOPER ET.AL., 2002).....	156
TABLE 17: OCCUPATIONAL HEALTH HAZARDS AND THE ASSOCIATED SOURCES	157
TABLE 6-18: BRIEF DESCRIPTION OF SAMPLING LOCATIONS.....	158
TABLE 6-19: TEMPORAL MAXIMUM AND MINIMUM ON SITE NOISE LEVELS AT VARIOUS LOCATIONS (MAXIMUM AND MINIMUM VALUES BASED ON VALUES IN APPENDIX F).....	160
TABLE 7-1: COORDINATES OF THE FIVE (5) CAMPS, THE HEADS OF EACH CAMP AND LOCATION WITH RESPECT TO THE PLANTATION'S ENTRANCE GATE.....	169
TABLE 7-2.SCHOOLS WITHIN THE PLANTATION SITE	201
TABLE 7-3: MIGRATION FLOW	204
TABLE 7-4: ATTITUDE TOWARDS SRC (ENVIRONMENT, HEALTH AND SAFETY).	206
TABLE 7-5: ATTITUDE TOWARDS SRC'S (COMMUNITY SERVICES).	208
TABLE 7-6: ATTITUDE TOWARDS SRC (LAND USE & ARCHEOLOGICAL RESOURCES)	209
TABLE 8-1: ENVIRONMENTAL AWARENESS CHECKLIST FOR MANAGEMENT.....	212
TABLE 8-2: LIST OF SOIL PRESERVATION MEASURES (UNCTAD/IRSG, 1997, ZHANG ET AL, 2006, UN, 2006 AND SONETRA, 2001).....	216
TABLE 8-3: SUGGESTED ALTERNATIVES FOR SOME OF THE AGROCHEMICALS USED AT SRC'S PLANTATION.....	219
TABLE 8-4: FACTORS TO BE CONSIDERED IN SCHOOL DESIGNS.....	233
TABLE 9-1: SUMMARY OF PROPOSED ENVIRONMENTAL MONITORING PLAN AT SRC (BOTH FACTORY AND PLANTATION).	241
TABLE 9-2: WATER PARAMETERS TO BE TESTED ON A FREQUENTLY ALONG WITH WHO GUIDEINES FOR DRINKING WATER.	243
TABLE 9-3: PARAMETERS TO BE MONITORED IN EFFLUENT POND AND EFFLUENT DISCHARGE.	244
TABLE 9-4: STANDARDS FOR ATMOSPHERIC POLLUTANTS AND MONITORING FREQUENCY.....	245
TABLE 9-5: VOC, CO, SO ₂ , AND NO _X MONITORING SCHEME FOR SRC.....	246
TABLE 9-6: NOISE MONITORING SCHEME RECOMMENDED FOR SRC.	247

LIST OF ABBREVIATIONS

EXECUTIVE SUMMARY

1. INTRODUCTION

Liberia has recently been making significant effort, through the Environmental Protection Agency (EPA) and other relevant stakeholders, towards sustainable development, and has placed more attention to environmental matters and the need to reduce the burden on the environment. The relatively young Environmental Protection Agency (EPA) has been able in the last few years to considerably improve its capabilities in protecting the environment from the various sources of pollution. Even though at the time of writing this report, it is still considered poorly financed and barely equipped with the appropriate human and technical resources, the EPA is seriously working on setting new environmental standards, building its staff capacity and informational database, and providing the framework to prevent future pollution to widespread in Liberia.

In particular, the EPA has developed guidelines for Environmental Impact Assessment (EIA) administrative procedures which are supposed to reflect the objectives of the Environmental Protection and Management Law (EPML). This law has been approved by the Government since November 26, 2002. The Law states that any planned project that could cause significant environmental impacts should be subject to the preparation of an EIA that would anticipate these impacts and allow provision of mitigation measures to minimize the significance of these impacts, or even eliminate their likelihood. The EPA has even gone a step ahead in requesting an Environmental Management Plan (EMP) from most existing projects in order to secure environmentally sustainable operations. However, the EPA still needs to set standards and guidelines for: 1) Monitoring systems; 2) Measurement of water quality (including drinking water and water for industrial and agricultural purposes); 3) Monitoring ambient and occupational indoor air quality; 4) Better Management of Soil and 5) Reducing Noise pollution.

On the other hand, Liberia has abundant natural resources in terms of mining and agriculture. Rubber is one of the main natural resources and exports of Liberia. Salala Rubber Company (SRC) is one of the several companies operating in Liberia and is today Liberia's fourth largest rubber producing and processing company (IFC, 2008). The company was established in July 2007 based on a merger of Weala Rubber Company (WRC) - a rubber processing company- and Salala Rubber Corporation-a rubber plantation.

Weala Rubber Company, previously located in Margibi County, was formed in 1998 and produced 160,000 tons of high specification tire rubber. WRC mainly operated a rubber processing factory where it bought majority of the rubber from farmers and small holders in addition to some rubber plantations. Meanwhile, Salala Rubber Corporation started in 1975 as a concession which was owned by a Dutch group and mainly cultivated rubber trees. For unknown reasons, the plantation was neglected during the middle 80's and mismanaged by individuals till the date of merger. The majority of trees on the plantation are considered to be on the end of their production life and replant is being taking place.

The main objective of the project is to cultivate rubber tree plantations and produce good quality and competitively priced rubber to be supplied to international markets, and help the economy of the country and improve the standards of living.

Salala Rubber Company (SRC) is the responsible authority with respect to the proper operation of both the factory and the plantation. The Company will oversee the works and ensure its execution and operation according to specifications as well as ensure the safety of the environment and the employees.

1.1 THE ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

The purpose of this preliminary ESIA is to ensure that the potential impacts from SRC are identified, their significance is assessed, and appropriate environmental and social management plan (mitigation, monitoring, and institutional strengthening) is developed for the facility and implemented during the project life cycle using. The objectives of the management plan are to ensure environmental protection and assist the project designer and operator to recognize environmental, social, and economic impacts of the facility.

1.2 SCOPE OF WORK

Besides the introductory section, the scope of work implemented in the preparation of the current report includes the following:

- Definition of the legislative and institution framework (Section 2);
- Description of the environment (Section 3);
- Description of the plantation and factory plan (Section 4);
- Description of the processes within the factory and plantation;
- Identification and analysis of potential environmental impact (Section 5);
- Analysis of potential alternatives (Section 6);
- Development of environmental management plans including mitigation, monitoring, and institutional strengthening (Section 7).

The present ESIA report shall be updated and detailed by potential contractors with emphasis on implementation mechanisms of environmental management plans to reflect the elements of the complete design and site specific characteristics.

2 LEGISLATIVE AND INSTITUTIONAL FRAMEWORK

2.1 LEGISLATIVE FRAMEWORK

Article 7 of the 1986 Constitution of the Republic of Liberia sets the fundamental basis for the constitutional, legislative, and institutional frameworks for the protection and management of the environment. It also encourages public participation in the protection and management of the environment and the natural resources in Liberia.

The Environment Protection Agency of Liberia (EPA) was created by the Legislative Act of November 26, 2002 and published on April 30, 2003. The establishment of the EPA marks a significant step forward in the protection and management of the environment of Liberia.

Part II, Section 5 of the Act designated the EPA as the principal Liberian authority for environmental management which shall co-ordinate, monitor, supervise, and consult with relevant stakeholders on all the activities for environmental protection and the sustainable use of natural resources. Section 6 (b) of the Act stipulates that the EPA should propose environmental policies and strategies to the Policy Council and ensure the integration of environmental concerns in the overall national planning.

Meanwhile, Section 1 of The EPML gives the responsibilities of sustainable development, protection and environmental management to the EPA in partnership with regulated Ministries and organizations and in a close relationship with the people of Liberia. The EPA should also provide high quality information and advice on the state of the environment and for matters connected therewith. This article indicates that environmental protection by the EPA should be accomplished taking into consideration public health and welfare of the Liberian societies. In addition,

Section 15 of the EMPL states that business investors should present an environmental mitigation plan to the EPA, which should include the following sections:

- objectives
- Description of activities to be carried out by the project to mitigate any adverse effects on the environment
- Period within which the mitigation measures shall be implemented
- Proven efficacy of the mitigation measures of indicating their experimental nature.

Moreover, Section 27 of the same law requires Mitigation Plan Audits, and monitoring for existing industries, projects and activities. These shall submit to the EPA their plans for improving environmental performance including:

- Identification of the major environmental effects; and
- A comprehensive mitigation plan in accordance with section 15 of this Law

The Agency is empowered to carry out among others, the following aspects of environmental protection and management in Liberia:

- Establish environmental criteria, guidelines, specifications, and standards for production processes and the sustainable use of natural resources for the health and welfare of the present generation, and in order to prevent environmental degradation for the welfare of the future generations;
- Identify projects, activities, and programs for which environmental impact assessment must be conducted under this Act.
- Review and approve environmental impact statements and environmental impact assessment submitted in accordance with this Act;

- Monitor and assess projects, programs, and policies including activities being carried out by relevant ministries and bodies to ensure that the environment is not degraded by such activities and that environmental management objectives are adhered to and adequate early warning and monitoring on impending environmental emergencies is given;
- Review of sectoral environmental laws and regulations and recommend for amendments and to initiate proposals for the enactment of environmental legislations in accordance with this Act or any other Act;
- Encourage the use of appropriate environmentally sound technologies and renewable sources of energy and natural resources;
- Function as the national clearinghouse for all activities relating to regional and international environment-related conventions, treaties and agreements, and as national liaison with the secretariat for all such regional and international instruments.

Table 2-1 describes the main categories of legislation in Liberia. Table 2-2 shows international conventions that are signed and ratified by the Liberian Government. In terms of environmental legislation, Table 2-3 represents a list of all issued legislation.

Table 2-1: Categories of Legislations in Liberia.

Law	Laws are passed by the National Legislature of Liberia comprising of the Senate and the House of Representatives. Any citizen or group of citizens, Cabinet Ministers, Managing Directors of public corporations or agencies can propose a bill to the National Legislature for enactment. The draft bill is first passed over to the appropriate Steering Committee of the Legislature. In case of environmental bill, this committee is generally the Committee on Natural Resources and the Environment. The Committee reviews, assesses and presents the bill to the Legislative Plenary with appropriate amendments for debate, public hearing and subsequent enactment by the Legislature.
Executive Order	The Executive Branch of government headed by the President can issue Executive Order without the approval of the National Legislature. The Executive orders have the power of a law provided that they do not contravene the existing law. The power of such orders has a limited time of existence.
Regulations	The national Legislature has empowered Cabinet Ministers and Managing Directors of public corporations and agencies to issue regulations for their respective functionaries without legislative approval or supervision, provided that such regulations are not inconsistent with the statutory Laws and the Constitution of Liberia.

Table 2-2: International Environmental Conventions Signed/Ratified by the Government of Liberia.

CONVENTION	STATUS	YEAR
African Convention on Conservation of Nature and Natural Resources	Ratified	NA
Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES)	Ratified	1981
Convention Concerning the Protection of the World Cultural and Natural Heritage	Signed	2002
Framework Convention on Climate Change and the Kyoto Protocol	Signed	2002
Stockholm Convention on Persistent Organic Pollutants (POP)	Signed	2002
Ramsar Convention on Wetlands of International Importance	Signed	2003
Convention on Biodiversity	Ratified	2000
Bio-Safety Protocol	Ratified	2003
Convention on Desertification	Signed	1998
Vienna Convention for the Protection of the Ozone Layer	Signed	1996
Montréal Protocol on Substances that Deplete the Ozone Layer	Signed	1996

Table 2-3: Relevant Environmental Legislations.

LEGISLATION (ACT)	DATE	TITLE/ DESCRIPTION
Law	1953	Conservation of the Forests of the Republic of Liberia. This Law provided the framework for the use of forest and wildlife resources and allowed for the creation of government reserves, native authority reserves, commercial forests, national parks and wildlife refuges.
Law	1957	Supplementary Act for the Conservation of Forests. This Supplementary Law also provided the framework for the use of forest and wildlife resources and allowed for the creation of government reserves, native authority reserves, commercial forests, national parks and wildlife refuges.
Law	1976	The Act that created the Forestry Development Authority (FDA). The Act established and defined the responsibilities of the FDA, outlined forest offences and penalties; made provision for an Advisory Conservation Committee and specified powers of forest officers with regard to trees in reserve areas.
Law	1976	Public Health Act. It contains provision for the protection of drinking water resources and the inspection of potential sources of pollution.
Law	1979	The Natural Resources Law of Liberia. This Law includes chapters on forests, fish, and wildlife, soil, water, and minerals.
Law	1988	Wildlife and National Parks Act. The Act identifies a number of protected areas; specifies policies and objectives regarding wildlife and conservation in the country.
Law	03/04/ 2000	The New Minerals and Mining Law. The Law and its resulting policy call for restoration of land to its previous state as much as possible after mining activities. All medium to large-scale mining activities are to submit Environmental Impact statements. Environmental audits and periodic assessments will be undertaken to ensure compliance.
Law	26/11/ 2002	The Environment Protection Agency (EPA) Act. The Act provides the Agency with the authority of government for the protection and management of the environment in Liberia. It provides for an Environmental Administrative Court to hear from aggrieved parties. It requires that an Environmental Impact Assessment (EIA) be carried out for all activities and projects likely to have an adverse impact on the environment.
Law	26/11/2002	The Environment Protection and Management Law. The Act enables the Environment Protection Agency to protect the environment through the implementation of the Law. It arranges the rules, regulations, and procedures for the conduct of EIA. It establishes regulations for environmental quality standards, pollution control and licensing, among others.

Law	26/11/2002	The National Environmental Policy Act. It defines policies, goals, objectives, and principles of sustainable development and improvement of the physical environment, quality of life of the people and ensures coordination between economic development and growth with sustainable management of natural resources.
Law	2006	National New Forestry Reform Law. The administration of this Act provides for the Forestry Development Authority to exercise the power under the Law to assure sustainable management of the Republic's forestland, conservation of the forest resources, protection of the environment, sustainable economic development with the participation of and for the benefit of all Liberians and to contribute to poverty alleviation in the country.

2.2 ENVIRONMENTAL QUALITY STANDARDS

Several environmental quality standards are under preparation by EPA. Some of these environmental quality standards shall include: 1) Air Quality Standards; 2) Noise Level Standards; 3) Combustion Conditions and Emission Standards for Municipal and Hospital Wastes Incineration; and 4) Selected Standards for Discharge into surface waters.

2.3 INSTITUTIONAL FRAMEWORK

At a regional cooperation level, Liberia is a member of a number of organizations that play an important role in the protection and management of the environment. These organizations include the Economic community of West Africa (ECOWAS), The Mano River Union (MRU), The West African Rice Development Association (WARDA), and the African Union (AU).

In addition to the EPA, other organizations play a vital role in environmental protection and management, particularly the Forestry Development Authority (FDA), Ministries of Lands, Mines and Energy (MLM&E), Ministry of Planning and Economic Affairs (MPEA), Ministry of Justice (MOJ), Ministry of Public Works (MPW), and Ministry of Health and Social Welfare (MHSW), Ministry of Agriculture

(MOA), Ministry of Commerce (MOC), Monrovia City Corporation and the Liberia Water and Sewer Corporation (LWSC).

However, EPA is the main agency and principal authority in Liberia for environmental management and shall co-ordinate, monitor, supervise and consult with relevant stakeholders when needed.

The main functions of the EPA are:

1. Co-ordinate, integrate, harmonize and monitor the implementation of environmental policy and decisions of the Policy Council by the Line Ministries,
2. Propose environmental policies and strategies to the Policy Council and ensure the integration of environmental concerns in overall national planning;
3. Collect, analyze and prepare basic scientific data and other information pertaining to pollution, degradation and on environmental quality, resource use and other environmental protection and conservation matters and undertake research and prepare and disseminate every two years a report on the state of the environment in Liberia;
4. Encourage the use of appropriate environmentally sound technologies and renewable sources of energy and natural resources;
5. Establish environmental criteria, guidelines, specifications and standards for production processes and the sustainable use of natural resources for the health and welfare of the present generation, and in order to prevent environmental degradation for the welfare of the future generations.

In the case of Salala Rubber Company., the EPA along with the Ministry of Health and Social Welfare, and the Ministry of Agriculture have an instrumental role in

assuring an environmentally safe operation of the project in the area in coordination with company's management.

3 DESCRIPTION OF THE ENVIRONMENT

This section presents a description of the environmental (physical and biological) socio-economic settings of the area hosting both the factory and the plantation of Salala Rubber Company. While several field visits were conducted to the site, part of the baseline data was obtained from previous studies. The collected data will be used to assess the baseline environmental quality of the area and identify environmentally significant impacts that the project may introduce to its region of influence. Whenever applicable, additional baseline characterization activities are outlined. Such activities shall be implemented by the contractor prior to project implementation.

3.1 GENERAL SETTING

The quadrangle of Liberia is located on the western side of the African Continent. It is positioned on the Atlantic coastline of Africa, and has a surface area of 111,370 km². It is bordered by Guinea on the north, Sierra Leone on the west and Côte d'Ivoire on the east (Figure 3-1). The border with Guinea is approximately 563 km, Sierra Leone 306 km, and Cote d'Ivoire 716 km. Generally, Liberia has low relief topography. Its studded coastline is approximately 560 km long characterized by unbroken sand strips, and is dominated by lagoons and marshes. However, the hinterland is made up of ill-defined and dissected plateaus and low relief mountains few rising abruptly above the surface to an elevation of 400 m asl. The highest mountain (Mount Wutivi) is located in the northeast (Yekepa) and rises to an elevation of approximately 1,380m a.s.l.

Virgin rain forests are primarily located inland and in mountainous areas. The rest of the area is occupied by small farms. Four types of vegetation cover are present in Liberia (Figure 3-2). Brush, grassland, cultivated and tree crops dominate the central

and coastline areas; swamps are present as patches along the coastline mainly near river mouths; broadleaf evergreen forests are present in the southeastern part of the country; and broadleaf deciduous and evergreen forests dominate the northern parts and are present in the central parts of Liberia.

Liberia has approximately six major rivers that desiccated the country into several quadrants. The rivers are Cavalla, Cestos, St. Paul, St. John, Lofa, and Mano. The longest and largest is the Cavalla River (Table 3-1).

Table 3-1: Major Rivers in Liberia. (Liberia Hydrological Services, 1988)

Basin	Area (km²)	Annual Flow (m³/sec)
Mano	6,604	251
St. Paul	12,820	512.3
St. John	14,762	N/A
Cavalla	13,726	380
Cestos	10,000	60.3
Lofa	9,194	N/A



Figure 3-1: Liberia bordered by Ivory Coast, Guinea and Sierra Leone.

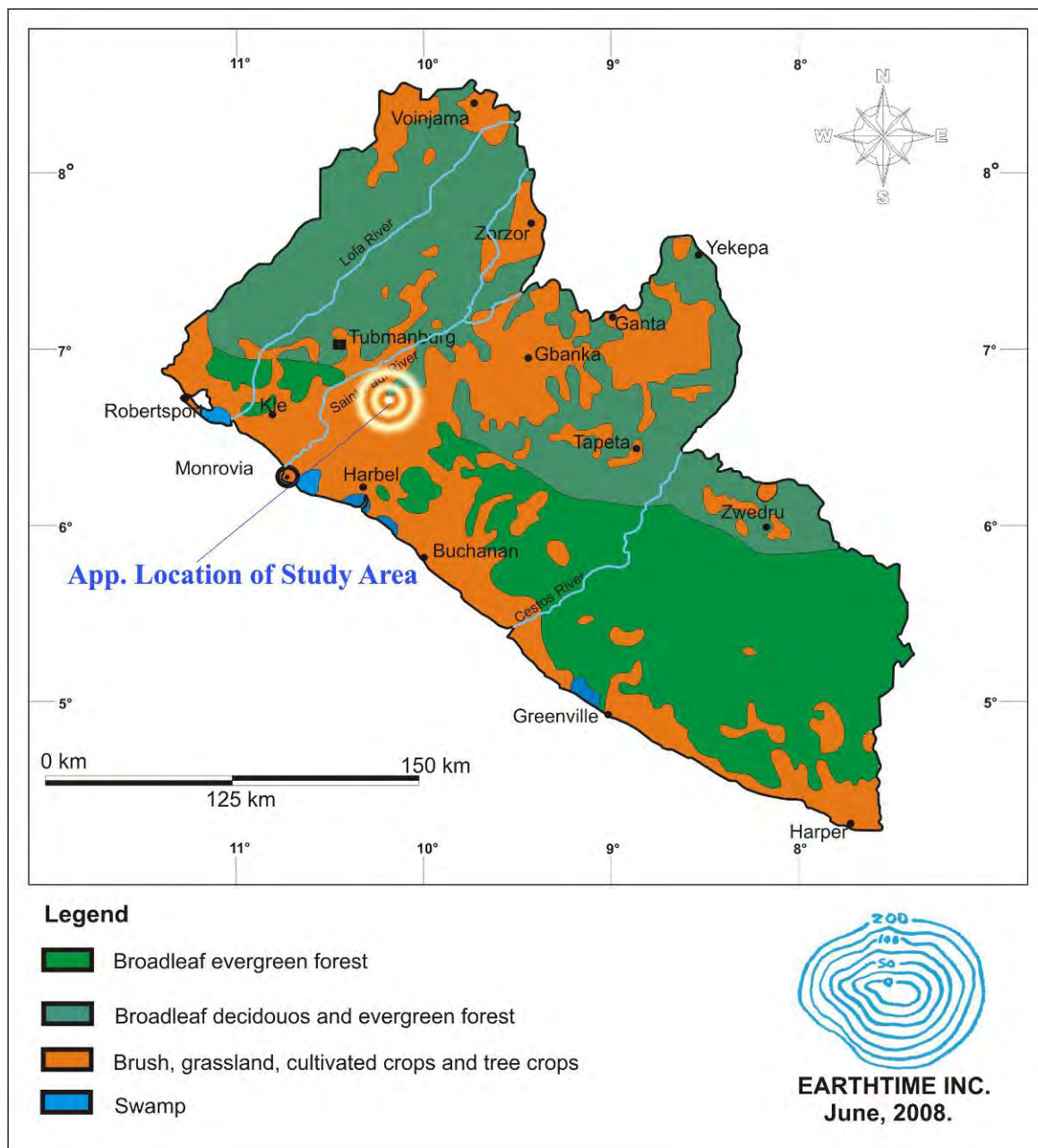


Figure 3-2: Vegetation cover in Liberia (1973).

3.2 LOCATION

Both the factory and the plantation of Salala Rubber Company are located in Margibi County. A distance of approximately 7.8 km separates between the factory and the plantation (Figure 3-3). The factory is located on the bank of the Yia Creek at approximate coordinates 29 N 3666417 UTM 739759. The elevation ranges between

90 -100 m above sea level. It is approximately 24 km northeast of Kakata, and 13 km southwest of Salala. The factory covers a surface area of 85,000 m². The nearest villages/towns to the factory include:

- Noigata: 2.6 km southeast.
- Blakuala: 3.7 km northwest.
- Janeta: 4.1 km southwest.

On the other hand, the plantation covers a surface area of 8,500 ha with a mature area of 2790.83 ha and immature area of 714.14 ha. The plantation is approximately 6.5 Km south of Salala and 27 km northeast of Kakata. The plantation falls within the following coordinates: 29 N 373140 UTM 738850, 29 N 376698 UTM 739393, 29 N 375200 UTM 732842, and 29 N 381090 UTM 733033. The elevation ranges between 100m and 115m above sea level. The plantation is accessed through two main roads branching from the Kakata-Salala Highway, and is bounded on the southern side by the Gibi Mountain which is 3.9 km from the plantation with an elevation of 620 m above sea level. The plantation is also 1.6 km south of the Bolo River which flows in the east-west direction adjacent to the northern side of the plantation. In addition to the five camps existing within the plantation, it is surrounded by several towns such as Bauakla (towards the north), Kuatata (east), Buiela (east), Pee (south), Sakuta (west), Konata (southwest) and Noigata (west).

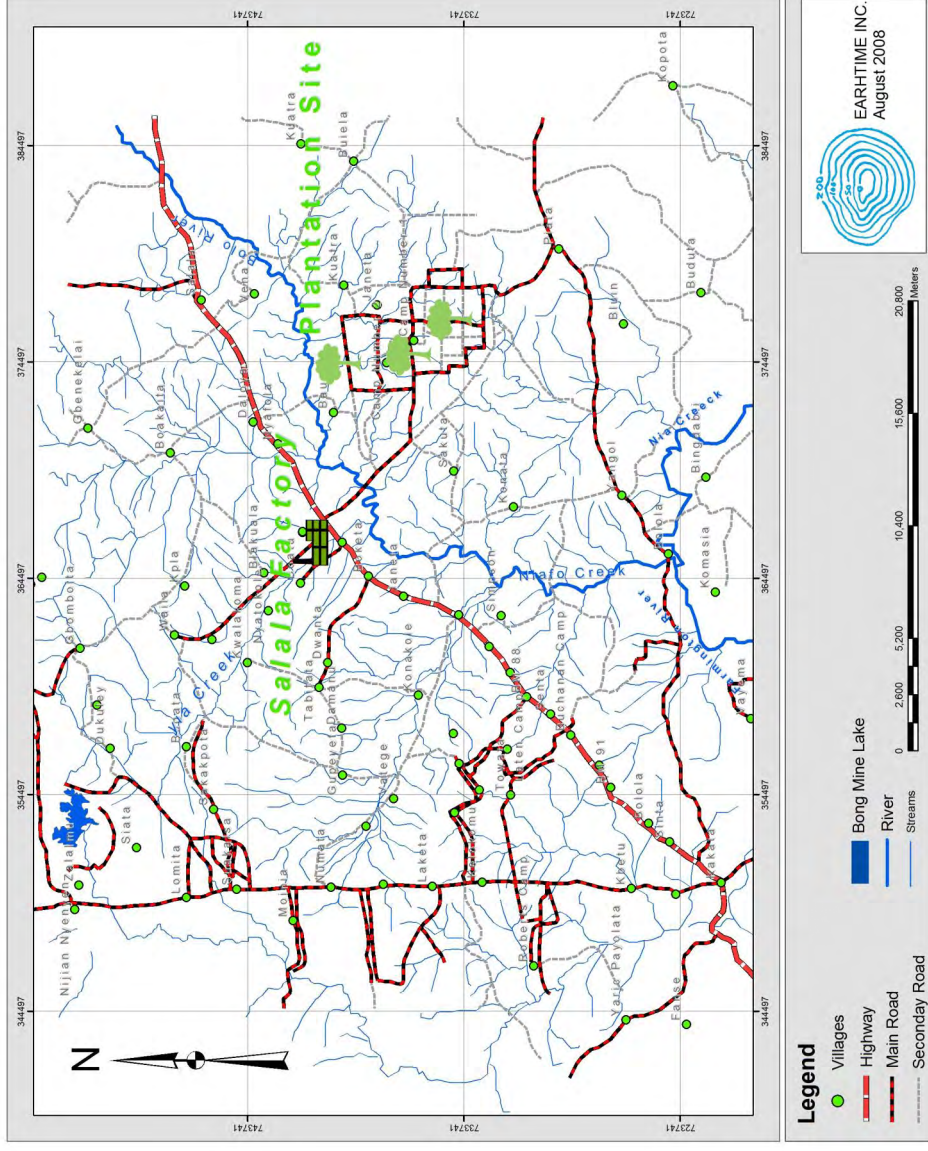


Figure 3-3: Location map of the study area showing the location of the factory as well as the plantation. Maps with better resolutions are available in Appendix.

3.3 METEOROLOGICAL SETTING

Liberia has a typical tropical climate, with heavy rainfall that ranges between 2,000 mm/year and 4,000 mm/year (UNEP, 2004) most of the rainfall occurring between April and November. Precipitation varies between 2,240 mm/year along the coast and 5,210 mm/year inland. Measurements indicate that the rainfall ranges between 4000 and 5000 mm/year. The average temperature in Liberia is approximately 28°C with a maximum that rarely exceeds 38°C. Generally, the temperature is warm throughout the year with very high humidity (UNDP, 2006).

Meteorological data including primarily precipitation, ambient temperature, as well as wind direction and speed, are necessary for developing and understanding an important part of the environmental conditions in the region and consequently for adequately assessing environmental impacts in a comprehensive approach.

Unfortunately, meteorological records in Liberia are scarce, and the obtained meteorological data on the study area date May 1981.

The climatic information provided in this report consists primarily of the measured temperatures and rainfall at the meteorological station that was located at the formerly known Salala Rubber Corporation during the eighties. The reported data can be considered old and should not be attributed to local site conditions.

SRC shall install meteorological station at the site to monitor atmospheric indicators that are useful information on temperature, barometric pressure, humidity, wind speed, wind direction and precipitation.

3.3.1 Precipitation

Data on precipitation was obtained from records of a station that was located on the plantation and range from the years 1961 until 1980. The average annual rainfall

between the years 1961 and 1980 was 2474 mm (Table 3-2). Figure 3-4 shows the average yearly precipitation form year 1961 till 1980. Figure 3-5 shows the average monthly precipitation with a major increase of precipitation in the months of August and September. Rainfall events are particularly concentrated in the season of March until November with a maximum recorded value of 418.1 mm and a minimum value of 15.8 mm.

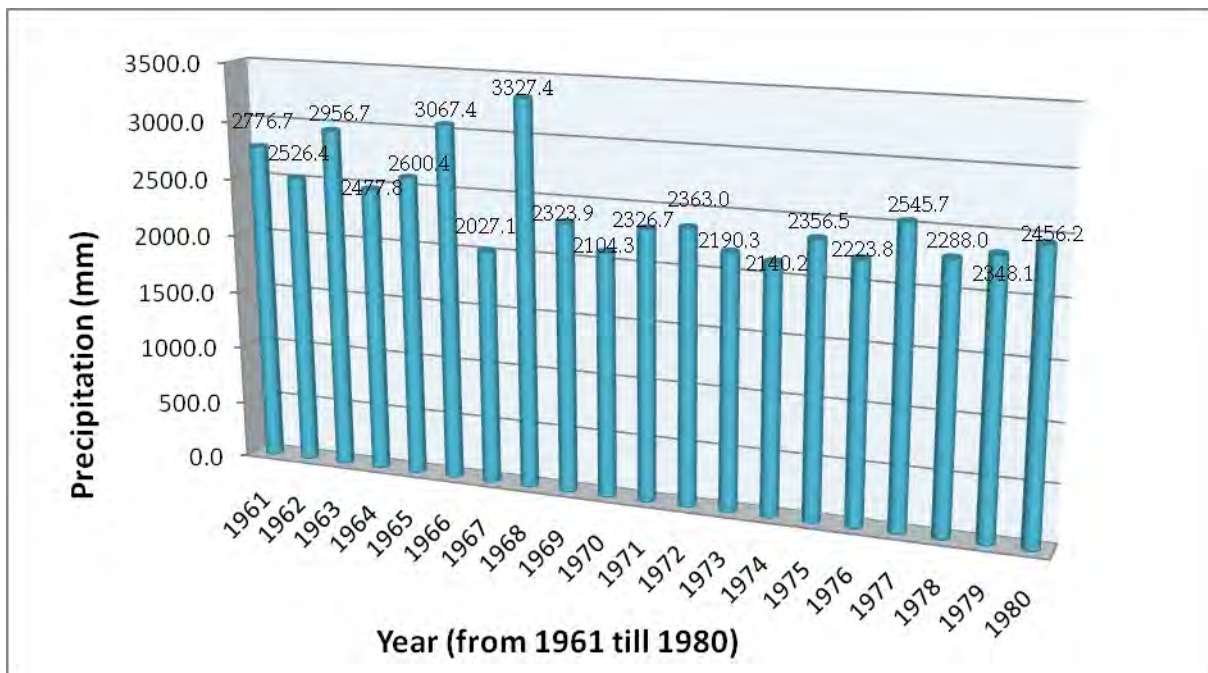


Figure 3-4: Average annual precipitation between 1961 and 1980 (Liberian Hydrological Service, 1981).

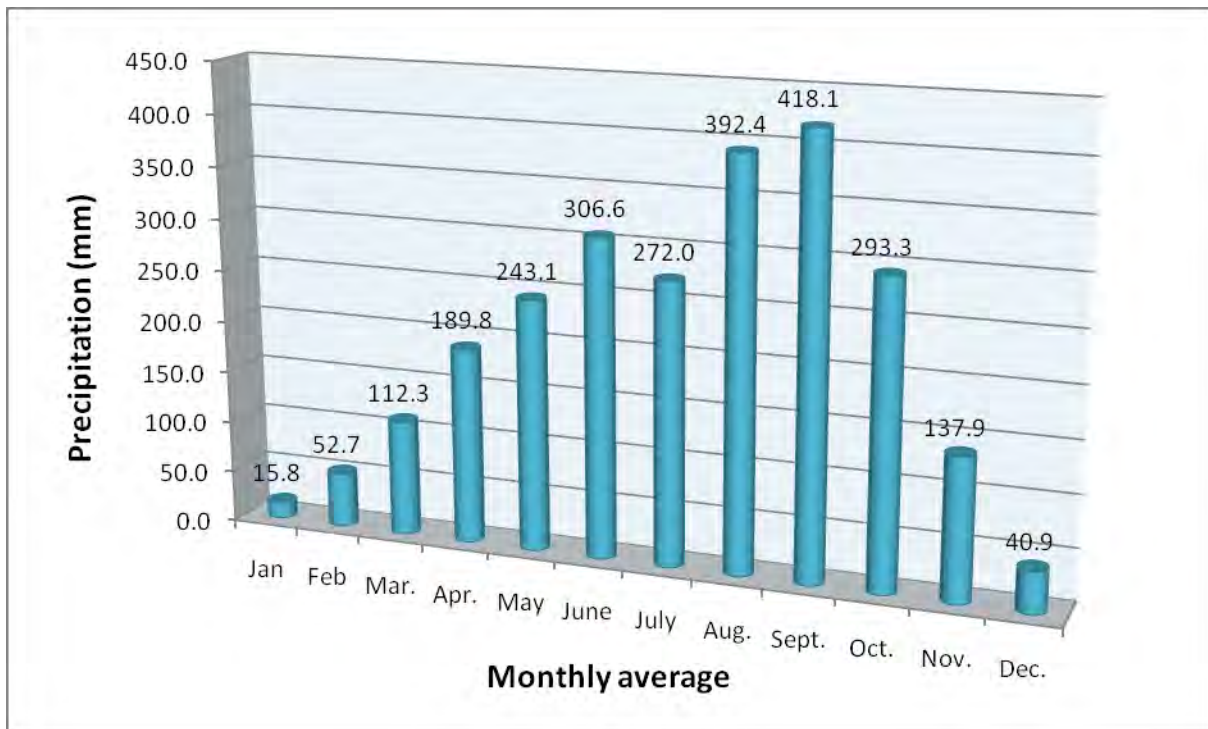


Figure 3-5: Average monthly precipitation from year 1961 till 1980 (Liberian Hydrological Service, 1981).

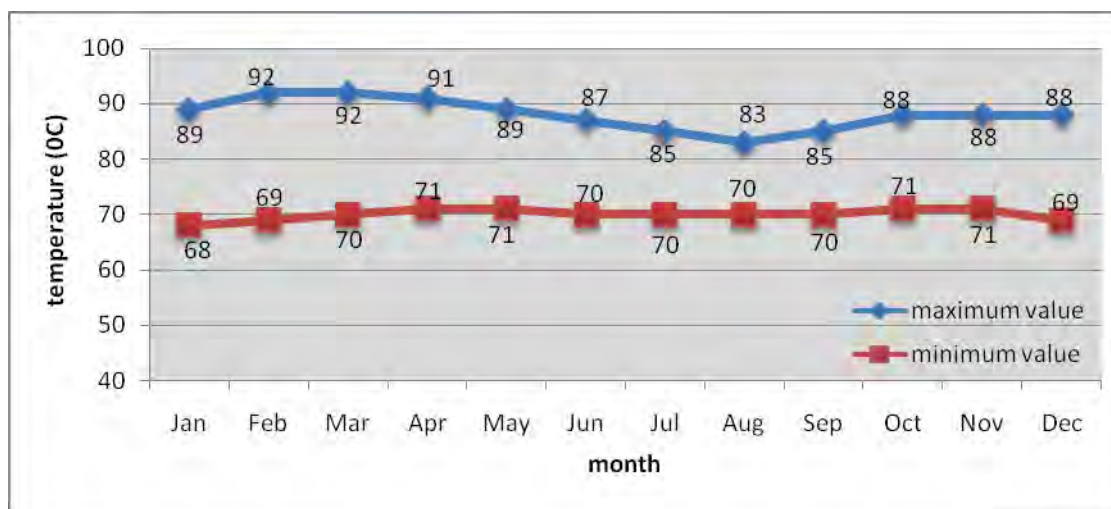


Figure 3-6: Monthly temperature variation (Liberian Hydrological Service, 1981).

3.3.2 Temperature

Temperature data in that area are available from year 1963 till 1981. Records (insert table of rainfall in Appendix) from temperature-reading station in that was

previously installed in the area, indicate that minimum temperatures fall within the months of January, December and August while hot weather condition prevail in the months of March, April and May (Figure 3-6) (Liberian Hydrological Service, 1982, 1981). Moreover, the mean minimum temperatures in the area range from 68 °F to 71 °F, while mean maximum temperatures vary from 87 °F till 92 °F.

3.3.3 Winds

No specific data on wind direction is available on the area.

Table 3-2: Average Annual Rainfall (1961-1980) (Liberian Hydrological Service, 1981).

1961	N.A	157.3	259.3	228.9	533.7	522.9	224.9	480.2	243.4	57.8	68.3	2776.7
1962	26.6	64.3	220.3	225.1	395.7	235.1	360.9	397.1	279.0	198.5	62.3	2526.4
1963	33.8	106.1	255.9	250.1	307.6	430.2	343.6	529.5	332.4	246.5	18.4	2956.7
1964	13.9	34.1	188.8	238.0	364.4	207.7	397.8	491.0	234.9	78.4	135.6	2477.8
1965	36.6	67.8	97.5	332.7	242.1	265.9	324.7	234.4	402.7	114.6	0.0	2600.4
1966	8.0	26.6	101.3	188.9	311.4	423.6	774.5	306.7	563.8	105.0	17.8	3067.4
1967	0.0	33.7	31.8	134.3	273.4	240.9	294.5	364.5	363.2	172.2	8.0	2027.1
1968	11.5	26.2	190.0	222.9	229.1	433.3	727.9	398.5	351.1	230.8	72.4	3327.4
1969	8.5	47.5	139.4	215.8	240.5	280.9	303.1	261.9	307.9	249.6	27.8	2323.9
1970	37.7	0.3	129.6	170.3	293.2	267.3	422.8	364.6	229.4	96.1	10.0	2104.3
1971	35.0	166.0	124.1	119.0	144.7	310.2	335.0	467.9	200.2	107.6	180.9	2326.7
1972	8.5	70.5	160.7	164.1	411.4	189.0	442.1	373.9	218.7	73.0	22.8	2363.0
1973	0.0	74.5	150.7	154.7	147.8	282.0	377.5	462.4	193.9	60.5	12.5	2190.3
1974	0.0	34.0	108.4	181.2	66.5	289.1	445.2	429.7	190.3	77.1	7.1	2140.2
1975	0.0	50.0	98.5	305.4	309.4	294.3	255.6	432.3	213.8	86.0	97.7	2356.5
1976	13.0	84.8	102.0	146.9	310.4	233.3	205.4	397.5	291.6	304.4	0.0	2223.8
1977	14.0	25.2	78.5	107.0	315.6	305.8	334.9	645.4	405.5	116.8	2.5	2545.7
1978	0.0	64.5	27.9	261.4	169.5	245.8	164.4	562.2	436.3	132.0	25.5	2288.0
1979	27.5	2.5	117.4	89.1	159.7	327.6	393.5	222.0	277.9	74.0	12.0	2348.1
1980	26.5	26.3	74.4	172.9	294.4	142.3	563.2	539.4	129.7	176.2	36.0	2456.2
Total	301.1	1002.1	2245.2	3795.3	4861.2	6132.7	7848.2	8361.1	5865.7	2757.1	817.6	--
Average	15.8	52.7	112.3	189.8	243.1	306.6	392.4	418.1	293.3	137.9	40.9	2474.8

3.4 GEOLOGICAL SETTING

Geologically, the study areas are located in the north eastern parts of Monrovia Quadrangle in the Liberian age province (Figure 3-7) northwest of the Gibi Mountain thrust. The Monrovia Quadrangle is within the Guinean Shield of West Africa and includes parts of the Liberian and Pan-African age provinces (Figure 3-7).

The geology of the study area, including subsurface stratigraphy and structure, was developed based on: 1) review of available maps and literature, 2) analysis of satellite images, and 3) geological surveys and site visits conducted by Earthtime geologists. The result was a better understanding of the geological formations and structures in the surrounding of the location of both the plantation and the factory.

The geological investigation focuses on two parts (Figure 4-8); the Factory area and its surrounding as well as the Plantation area. A geological map covering an area of approximately 1025 Km² and falls within the following coordinates: 29 N 338584 UTM 753584, 29N 389080 UTM 753584, 29N 338584 UTM 718174 and 29N 389158 UTM 718174 (Figure 3-8).

The outcropping units are mainly Precambrian and Jurassic rocks. Due to the tropical weathering that has created a thick laterite and saprolite cover, which supported dense vegetation and rain forests were formed covering most of the rocks in Liberia (Tysdal and Thorman, 1983).

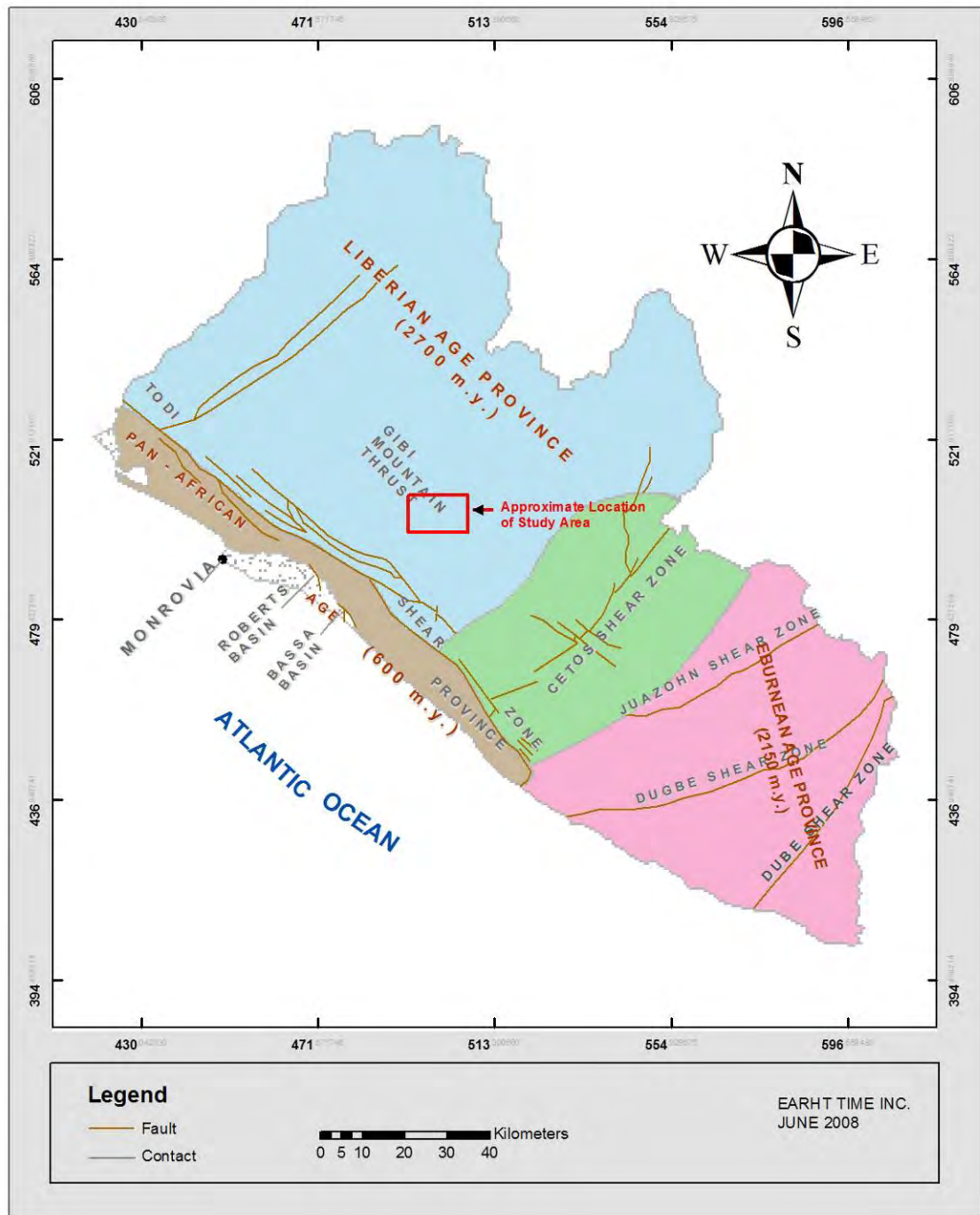


Figure 3-7: Geological provinces of Liberia (Tysdal and Thorman, 1983).

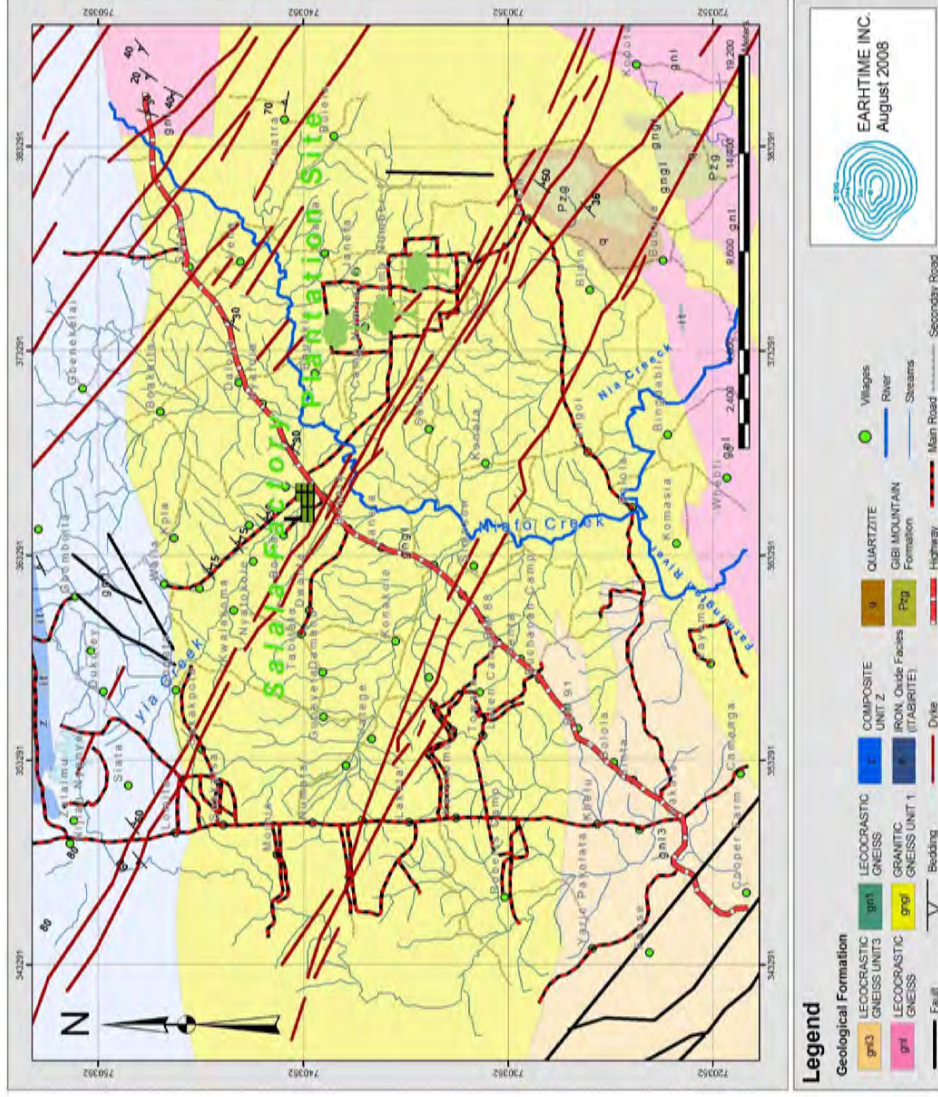


Figure 3-8: Geological map obtained from Geological Quadrangle of Monrovia (C. H. Thorman, 1977). Maps with better resolutions are available in appendix.

3.4.1 Stratigraphy

3.4.1.1 Plantation Area

The largest outcropping formation the plantation is the Granitic gneiss (gng1). It forms a big patch in the middle of the study area. Those gneisses are banded and predominantly granodiortic but range from granite to granodiorite. Sub-unit gng1 is characterized by diversely oriented large-scale folds and a general lack of structural continuity and vary over short distances from banded to nonbanded. The sub-unit gng1 is nearly massive coarse grained.

The composite gneiss unit (gn1) is present in the NE and the SW parts of the plantation and consists primarily of layered biotite-rich gneiss that in many places encloses or is associated with itabirite, schist, quartzite, and amphibolite. Northeast of the Todi shear zone, the gneiss contains mineral assemblages of the amphibolite facies, and southwest of the fault zone, it contains mineral assemblages of the granulite facies.

The Gibi Mountain Formation (pzg) (Thorman, 1976) is exposed in the south eastern parts of the plantation on Gibi Mountain. It is pre-Jurassic in age. This formation consists of three units; the basal massive conglomerate unit (0-100? M), which consists of subrounded clasts of crystalline rocks, as much as 15 cm across, in a dirty arkosic matrix; a medial unit, generally massive sandstone member (150-200? m) consists of nearly equal amounts of medium- to coarse-grained, sub-angular to sub-rounded, fairly well sorted quartz and feldspar in a matrix of sericite and very fine grained quartz and subordinate chlorite; an upper shale and mudstone unit (150m) consists of sericite and very fine grained quartz and feldspar. Most of the rocks are tan to brown, but some fine-grained sandstone and shale beds are various shades of purple and drab green.

Another formation at Klippe in the Gibi Mountain is made up of Quartzite Fommration (q) dominated by quartzite with minor amounts of itabirite. It is Precambrian in age. Small pods of graphitic schist crop out at and near the base of the klippe. The entire sequence, about 200 m thick, is mylonitized, and no relict textures were found.

Rocks mapped as leucocratic gneiss (gnl) crop in the south eastern sections of the study area and are considered to be Precambrian in age. This unit consists of granodiorite gneiss with subordinate granite and quartz diorite and minor diorite gneiss. Amphibolite appears to be common in gnl.

A dominant feature in the study area is the northwest-trending tholeiitic diabase dike (jd) system. They cross the area in three different zones in the extreme NE, in the middle and in the extreme SW. Those diabase dikes form long continuous ridges and are Early Jurassic in age the ages ranging from 173 to 192 m.y. (Grommé and Dalrymple, 1972).

3.4.1.2 Factory Area

The largest outcropping formation the plantation is the Granitic gneiss (gngl). It forms a big patch in the middle of the study area. Those gneisses are banded and predominantly granodiortic but range from granite to granodiorite. Sub-unit gng1 is characterized by diversely oriented large-scale folds and a general lack of structural continuity and vary over short distances from banded to nonbanded. The sub-unit gng1 is nearly massive rocks, and are commonly coarser grained than gng.

A dominant feature in the study area is the northwest-trending tholeiitic diabase dike (jd) system. They cross the Factory area in several locations. Those diabase dikes form long continuous ridges and are Early Jurassic in age the ages ranging from 173 to 192 m.y. (Grommé and Dalrymple, 1972).

3.5 HYDROGEOLOGICAL SETTING

Table 3-3 summarizes the hydrogeological setting surrounding the study area. The study area including the plantation and the factory is located on the Granitic Gneiss Unit (gngl) (Figure 3-8), which is biotite-bearing gneiss ranging from banded to massive in short distances and forming a fracture aquifer. The water level in the study area varies from 1.5 meters to 2.5 meters between rainy and dry season.

Records on depth of wells in the area are limited, yet some wells were reported to have a depth of around 60 meters. It is expected that these wells are tapping the Granitic Gneiss Unit fracture aquifer, yet this cannot be confirmed due to the lack of data of depth of wells in the area. The water levels in wells vary from 1 meter to 10 meters and from one location to another (Table 3-4).

Table 3-3: Hydrostratigraphic table of the area shown in the geological map.

Jurassic					
	Diabase and basalt (Jd)	northwest-trending tholeiitic diabase dike Tholeiitic amygdaloidal basalt overlies the Dp at two localities along the coast	-	aquiclude	Early Jurassic
Palaeozoic	Gibi Mountain Formation (Pzg)	Basal conglomerate with gneiss boulders in arkosic matrix; medial sandstone or arkosic wacke consists of medium- to coarse-grained, fairly well sorted, subangular to subrounded quartz and feldspar in sericite-quartz-chlorite matrix	300-450m	Fracture aquifer	Lower Paleozoic
Precambrian	Quartzite (q)	pure to slightly micaceous quartzite that displays only cataclastic textures and includes thin lenses of graphitic mylonite schist at base of unit	200m	Fracture aquifer	Varies with location
	Leucocratic Gneiss (gnI)	Light-colored medium-grained commonly banded biotite-bearing granitic to quartz diorite gneiss; appears to contain more amphibolite than			

		adjacent gng1;			
	Composite gneiss unit (gn1)	layered biotite-rich gneiss that in many places encloses or is associated with itabirite, schist, quartzite, and amphibolite	-	Fracture aquifer	Precambrian
	Granitic Gneiss Unit 1 (gng1)	Biotite-bearing gneiss but ranges from banded to massive in short distances	-	Fracture aquifer	Precambrian
	Granitic Gneiss (gng)	Light-colored medium-grained banded biotite-bearing Granitic to Granodioritic gneiss;	-	Fracture aquifer	Locally grades into massive Granitic rock

Table 3-4: Overview of water wells within the plantation and the factory.

							Plantation		
Camp 1	Well 2	736128.89	375418.86	58	60		370	NA	Active
	Well 3	736164.31	375427.60	58	07		358	3.18	Active
	Well 10	736077.19	375503.33	47	95		388	NA	Active
Camp 2	Well 16	737271.23	374637.90	80	54		380	NA	Active
	Well 17	737475.17	374599.49	62	33		367	NA	Active
	Well 18	737426.83	374449.75	82	35		359	4.61	Active
Camp 3	Well 19	737286.49	374370.29	62	83		362	NA	Active
	Well 13	734655.40	377654.10				429	10.19	Active

¹ Earthtime's reference ID for Salala Wells

² Depth to water with respect to ground level.

³ Tapped aquifers could not be identified due to lack of records related to depth of wells at the plantation. The wells were constructed before the war and the plantation was not under the current management's control.

Camp 4	Well 14	cross farm area	63	62	411	NA	Active	
	Well 15	Camp3 – pump 2 cross farm area	734868.90 65	377705.99 40	406	NA	Active	✓
Camp 5	Well 11	Camp 4 – pump 1 plantation central school	734747.78 04	377722.45 76	391	NA	Active	✓
	Well 12		736927.35 69	375582.52 97	401	NA	Non active	
	Well 1	Camp 5 staff compound	736898.03 56	375709.56 75	417	NA	Active	✓
Clinic	Well 4	Camp 5 – pump 1 close to road	735321.54 58	375209.96 70	551	NA	Active	✓
	Well 5		735527.27 21	372684.48 52	466	NA	Non active	
	Well 6		735449.98 38	372638.68 64	395	NA	Active	
	Well 7		735234.38 27	372602.20 23	423	NA	Active	
Factory	Well 8		735315.79 39	375525.86 45	399	NA	Active	
	Well 9	Clinic pump	735634.37 92	375581.07 54	432	NA	Active	
	Well F1		735734.17 30	375377.34 14	Factory	NA	Active	✓
					1			In-Situ Analysis

3.5.1 Water Resources

The hydrogeological assessment indicated several springs, creeks, swamps and a river. Physically, several springs at different locations have their sources within the confines of the concession area. The Vast expanse of swamps is indicative of rainforest vegetation, several floral species, and existing agricultural activities. One major river flows down before reaching the entrance of Weala Concession Area. It is mostly used for off-division drinking purpose, laundry, fishing, swimming, and local transport.

The study area falls within the upper basin of the Farmington River. This basin is drained by the Yia Creek, the Nia Creek and the Bolo River, all of which flow into the Farmington River (Figure 3-9).

3.5.2 Farmington River

The Farmington River is considered as 3rd order stream with a drainage area of 1,656 km² (Table 3-5). The Farmington River has a drainage density of 0.2 km/km² which reflects a poor ability to respond rapidly to rainfall inputs, and subsequently not highly dissected and not well drained.

Several streams and creeks contribute to the Farmington River. Among these is the Niafo Creek which is fed by the Yia Creek, Bolo River, as well as other minor streams. At coordinates 29 N 365138.43 UTM 723959.89, the Niafo Creek bifurcates to form the Farmington River and the Nia Creek. The Farmington River from this location, flows in the southwest-northeast direction for a distance of approximately 3.3 km before it meanders 90° at approximate coordinates 29 N 361454.92 UTM 722645.39. The river then extends in the south-southeast-north-northwest direction for a distance of 5.7 km before it makes another 90° turn towards the north and flows for a distance of 792 meters and then another 90° turn towards the east followed by

90° turn towards the south-southwest (Figure 3-10). Following this, and with several streams and creeks contributing to the river (Table 3-5), it generally extends in the SSW-NNE direction and flows towards the SSW to enter the Atlantic Ocean.

Currently, the major water use categories in the Farmington River range between Industrial (mainly rubber production and Hydropower) and water supply (village and irrigation).

Table 3-5: List of classified tributaries (Liberian Hydrological Survey, 1983).

Farmington River	1,656
Du, Junk, Bo River	1,499
Wo River	661
Bolo River	1,107
Nia, Din Creeks	329

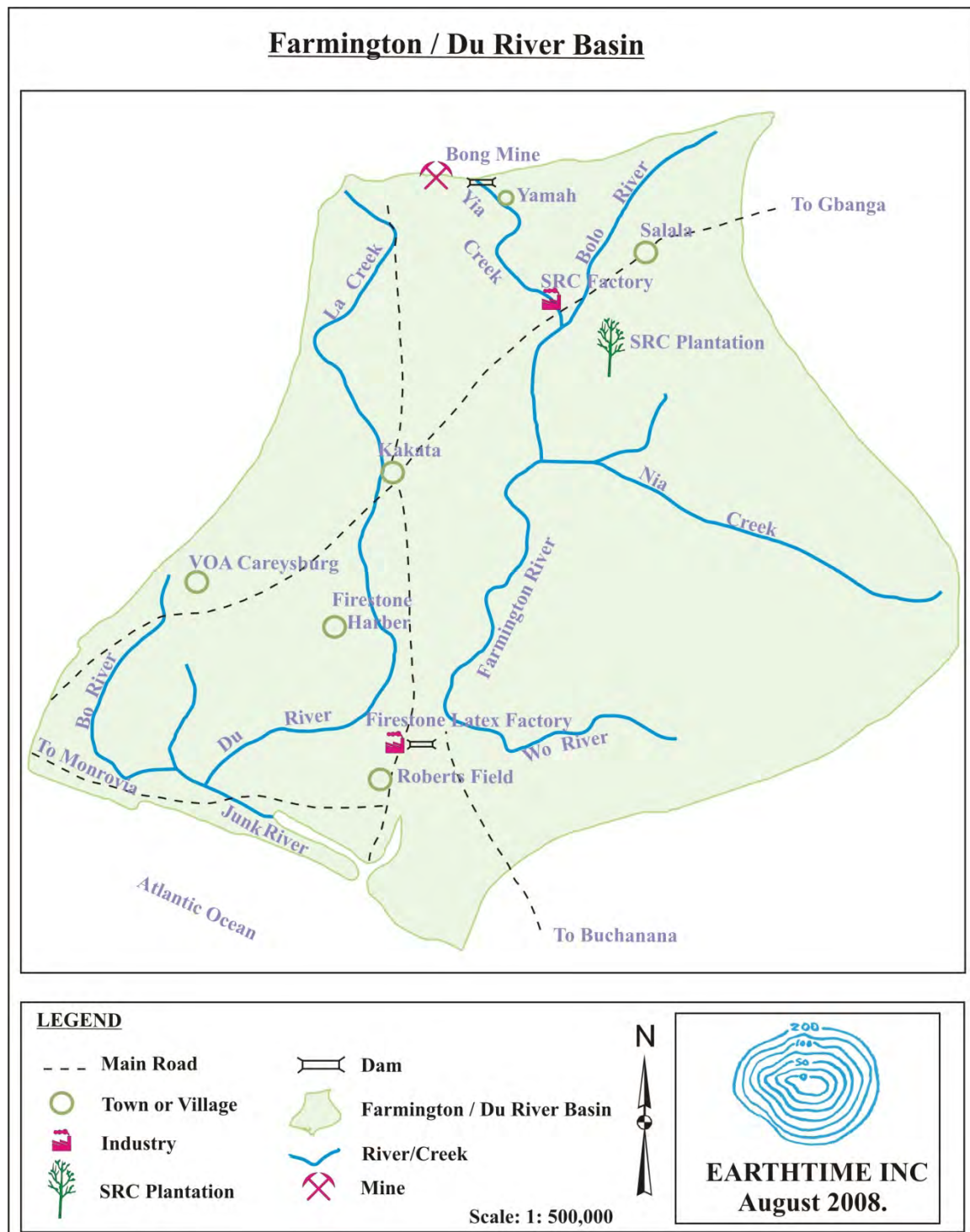


Figure 3-9: Farmington / Du River Basin (modified from Liberia Hydrological Service, 1983).

3.5.3 Yia, Niafo Creek and Bolo River

The Yia Creek originates from the Bong Range where it extends in a northeast-southwest direction and flows towards the southwest. The creek meanders 90° at

approximate coordinates 29 N 0354062 UTM 747987 to extend in the northwest-southeast and flow in the southeast direction (Figure 3-10). The total length of the Yia Creek is approximately 24 km. At coordinate 29 N 366890.25 UTM 737994.21, the Yia Creek meets the Bolo River where they both pour into the Niafo Creek about 1.8 km northeast of the factory. Meanwhile, the Niafo Creek generally extends in the north-south direction and flows a distance of approximately 1.9 km towards the south where it pours into the Farmington River (Figure 3-10).

Several streams flow into the Yia Creek at different locations. The Kono Creek which generally extends in the northeast-southwest direction pours into the Yia creek at two different locations; the first location is at approximate coordinates of 29 N 0459013 UTM 744998 while the second location is at approximate coordinates of 29 N 0357175 UTM 746535 The source of Kono Creek also appears to be from the Bong Range.

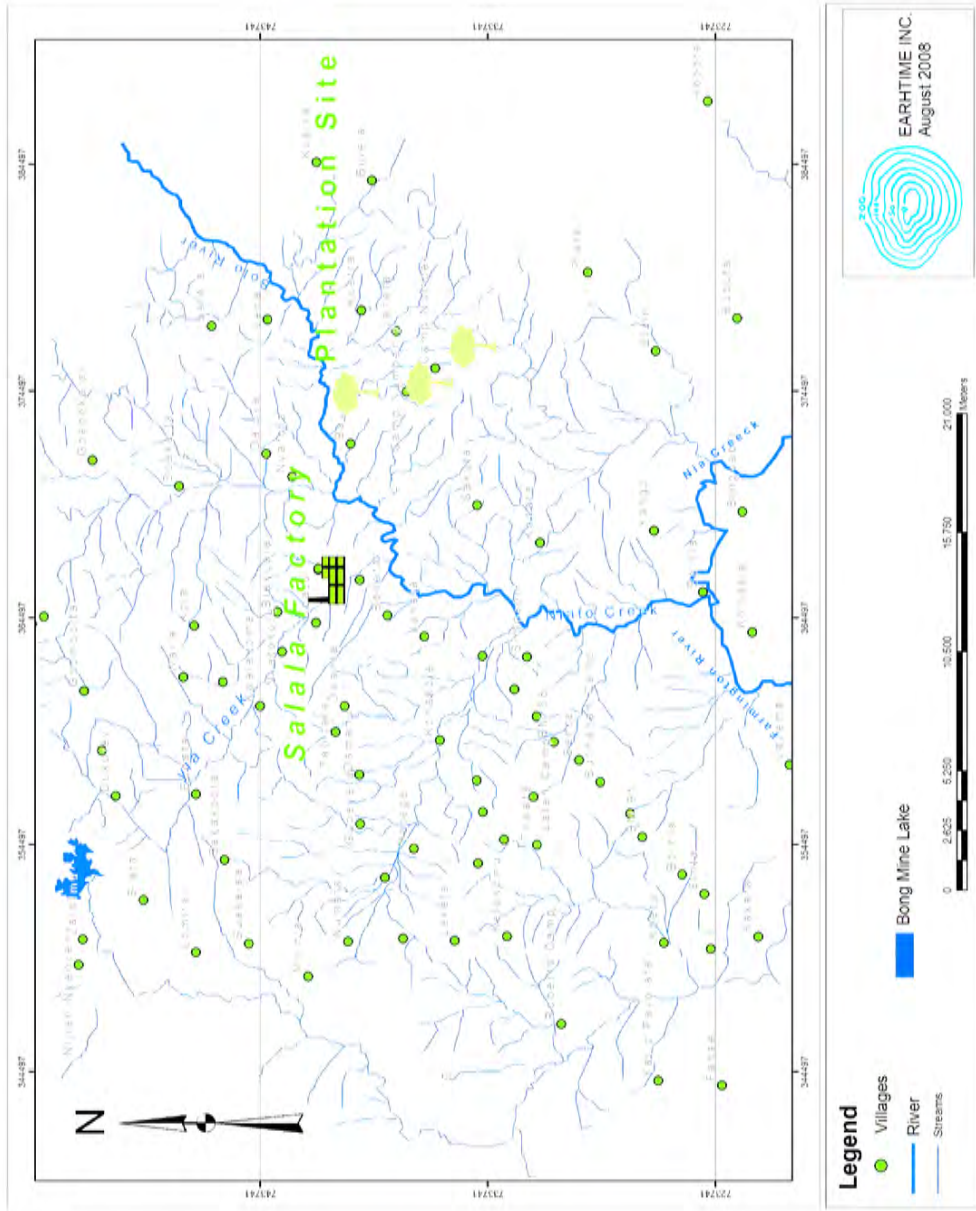


Figure 3-10: Hydrological map of the study area. Maps with better resolutions are available in appendix.

3.5.4 Groundwater Wells

Nineteen wells are located within the plantation to supply water to the camps while one well exists in the factory and being used to provide drinking and potable water (Figure 3-11). Records on the depth of the wells are not available. These wells have been drilled several years before the war while most of them were rehabilitated after the merger between Weala and Salala. Measurements taken on the plantation's site indicate that the static water level in the wells vary from 1 meter to 10 meters, while that of the factory is 1 meter. The static water level could drop down to 2 meters under pumping conditions. Records on the year of drilling and installing the wells are not available. All the wells are protected with cement covers (Figure 3-12). Hand pumps are installed in the plantation's wells, and an electrical pump is used to pump water from the well on the factory's site.

The physic-chemical properties of water in at least one well in each camp were tested. The physic-chemical properties of water of the well on the factory (Well F1) were also tested. Analysis of the results is presented in **section xxx**.

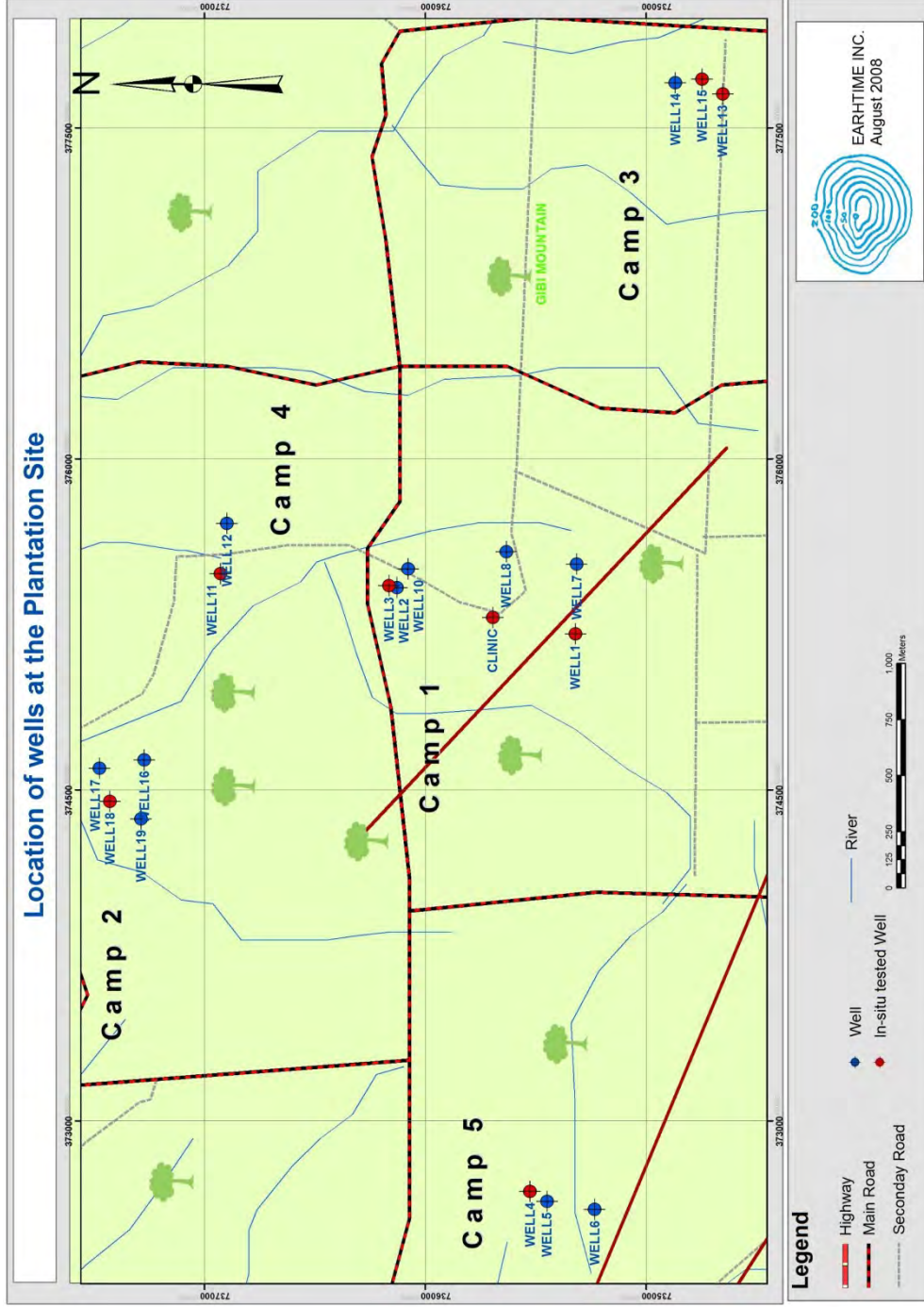


Figure 3-11: Location of wells within the plantation. Maps with better resolutions are available in **appendix**.



(a)



(b)

Figure 3-12: Wells covered with cement.

3.6 ECOLOGICAL STATUS

The forest area of SRC concession hosting the rubber plantation shows tropical features of tropical rainforest vegetation and a pronounced predominance of rubber tree species (*Havea Brasiliensis*).

The forest area and general site location are indicative of agricultural degradation, largely due to rubber culture or monoculture and swamp based farming activities.

Owing to disturbance correlated to agricultural degradation, the biological richness of the SRS concession is notable of secondary endemic tropical plants and silviculturally degraded vegetation including remnant of Cotton Trees, Abura (*Mitragyna Ciliata*), Niangon (*Niangon sp*), Makore (*Dumoria Heckelii*), Taima Tree Species (*Taima sp*), as well as other plants endemics found in the area. Moreover, cover up plants, mimosas species (*Mimosa Pigra*), and ferns are predominantly found throughout the concession. Liberia hosts the largest portion of relatively intact forest. Approximately 2000 flowering plants and 240 timber species are known to inhabit Liberia's forests (Shulze, W. 1973). Table 3-6 contains a list of the most common commercial species within the forest.

Table 3-6: Predominant mature forest tree species.

Common Name	Predominant Species	Uses
Sikon	<i>Tetraberlinia tubmaniana</i>	Timber / construction
Iroko	<i>Iroko sp.</i>	Furniture
Ekki (ironwood)	<i>Lophira alata</i>	Bridge construction
Makore	<i>Dumoria heckelii</i>	Local construction
African Walnut	<i>Lovoa trichiliodes</i>	Furniture purpose
Dahoma	<i>Dahoma sp.</i>	Furniture
Latex	<i>Latex sp.</i>	Timber /furniture
Neaongon	<i>Neaongon sp.</i>	1 st class furniture making
Mango/Upaca	<i>Upaca spp.</i>	Furniture
Yellow-wood	<i>Opheria Africana</i>	Construction
Tali	<i>Tali sp.</i>	Construction
Canarrium	<i>Canarrium sp.</i>	Furniture
Upaca or Mango (Ironwood)	<i>Upaca sp.</i>	Furniture
Mamia	<i>Mamia Sp.</i>	Furniture
Taima	<i>Taima Sp.</i>	Construction

The SRC concession domain also lies within the Upper Guinean Forest Belt of West Africa and play an integral role in attracting avifauna since it provides conveyance and transit for migratory birds. This belt stretches from western Togo eastern Sierra Leone and is considered to as one of highest global conservation priorities due to its high levels of endemism, species rarity and the extreme and immediate threats facing its survival. The relative fauna species endemism includes grass cutter (locally referred to as groundhog), fruit bat (*Scotonycteris Zenkeri*), porcupine, tree

pangolin, hare hog, palm tree civet, scaly-tailed squirrel (*Anomalurus cf. Pusillus*), rodent (*Hylomyscus Alleni*), funny tunker, and rats. Other avifauna includes long-tailed hawk (*Urotiorchis Macrourus*), common bulbul (*Pycnonntus Barbatus*), palm-nut-vulture (*Gypohierax Angolensis*), balck bee-eater (*Merops Muelleri*), bron-eared woodpecker (*Campethera Caroli*), swamp palm bulbul (*Thescelocichla Leucopleura*), brown sunbird (*Anthreptes Gabonicus*), cowbird (*Molothrus Ater*) and black casqued-hornbill (*Ceretogumna Atrata*).

Liberia’s forest is known to host 150 mammals, 590 birds, 125 reptiles, and amphibians and over 1000 insects. Meanwhile, the forest area hosting the SRC concession were known to host a wide range of animals such as large hornbills, elephants, large primates, pygmy hippopotamus, and buffalo. These species are negatively affected and disturbed by hunting, farming and logging. Rare species such as Zebra and Jentink’s duiker as well as species of antelope are reported to be commonly seen and abundant; such species dwell in patchy forest and regenerating forest/bush fallow areas. Table 3-7 outlines a list of animals expected to be present in the area.

Table 3-7: Expected fauna present in the area.

Common Name	Current Status	Genus & Species
Pygmy Hippopotamus	Common in Bolo River	<i>Hippopotamus liberiensis</i>
Elephant	Rare	
Forest Black Buffalo	Fairly common	<i>Synerus caffer nanus</i>
Jentinki Duiker	Common	<i>Cephalopus jentinki</i>
Zebra Duiker	Fairly common	<i>Cephalopus doriae</i>
Ogilby Duiker	Fairly common	<i>Cephalopus brooke</i>
Yellow –backed Duiker	Fairly common	<i>Cephalopus silvicolor</i>
Black Duiker	Fairly common	<i>Cephalopus niger</i>
Blue Duiker	Fairly common	<i>Cephalopus monticola</i>
Royal Antelope	uncommon	<i>Ncotragus pygmaeus</i>
Bush Pig	common	<i>Potamochoerus Porcus</i>
Tree Dassie		<i>Dendrohyrax Arboreus</i>
Aardvark/Antbear	common	<i>Orycteropus Afer</i>
Marsh Mongoose		<i>Atilas Paludinosus</i>
Dark Mongoose		<i>Crossarchus Obscurus</i>
Lesser Mongoose		<i>Herpests (Galerella) Sanguineus</i>

Great Grey Mongoose		Herpestes Ichneumon
African Linsang		Poiana Richardsoni
Forest Genet		Genetta Paradina
Bush Pig	common	
Groundhog	common	
Fresh water turtles(2 spp)		
Dark Mongoose	Fairly seen	Crossarchus obscurus
All Black Snakes	common	
All Green Snakes	common	
Rats (about 3 species)	common	
Squirrel	common	

3.7 SOCIO-ECONOMIC STATUS

Salala Rubber Company is located in Margibi County (**Error! Reference source not found.**), which is known for its revenue generation from its educational facilities thus classifying the county as one of the most important counties.

In addition to Salala Rubber Company, the county hosts other important rubber plantations such as Firestone Plantation Company.

The county is bordered by Montserrado County on the north, Grand Bassa on the south, Bomi County in the east and Bong County in the west. There are ten-political divisions which include two districts (Gibi and Mambahn-Kabah) two cities (Kakata and Marshall) and six townships (Cinta, Borlorla, Larkayta, Schiefflin, Charlesville and Lloydsville).

The hierarchy of administrative officers is headed by superintendent, cities are headed by mayors, and townships and districts are headed by commissioners.

The County's population as estimated by the Ministry of Planning and Economic Affairs (MPEA) in year 2000 was 224,418. However, the population before the war was 345,000. The Bassa and Kpelle ethnic are the main two ethnic groups (among the sixteen living in Liberia) living in the County. Meanwhile, Christians and

Muslims are roughly estimated to be about 90 percent and 5 percent, respectively whereas the other 5 percent are animist.

The two main functional government hospitals in the county are C.H Rennies Hospital, a referral in Kakata (Upper Margibi County) and Mike M. Baydoun Health Centre in Marshall City (Lower Margibi County). These medical facilities are not fully functional and need renovation and supplies for full operation.

In addition to the two government hospitals, there are three private clinics/primary health centres; namely, Borcollah, Madina and City Clinics, all in Kakata as well as the clinic existing on the Plantation of SRC.

The area where the Salala Rubber Corporation is situated hosts several well established wholesale and retail businesses, individual agricultural farms, and major industry, namely the Salala Rubber Corporation's (SRC) Factory and Plantation. These businesses vary from assorted building materials and dry goods stores (e.g. David Kollie Store), petroleum stations, vehicle repairing garages, local construction groups to scores of self-managed economic activities.

In addition, there are a number of other micro-enterprises such as cookshops, petty trading in dry goods, used clothing, petroleum products and engine oils, and domestically consumed agricultural crops including corn, sugarcane, palm nuts and oil, cassava, plantain, and vegetable crops consisting of greens, pepper, bitter balls, onion, cabbages, etc. Agriculture is supported by various employment entities, including SRC, NGOs, several Local Implementing Partners (CDC, NAEAL, and AGRHA) and CBOs involved with Community Peace Building, Development Program and provision of smaller job opportunities.

Other undersized businesses include several communication and phone repairing centers (e.g. Trust Business Link), local entertainment center (e.g. Beer Garden),

tailoring shops, hair dressing and barbing saloons, tire shops, video club, scratch cards dealers, local currency exchangers, rural marketers and street vendors.

SRC creates 1659 job opportunities in several domains such a management, engineering, accounting, secretaries, drivers, tappers, Physician Assistants, etc (Table 3-8).

Table 3-8: Distribution of SRC's employees.

Department	Occupation	No. of Employees	Level
General Management	General Manager	1	Management
	Secretary	1	Staff
	Radio Operator	1	Workers
	Office Boy	1	Workers
	Driver	1	Workers
	Steward	1	Workers
	Gardeners	12	Workers
Plantation	Operations Manager	1	Management
	Estate Superintendent	1	Superintendent
	Tapping Quality Inspector Superintendent	1	Superintendent
	Tapping Quality Inspectors	2	Staff
	Overseer	8	Staff
	Clerk	30	Staff
	Headman	30	Staff
	Tapers and Spares	345	Workers
	Regular workers	171	Workers
	Regular workers	32	Contractors
	Acid Boys	3	Workers
	Extension Supervisor	2	Staff
	Nursery Supervisor	2	Staff
	Contractors	227	Contractors
	Administrative Assistant	1	Staff
	Office workers	3	Workers
	Plantation Warehouse	2	Workers
	Plantation Road / Transport Supervisor	1	Staff
	Workshop	3	Staff
	Drivers	6	Workers
	Tractor Operators	2	Workers
	Tractor Boys	30	Workers
Technical	Technical Manager	1	Management
	Secretary	1	Workers
	Driver	1	Workers

	Steward	1	Workers
	Processing Superintendent	1	Superintendent
	Shift Supervisor & Deputies	1	Staff
	Factory Management	1	Workers
	Wet End Workers	5	Workers
	Wet End Workers	56	Contractors
	Dry End Workers	1	Workers
	Dry End Workers	57	Contractors
	Supervisors	2	Staff
	Packing Workers	7	Workers
	Packing Workers	21	Contractors
	Engineering & Maintenance Superintendent	1	Superintendent
	Vehicle Workshop Supervisor	1	Staff
	Mechanical Technician	7	Staff
	Mechanical Technician	16	Workers
	Mechanical Technician	27	Contractors
	Welders	1	Staff
	Electrical Supervisor	1	Staff
	Electrical Technician	5	Workers
	Electrical Technician	2	Contractors
	Construction Technician	2	Staff
	Construction Technician	7	Workers
	Construction Technician	7	Contractors
	Technical Warehouse Supervisor	1	Staff
	Technical Warehouse Workers	1	Staff
	Technical Warehouse Workers	4	Workers
	Technical Warehouse Workers	2	Contractors
	Quality Assurance Superintendent	1	Superintendent
	Quality Supervisor	1	Staff
	Laboratory Technicians	2	Workers
	Inspectors	2	Workers
	Labourers	1	Workers
	Labourers	18	Contractors
Rubber Purchase	Rubber Purchase	1	Management

	Manager		
	Driver	1	Workers
	Steward	1	Workers
	Senior Purchase Superintendent	3	Superintendent
	Regional Supervisor	1	Staff
	Senior Rubber Buyers	7	Staff
	Junior Rubber Buyers	14	Workers
	Weighing Clerks	9	Workers
	Weighing Clerks	4	Contractors
	Loaders	111	Contractors
	Monitors	14	Workers
	Weighbridge Superintendent	1	Superintendent
	Weighbridge Supervisor	1	Staff
	Weighbridge Clerk	1	Staff
	Weighbridge Rubber Reception	1	Staff
	Weighbridge Rubber Reception	10	Workers
	Weighbridge Rubber Reception	36	Contractors
	Quality Control Supervisor	1	Staff
	Logistics Supervisor	1	Staff
	Drivers & Truck Boys	43	Workers
	Farm Supply/Support Warehouse Supervisor	1	Staff
	Farm Supply/Support Warehouse Supervisor	1	Workers
Finance, Accounting & Operations	Financial Controller	1	Management
	Driver	1	Workers
	Steward	1	Workers
	Senior Accountants	4	Staff
	Junior Accountants	3	Staff
	Operations	2	Staff
	Bank & Cash Handling	2	Staff
	Debt Collection Supervisor	1	Staff
	Auditing	1	Staff
	Shipping Superintendent	1	Superintendent
Administration	Administration Superintendent	1	Superintendent
	Secretary	1	Staff
	Driver	3	Workers
	Clinic Superintendent	1	Superintendent
	Factory Clinic	1	Staff
	Factory Clinic	1	Workers

	Plantation Clinic	1	Superintendent
	Plantation Clinic	3	Staff
	Plantation Clinic	6	Workers
	School Superintendent	1	Superintendent
	School Superintendent	1	Contractors
	Factory School	15	Contractors
	Plantation School	21	Staff
	Factory Security	3	Staff
	Factory Security	33	Workers
	Factory Security	25	Contractors
	Plantation Security	65	Contractors
	JLU Monrovia Security	1	Staff
	JLU Monrovia Security	4	Workers
Human Resources	HR Superintendent	1	Superintendent
	HR Administration	1	Staff
	Social Security Officer	1	Staff
	HR Payroll	1	Staff
	HR Payroll	1	Workers
	Total	1659	

4 DESCRIPTION OF THE PLANTATION AND THE FACTORY

4.1 GENERAL DESCRIPTION OF THE FACTORY

The factory of SRC was established in June 1998 by Weala Rubber Company to process natural rubber (coagulated latex from *Hevea Brasiliensis*) and produce high grade crumb rubber that meets the requirements of TSR grades. The factory is originally designed to process 2 tons per hour but currently has an output of 2.6 tons per hour. At full output the factory can produce 20,000 tons per annum whereas the actual output depends on the availability of raw rubber.

The natural rubber processes at the factory is received from SRC's Plantation and purchased (Table 4-1) from local farmers or other buying stations. The output production of the factory depends on availability of raw rubber and varies from one year to another (Table 4-2).

Table 4-1: Wet rubber purchases in tons/year. Note that 2003 is considered only as 9 months and a half or real operation

		Year						
		2002	2003	2004	2005	2006	2007	2008
Month	Jan.	2,425	3,330	2,543	2,492	2,944	2,516	2,723
	Feb.	1,675	2,748	2,340	2,056	2,066	1,790	1,920
	Mar.	1,748	2,241	2,687	1,743	1,714	1,700	1,234
	Apr.	1,567	1,548	2,228	1,736	1,637	1,778	1,309
	May	1,757	2,279	2,904	2,269	2,174	2,248	
	Jun.	1,624	418	2,628	2,236	2,399	2,057	
	Jul.	1,791	905	2,838	2,893	2,708	2,154	
	Aug.	2,283	0	2,589	2,301	2,057	1,433	
	Sep.	2,449	198	2,646	2,873	2,727	2,074	
	Oct.	2,366	1,350	2,225	3,190	2,716	2,620	
	Nov.	2,625	1,893	2,555	3,614	2,973	2,744	
	Dec.	3,643	2,782	3,184	3,739	3,310	3,999	
	Totals	25,953	19,692	31,367	31,142	29,425	27,113	7,186
Average	2,163	2,073	2,614	2,595	2,452	2,259	1,797	

Table 4-2: SRC's factory output production (tons/year). Source: SRC records. Note that 2003 is considered only as 9 months and a half or real operation

Month	Year								
	2001	2002	2003	2004	2005	2006	2007	2008	
Jan.	1,107	1,381	1,555	1,545	1,573	1,636	1,650	1,691	
Feb.	1,193	1,167	1,607	1,562	1,502	1,588	1,609	1,555	
Mar.	1,320	1,437	1,433	1,692	1,704	1,842	1,662	1,370	
Apr.	1,317	1,136	1,368	1,557	1,690	1,647	1,477	1,432	
May	1,513	1,269	1,635	1,543	1,658	1,609	1,292		
Jun.	1,263	1,400	716	1,397	1,809	1,465	1,267		
Jul.	1,175	1,261	838	1,477	1,308	1,672	365		
Aug.	1,308	1,280	-	1,566	1,377	1,671	1,644		
Sep.	1,270	1,362	104	1,220	1,549	1,617	1,317		
Oct.	1,306	1,478	1,367	1,480	1,630	1,666	1,451		
Nov.	1,379	1,422	1,472	1,536	1,247	1,627	908		
Dec.	1,366	1,503	1,471	1,642	1,461	1,578	1,463		
Totals	15,517	16,096	13,566	18,217	18,508	19,618	16,105	6,048	
Average	1,293	1,341	1,428	1,518	1,542	1,635	1,342	1,512	

4.2 GENERAL DESCRIPTION OF THE PLANTATION

The plantation of SRC covers a concession area of 8500 ha situated in the Dining- Ta Clan and Gibi District in Margibi County. It has 2790.83 ha mature area plus 714.14 ha immature area (SRC, 2008). Table 4-3 and Table 4-4 show the types of rubber trees grown and cultivated on the plantation's mature and immature areas, respectively. The rubber trees in the plantation are selected and propagated by means of budgrafting rootstock seedlings with the desired clone (SRC, 2008).

Table 4-3: Distribution of the surface per clone in mature area. Source: SRC.

Clone-ID	Planting Years	Surface (ha)	% per clone
Harbel-1	1961 - 1963	1096,43	39,29
LCB-510 / PR-107	1961/64/78/81	821,4	29,43
GT-1	1963/64	274,6	9,84
Chemaera-30	1964	86,5	3,10
PB-86	1964	29,5	1,06
PB-5/51	1966	64,3	2,30
RRIM-600	1966	31,9	1,14
RRIM-623	1965	92,5	3,31

RRIM-628	1965	96	3,44
Clonal Garden	1966/67	33,6	1,20
Various	1967	61	2,19
BD-5	1962	40,6	1,45
Seedlings	1963/64	62,5	2,24
TOTAL		2790,83	100,00

Table 4-4: Distribution of the surface per clone. Source: SRC, 2008.

Clone-ID	Planting Years	Surface (ha)	% per clone
Harbel-1	2001 - 2003	113,96	15,96
LCB-510 / PR-107	2001 / 2002 / 2003 / 2006	211,05	29,55
GT-1	2002 / 2003 / 2007	108,96	15,26
AVROS-2037	2003	4,1	0,57
RRIM-600	2002 / 2003	6,92	0,97
RRIM-623	2003 / 2006	162,58	22,77
Harbel-10	2002 / 2003	106,57	14,92
TOTAL		714,14	100,00

Wet rubber production at the plantation varies over the years. The production of wet rubber for years 2005, 2006 and 2007 are indicated in Table 4-5. An estimate for production overview per month for year 2008 is presented in Table 4-5

Table 4-5: Production of wet rubber for year 2005, 2006, 2007 and 2008. Source: SRC, 2008.

2005	4340
2006	4209
2007	4122
2008	4200 ⁴

⁴ Production projection for year 2008

Table 4-6: Estimated production overview per month for 2008. Source: SRC, 2008.

January	434	10,33
February	251	5,98
March	289	6,88
April	297	7,07
May	325	7,74
June	315	7,50
July	325	7,74
August	315	7,50
September	385	9,17
October	424	10,10
November	420	10,00
December	420	10,00
TOTAL	4200	100,00

The company has a plan to expand and cultivate plantable areas in the concession within the next five years. A replanting program will start after the extension program in order to gradually replace the existing old rubber trees (Table 4-7).

Table 4-7: SRC's extension and replanting program 2008-2015. Source: SRC, 2008.

year of planting surface (ha)	Extension						Replanting	
	2008	2009	2010	2011	2012	2013	2014	2015
	300	591,32	661,38	1126,3	1321	885,1	956,23	949,5

4.3 INFRASTRUCTURE

The factory's and the plantation's structures include power plants, rubber processing plant, clinics, schools, camps, residential units, offices complexes, warehouses and storage facilities, laboratory, and workshops (**Error! Reference source not found.**, Table 4-8 & Table 4-9).

Table 4-8: Distribution of SRC's main infrastructures.

No.	Structure	Factory	Plantation
1.	Power Plants	√	√
2.	Processing & Packaging	√	

Plant			
3.	Warehouse and storage facilities for fuel, raw material and chemicals	√	√
4.	Workshop and garage stations	√	√
5.	Clinic	√	√
6.	Laboratory	√	
7.	Office Complexes & Administration	√	√
8.	Residential Units / Complexes	√	√
9.	Camps		√
10.	Schools		√

Table 4-9: Type and number of structures of SRC.

Type	Number
Head Offices	
Plantation office	
Factory	
Compounds	
Camps	
Clinics	
Schools	
Management Staff Bungalows	
Workshop	
Clubs	
Guest Houses	

4.3.1 Workshops and Power Plants

A vehicle repair and maintenance workshop (Figure 4-1) and the power plant are located within SRC factory's compound. The workshop is used to facilitate repair and maintenance of factory's machinery and vehicles. Table 4-10 lists vehicles used by the SRC. The power plant is located within the factory's compound (Figure 4-2), houses three generators (Table 4-11). **Error! Reference source not found.** lists types and quantities of petroleum used at the facility.



(a)



(b)

Figure 4-1: Views SRC factory's workshop.

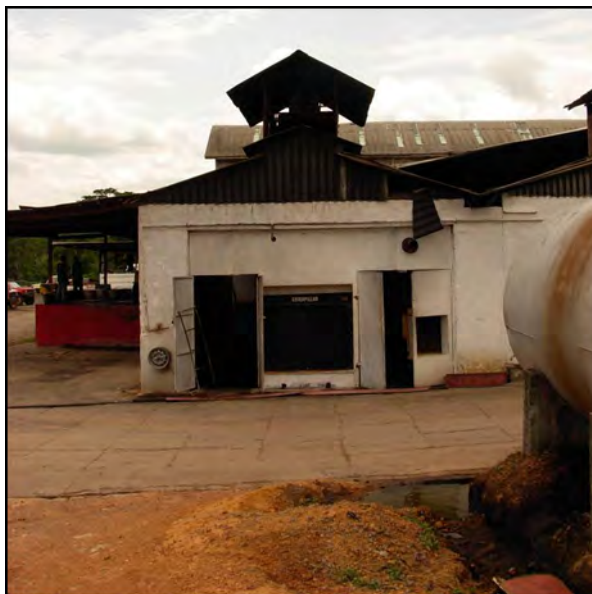


Figure 4-2: Power plant within SRC's factory.

Table 4-10: List of mobile equipment at SRC.

No.	Type of Vehicle	Make/Brand	Model	Engine HP	QTY
1	Trucks	DAF 4x4	1980/82	N/A	2
2	Trucks	Mercedes 4x4	1994/95	N/A	3
3	Land Cruiser-P/P	Toyota	1990	N/A	1
4	Jeep	Toyota 4Runner	1990	N/A	1
5	Mini Bus	Toyota	1991	N/A	1
6	Land Cruiser	Toyota	2000	N/A	1
7	Hilux	Toyota	1996	N/A	1
8	Hilux D/Cab.	Toyota	2004	N/A	1
9	Land Cruiser	Toyota 4x4	2007	N/A	6
10	Hilux D/Cab.	Toyota 4x4	2007	N/A	1
11	Tractor	M/Ferguson	1985	N/A	3
12	Sedan	Toyota Corolla	1998	N/A	1
13	Sedan	Toyota Corolla	1988	N/A	1
14	Motorcycle	Yamaha	2007	N/A	11
15	Motorcycle	Yamaha	2003	N/A	4
16	Dyna	Toyota	2004	N/A	2
17	Hilux	Toyota	2004	N/A	5
18	Hilux	Toyota	2005	N/A	7
19	Hilux 4x4	Toyota	2003	N/A	2
20	Tractor	Landini DT88605	2006	N/A	3
21	Land Cruiser	Toyota	2005	N/A	3
22	Pickup	Fawjiaao	2005	N/A	1
23	Land Cruiser	Toyota	2006	N/A	6
Total Motor Equipment					67

Table 4-11: Description of the SRC's Generators Operation Patterns.

Generator	Average Daily Running Hours	Average Annual Running Hours	Purpose	Approximate Fuel Consumption	Approximate Fuel Consumption Year 2007	Percentage
Caterpillar 850kVA	10.96	4,000	Factory Production, offices & compounds	50 gal/hr	200,000 gal	49.24%
Caterpillar 750kVA	10.96	4,000	Production, offices & compounds	44.05 gal/hr	176,168 gal	43.37%
Caterpillar 150kVA	2.05	750	For factory, offices & compound with no production Plantation	28 gal/hr	21,000 gal	5.17%
Perkins 50kVA	8.22	3,000	For plantation operation	1.88 gal/hr	5,640 gal	1.39%
Caterpillar 30kVA	8.22	3,000	For plantation operation	1.13 gal/hr	3,390 gal	0.83%
				Total	406,198 gal	100%

4.3.2 Storage Facilities

Storage facilities at SRC include diesel fuel storage tanks factory vary from building to another and compose essential components of the production process. The facilities comprise a number of fuel tanks with various volumes mounted above ground (Figure 4-3). Fuel from these tanks is directed to a distribution system for use by vehicles, generators and the process dryer. The generators and dryer have day tanks for short term storage and control of fuel (Figure 4-4).



Figure 4-3: Fuel storage tanks. (a) tank # 1 with capacity 2600 gals; (b) tank # with capacity of 2750; (c) tank # 3 with storage capacity of 3250 gals; (d) tank # 4 with storage capacity of 5100 gals; (e) tank # 5 with storage capacity of 5400 gals; (f) tank # 6 currently not used.



Figure 4-4: Short term storage tanks. (a) Located with the processing plant for the dryer and (b) located within the power plant for the generators.

On the other hand, chemicals including agricultural fertilizers, insecticides, herbicides, and formic acid are stored on site in substantial buildings from which they are issued as required. The three warehouses available at the factory's site are used to store technical instruments and spare parts, agricultural supplies, and chemicals separately (Figure 4-5).



(a)

Insert photo for agricultural supplies warehouse

Insert photo for chemical supplies warehouse

Figure 4-5: Warehouse located within the factory's and used for storage of spare parts, and other technical instruments.

Among the main storage facilities on the factory's compound are the bunkers that are used for storing raw rubber awaiting processing. There are sixteen of these bunkers that are made of concrete walls and concrete floors and have a total storage capacity of 4,000 tons of raw rubber (Figure 4-6).

The various storage facilities of SRC are summarized in

Table 4-12.



(a)



(b)



(c)



(d)

Figure 4-6: (a) & (b) bunkers filled with raw rubber before being processed; (c) raw rubber in bunker with syrup leachate; (d) bunker partially empty.

Table 4-12: Storage Facilities at SRC.

Storage Facility	Qty	Sizes/dimensions	Storage Capacity	Location/Stage
Fuel tanks	5	Length: m Width: m		Factory
Rubber Bunkers	16	Length: m Width: 0 m	4000 tons	Factory
Agricultural Warehouse	1	Diameter: m Height: m		Factory
Chemical Warehouse	1	Length: m Width: m		Factory

4.3.3 Clinics

SRC operates two clinics where one is located at the factory and one on the plantation. These clinics are headed by Physician Assistants.

The clinic at the factory is equipped mainly with first aid kits to handle and treat minor injuries resulting in the factory. Cases other than minor injuries are referred to the plantation's clinic. That is, the clinic on the plantation caters primarily to the employees and their dependants. According to the plantation's management patients from nearby villages are also given health services for little cost. The monthly average of patients treated at the plantation's clinic range from 500 to 600. Services provided at the clinic include: consultation, delivery, circumcision, simple procedure laboratory tests and vaccinations. There were 75 births in the plantation's clinic and both the clinics had a total of 13875 consultations in year 2007. Table 4-13 lists number and types of cases treated at SRC's clinic.

The current source of energy for the clinic is a 7.5 kVA petrol engine generator which runs for approximately 1,000 hours per annum (**Error! Reference source not found.**). A plan to upgrade the plantation's clinic into a hospital is being considered by SRC's management. Proposed modifications are shown in **Error! Reference source not found.** and **Appendix. This will further be discussed in the Social Impact Assessment Section.**



(a)



(b)

Figure 4-7: (a) Exterior view of plantation's clinic; (b) The only source of electricity for the clinic a gasoline generator.

Table 4-13: Number of cases treated at SRC's clinic.

Disease	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Malaria	204	198	196	152	197	271	246	217	197	214	113	99	2,304
Bloody Diarrhea	9	5	2	9	7	8	4	5	3	6	6	6	70
Watery Diarrhea	24	21	27	34	26	23	28	17	15	25	17	18	275
Cholera	-	-	-	-	-	-	-	-	-	-	-	-	-
Aneamia	45	57	46	59	41	69	59	63	71	27	19	17	573
ARI	72	69	34	38	37	68	63	59	41	46	32	19	578
Skin Disease	34	48	35	36	48	40	36	25	30	32	26	27	417
Worm	6	6	8	12	13	5	9	6	8	5	6	5	89
STI	5	7	8	17	11	11	11	10	10	19	6	7	122
UTI	41	28	32	38	32	54	34	47	43	22	13	30	414
PID	3	1	3	3	4	1	-	-	-	-	-	1	16
Injuries	29	20	19	21	17	21	20	19	33	23	13	7	242
Menigitis	-	-	-	-	-	-	-	-	-	-	-	-	-
Tuberculosis	-	1	3	1	-	1	-	3	1	-	-	1	11
Measles	-	-	-	-	-	-	-	-	-	-	-	-	-
Neonatal Tetanus	-	-	-	-	-	-	-	-	-	-	-	-	-
AFP	-	-	1	-	-	-	-	-	-	-	-	-	1
Whooping Cough	-	-	-	-	-	-	-	-	-	-	-	-	-
Lassa Fever	-	-	-	-	-	-	-	-	-	-	-	-	-
Schistosomiasis	-	-	-	-	-	-	-	-	-	-	-	-	-
Onchoscerciasis	-	-	-	-	-	-	-	-	-	-	-	-	-
Hepatitis	-	-	1	1	2	2	1	3	2	1	2	1	16
Hypertension	15	12	17	14	18	16	4	11	17	8	11	6	149
Eye Condition	13	13	19	24	14	16	21	13	17	10	10	1	171
Malnutrition	1	-	-	-	7	-	4	-	3	-	-	-	15
Obstructed Labor	-	-	-	-	-	-	-	-	-	-	-	-	-
Postpartum Hemorrhage	-	-	-	-	-	-	-	-	-	-	-	-	-
Antenal "	-	-	-	-	-	-	-	-	-	-	-	-	-
Eclampsia	-	-	-	-	-	-	-	-	-	-	-	-	-
Sepsis (abortion related)	-	-	-	-	-	-	-	-	-	-	-	-	-

Puerperal sepsis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shock (abortion related)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bleeding in early preg.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OTHERS ⁵	138	98	118	133	106	129	212	120	121	90	87	54	1,406						
Total # of Cases	639	584	569	592	580	735	752	618	612	528	361	299	6,869						
Total # of Consultat.																			

⁵ Others = Myalgia, Hernia, Hydrocele, Typhoid Fever, Epilipsy.

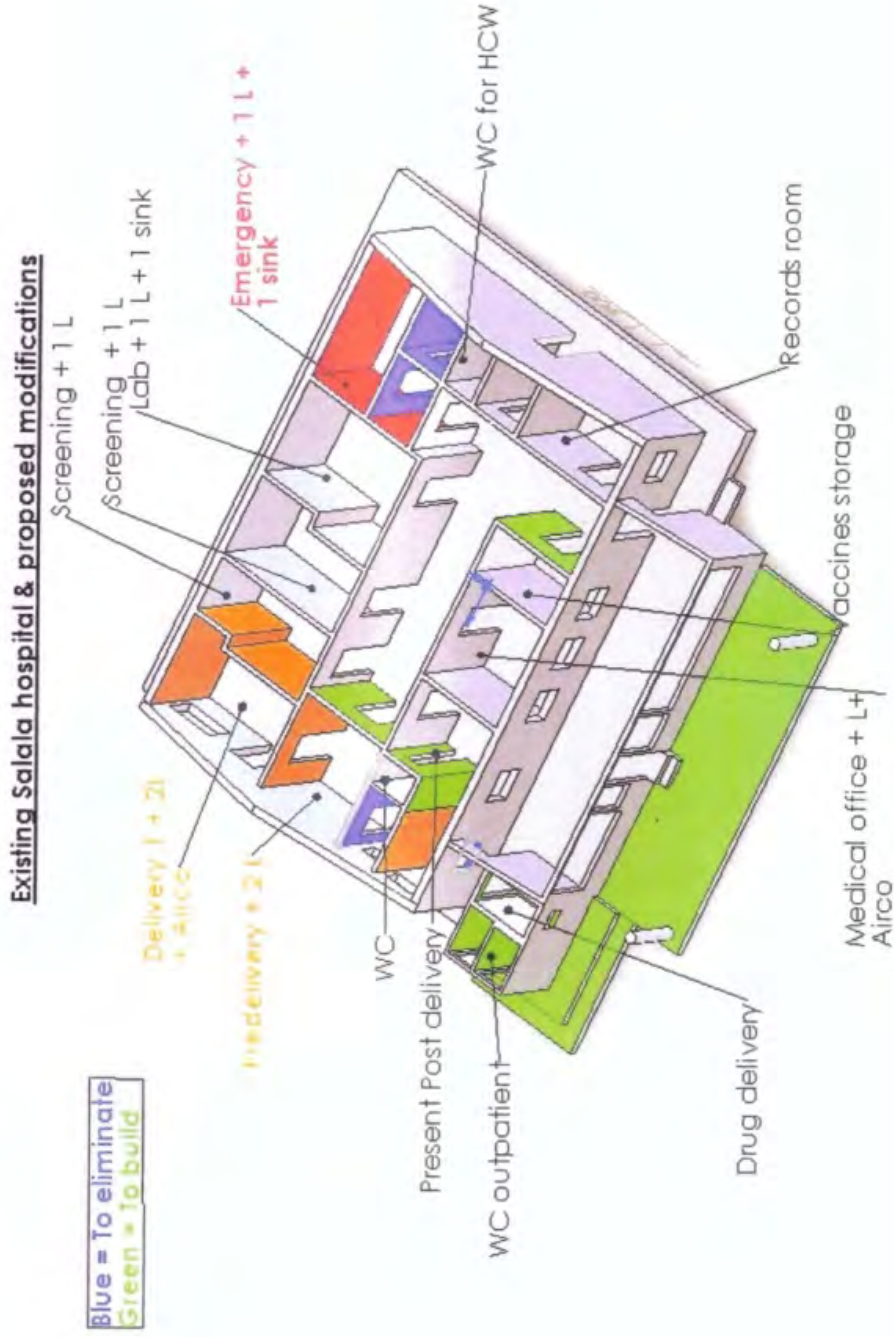


Figure 4-8: Proposed clinic modifications.

4.3.4 Laboratory

There is a small laboratory within the factory for testing the quality of the rubber produced. This laboratory is equipped to test for plasticity and viscosity as well as dirt content (cleanliness) and uses heat and white spirit in the process.

The laboratory is also being used to test for water quality for water samples collected from wells located within the factory as well as the plantation. The basic water parameters that are tested in the lab include E. Coli and Coliform. Table 4-14 lists chemicals used at SRC and Table 4-15 lists types and quantities of other materials used.

Table 4-14: Types and Quantity of Chemicals Used by SRC.

Item Description	Unit of Issue	Quantity
Nitric Acid	kg	2400
Sulphuric Acid	kg	360
Calcium Carbide		
Lime Powderr		
Formic acid		
Blue Dye (colouring for fungicide)		
Red Dye (colouring for coagulant)		
Tepol soap		
Formic Acid		
Detalcal (Insecticide for ants 7 termites)		
Pyrical Insecticide		
Folpan – Panel Fungicide		
Mancozebe (Ivory 80%) 25 kg – Fungicide (nursery)		
RCP Compound (60 kg) (wound paste)		
Garlon 4RF (Herbicide) (tree stump eradication)		

2-4-D (Herbicide)
(tree stump
eradication)
Ethephon Paste
(stimulant)
Chlorothalonil 500
G/L (Fungicide)
(nursery)
Kalach 360SL
(Glyphosate
Herbicide)
KCl
Dolomite
(Calcium &
Magnesium)
Rock Phosphate
(CaO)
Urea

Table 4-15: Types and quantities of other materials used at SRC.

Item Description	Unit of Issue	Quantity
Plastic Sheeting		
Base Sheet		
Container Base Sheet		
Interleave		
Shrimp Warp – housing poline		
Hydrate Lime [Ca(OH) ₂]		
Sodium Hydroxide Anhydrous		
White Spirit		

4.3.5 Housing and Offices Complexes

The houses of SRC are spread between the factory and the plantation. There are five camps within the plantation along with xxx bungalows for senior staff. In the factory there are xxx staff houses and xxx junior staff houses (Table 4-16). Houses within the factory are considered as recent construction and in good condition. However, houses on the plantation's camp do not seem to be in good conditions indicating that workers do not have good living conditions in regards to sanitation, and housing. In general, most of the houses seem to be overcrowded and substandard. According to SRC's management, this problem has been recognized by them and is being addressed in a rolling program of progressive improvement.

Table 4-16: Number of houses per camp.

Camp Name	Number of Houses
Camp 1	90
Camp 2	56
Camp 3	59
Camp 4	12
Camp 5	8

Some houses are built of mud brick that lack basic facilities such as toilets and kitchens. Other houses are also built of mud and stick that are affected by erosion and tough weather conditions. These houses are in danger of imminent collapse and practically do not meet the criterion for decent modern plantation housing. There are also some houses spread along the plantation that seem to be occupied by squatters and it's not known by known by the management of SRC if the occupiers of such houses are employees or not. However, there are many people on the plantation who are not legitimate workers or dependents and this issue is probably due to the displacement of the population during the recent civil war in Liberia.

Even though the majority of the houses within the plantation are in very poor conditions due to many years of neglect, there are some houses including the senior staff bungalows that are in relatively good conditions and constructed of cement blocks.

In terms of sanitation, there are virtually no bathing or latrine facilities and those in existent are made built of mud bricks or simple iron sheets. Almost all toilets are in the nearby bushes where bathing takes place in small shacks or streams.

There are 18 hand pump wells that are operational on the plantation and within the camps (**Error! Reference source not found.** & Table 4-17). Water is not piped and is only collected from the wells when needed. According to the management of SRC, these wells are chlorinated and the water quality is tested frequently. Electricity, on

the other hand, is not supplied to the camps. Meanwhile, the houses located on the factory's site benefit from electricity provided by operating generators.

Table 4-17: Number of wells in each camp.

Camp Name	No. Of wells
Camp 1	3
Camp 2	4
Camp 3	3
Camp 4	2
Camp 5	6

4.3.6 Schools

SRC runs a school system for employee's children. The system has an enrolment of 1401 students, where 838 of them are boys and 563 are girls. The school has four annexes in camps that are far away from the central school in Camp 4. The system also runs an evening session for your working adults.

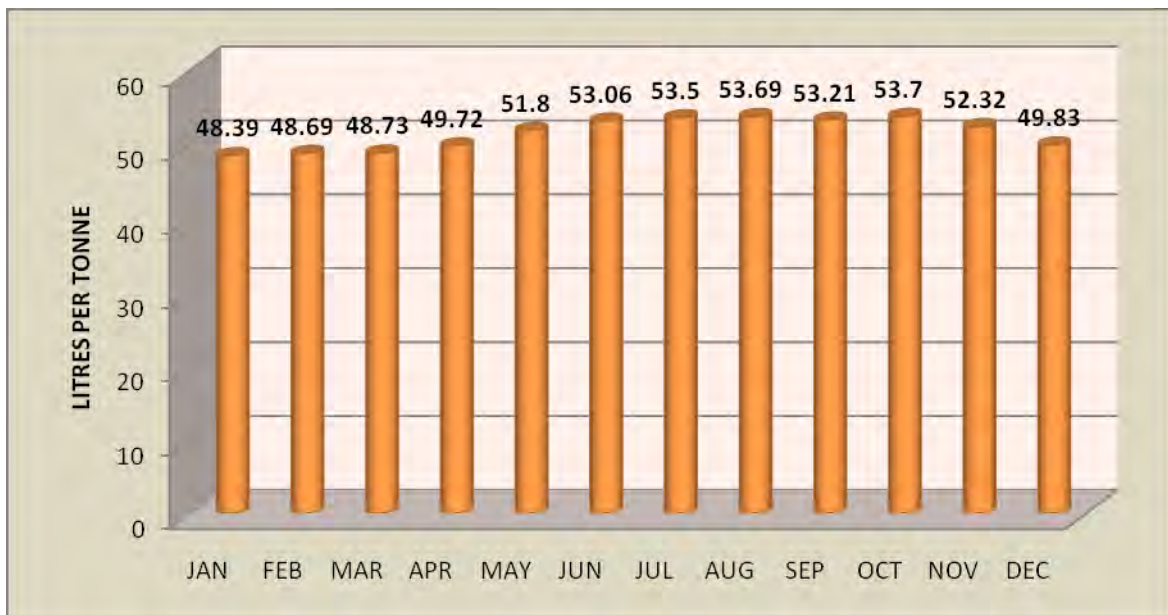
The four annexes of the school system are located in Camps 2, 3, and 5. The fourth is in Baypolu Town on the outskirts of the plantation. SRC has already started to improve the learning conditions by providing more seating capacity and more school tools. The new benches avoid students to sit any longer on the bare floor. Construction of toilets at the Central School has been finished.

Classes range from Kindergarten to 12th grade and there are a total of 22 teachers in the school system.

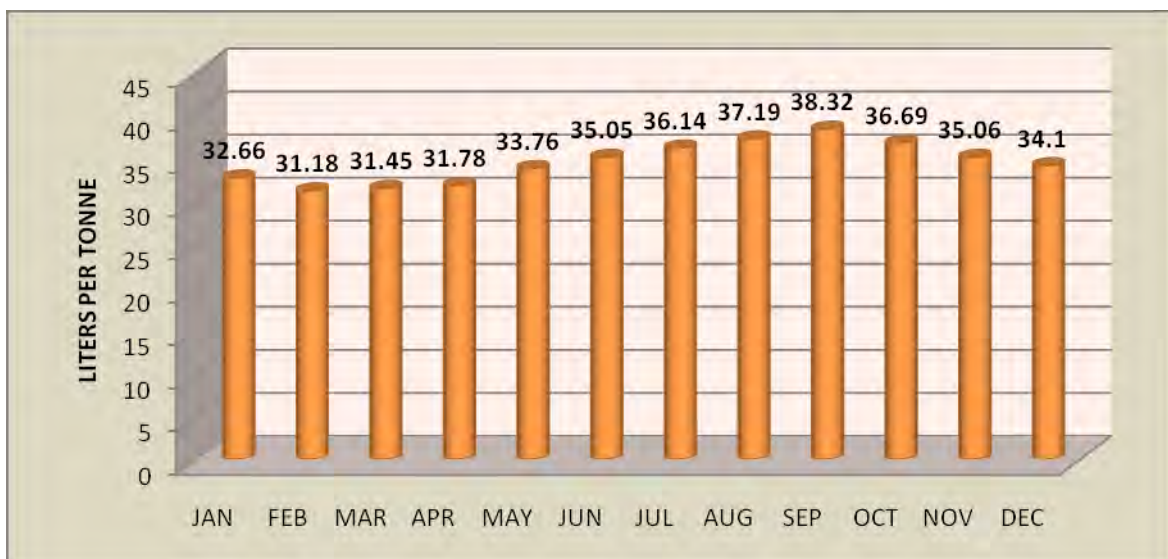
The factory's employees' children attend the Yea Riverside Elementary & Junior High School which was incorporated after the merger. Enrolment statistics indicate that 715 students enrolled in the academic year. This number consists of 370 boys and 345 girls. This school has 14 teachers and 2 support staff.

4.4 FUEL CONSUMPTION

Fuel consumption for all uses is approximately 45,000 liters of diesel fuel per week (11,887.74 gallons/week). The rubber processing, the dryer and the generators consume approximately 31,000 liters or diesel fuel per week (8189.334 gallons/week). The other 14,000 liters (369.84 gallons) are used by vehicles used for rubber purchasing, operation of plantation, movement of factory materials, administration and finished goods transport. Fuel consumption varies with the variation of seasons (Figure 4-9 & Figure 4-10).

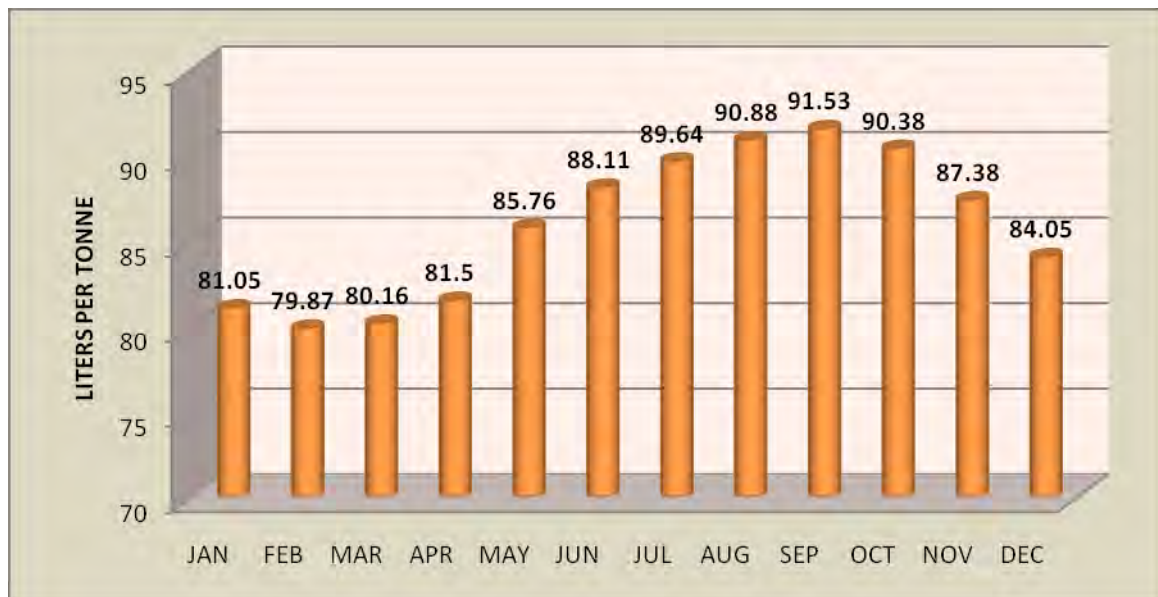


(a)



(b)

Figure 4-9: (a) Average fuel consumption of generators, 2001-2008. (b) Average fuel consumption of dryer, 2001-2008. Source: SRC, 2008.



(a)



(b)

Figure 4-10: (a) Average total fuel use on a monthly basis, 2001-2008; (b) Average total fuel use on a yearly basis, 2001-2008.

Table 4-18: Types and Quantities of Petroleum Used at the Facility.

Item Description	Unit of Issue	Qty. / Year
Gasoil	litre	
Gasoline	litre	
2 – Stroke Oil	kg	
Brake Fluid	gallon	
Engine Oil Sae 30		
Fluid Grease		
Gear Oil		
Hydraulic Oil		
Engine Oil		

5 PROCESS DESCRIPTION

Natural rubber and Caoutchouc are all names for the solid elastic material isolated, one way or another, from the "milk" or latex of various plants. The latex is therefore the white milk-like fluid which is obtained by wounding the plant and in the case of most common commercial source today, the tree *Hevea Brasiliensis*, by cutting a sloping incision in the outer bark from which the latex will "bleed" and then refreshing the wound by removing silvers from the surface of the cut on subsequent tapping days. The coagulated latex is transported from the plantation to the factory for processing.

5.1 PLANTATION

The process mainly involves extracting natural rubber which is originally a liquid (latex) from rubber trees (known as *Hevea Brasiliensis*) and transforming it from liquid to solid. This mainly includes activities such as tapping, coagulation of latex, application of stimulant, general maintenance, replanting of rubber trees and fire control. The tapping and the coagulation processes are the two main activities directly related to the extraction and preparation of latex at the plantation. The other activities can be classified as maintenance or servicing activities.

5.1.1 Nursing

The plantation rubber tress is a factory, specifically designed to produce as much latex as possible. The tress consists of three main parts:

1. The roots to take up substances;
2. The trunk to provide a good storage and distribution; and
3. The canopy to provide a high rate of biosynthesis.

Modern trees are often a “three part tree” with these three parts grafted together from seedlings of plants which excel in each particular area.

The three part trees are grown for a short time in a pot and later planted out in a nursery before finally being transplanted into the plantation (Figure 5-1).



Figure 5-1: Nurseries at SRC's plantation.

5.1.2 Tapping

The rubber trees are allowed to grow for about six years in the plantation in order to become cost effective to tap them.

Tapping is the name given to the physical activity of removing thin silver of bark so that the latex can flow on the surface for collection in a cup attached to the tree. Tapping mainly takes place in the early morning, and usually on a daily basis, or every other day.

The latex flows for few hours from the grazed trunk, runs down the gradient of the sloping panel to a vertical cut and then to a metal spike which sticks out of the tree and allows the latex to drip into the collecting cup. Eventually the flow stops as the wound heals.

At a later stage during the day, the tapper goes round his/her allocated tress and collect the latex in a pail. The pails are filtered and bulked into buckets (indicate size and photo), after which they are taken to the collection centre to be coagulated.

5.1.3 Coagulation of Latex

On the collection station, the latex is places in cement boxes (Figure 5-2) in volumes of 10 cm³. The latex is coagulated by the addition of few ml of 5% Formic acid. The effect is similar to curdling milk. It takes few hours to get the latex properly coagulated after which the latex turns into soft blocks known as coagulum. The coagulum is removed, cut into sizes and placed out on wooden platforms to dry (Figure 5-3) before being weighted (Figure 5-4) and transported to the factory for processing.



(a)



(b)



(c)



(d)

Figure 5-2: (a-c) Cement boxes in which latex is placed for coagulation after adding formic acid; note the small cup in the worker's hand in figure c which is used to add the formic acid to the rubber. (d) Formic acid bottle.



(a)



(b)

Figure 5-3: (a-b) Coagulated latex placed on wooden platform. Note the leachate in figure a. These tables are made bamboo that are replaced at least once a year while platform supports are tree sections that are replaced as needed.



Figure 5-4: Weighing the coagulum before being sent to the factory.

5.1.4 General Maintenance

This involve weeding, repair of platforms at collection stations, control of fungi, removal of branches and fallen trees, and road maintenance.

5.1.4.1 Weeding and Control of Fungi

Weed control is an important cultural practice in rubber plantation during the initial years, as they compete with rubber for light, moisture and plant nutrients and serve as alternate hosts for insects and pathogens. The weeds commonly found in the rubber plantations are *Eupatorium*, *Chromolaena*, *Borreria*, *Lantana*, *Mimosa*, *Clerodendron*, *Mikania*, *Sida*, *Pennisetum*, *Axonopus*, *Paspalum*, *Digitaria*, *Cynodon* and *Imperata*. Weeding is conducted by manual cutting and spraying (Figure 5-5) with a herbicide known as glyphosate using an ultra low volume sprayer once per year in

order to keep vegetation between the rows in check between the tree lines. Persistent tree stumps are sprayed with an equal mix of glyphosate and 2-4D is used (Table 5-1). Once established, cover crops help in smothering the weeds. But weeding requires to be undertaken in between strips of cover crop. Integrated Weed Management is an approach involving integration of manual and chemical weed control methods along with the establishment of cover crop during the first year itself which helps in smothering weeds in the inter spaces and thereby reducing the usage of herbicides to the minimum.

On the other hand, rubber trees are subjected to a number of diseases. Continuous rainy weather brings about an attack of 'Phytophthora' fungus causing abnormal leaf fall. This can be prevented by spraying fungicide (Table 5-1). There are minor diseases like secondary leaf fall caused by 'Gleosporium', bird's eyespot, leafspot and pink disease for which remedial measures are available. Besides, there are insects such as scale insect, mealy bug, cock-chafer grub and caterpillar. The pests and diseases problem can very easily be controlled by adopting effective plant protection measures.

Table 5-1: Overview of used herbicides, fertilizers and pesticides at SRC's plantation (SRC, 2008).

Type	Unit of Issue	Quantity in stock
Herbicides		
Glyphosate (Kalach360)	Liter	3000
Garlon 4E	Liter	25
2,4 – D	Liter	400
Fertilizers		
NPK 12/12/17/2	Kg	6850
NPK 15/15/15/6/4	Kg	0
Rock Phosphate	Kg	50550
Urea	Kg	38250
Dolomie (MgCO ₃)	Kg	16300
Potassium Chloride (KCl)	Kg	17600
Fungicides		
Sumi 8	Kg	190
Bayfidan	Kg	0
Mancozeb	Kg	185
Banko 500	Liter	85
Insecticides		

Deltacal

Liter

26



Figure 5-5: Workers equipped with spraying tools. Note the lack of use of safety tools and outfits.

5.1.4.2 Fertilization

Fertilizers (Table 5-1) are applied every year (Table 5-2). The fertilizers are broadcasted beneath the canopy of the rubber trees. Fertilizer can also be applied by digging holes in the spaces between the trees, and manure placed in the holes. This practice helps to maintain the humus content in the topsoil. Fertilizers are applied in square or rectangular patches in between rows, each patch serving four trees. Once the canopy is closed light forking to incorporate the fertilizers into the top soil is necessary.

Table 5-2: Fertilizer application schedule for 2008. Source: SRC, 2008.

Year	Ha	No. of Trees	No. of Applications	Planting	July	August	September	November
2004	18.94	10,455	2			200 g NP		200 g NP

2006	149.2	82,358	4	60 g K	150 g NP	60 g K	150 g NP
2007	52.82	29,157	4	50 g K	100 g NP	50 g K	100g NP
2008	300	166,800	1				70 g N
2008	300	166,800	1	400 g PMg			

N = urea

P = rock phosphate (RP)

K = potassium chloride (KCl)

Mg= Dolomite

RP + urea (NP): cannot be stored for longer than 3 days after mixing.

RP + KCl (PK): cannot be stored for longer than 3 days after mixing

KCl + urea (NK): cannot be stored for longer than 3 days after mixing

PMg-mixture = 3 parts P + 1 part Mg.

NP-mixture = 1 part N + 1 part P.

5.1.4.3 Repair and Maintenance of Platforms at Collection Stations

The tables on which the coagulated latex is placed are made of bamboo that are replaced at least once per year while the platform supports are tree section that are replaced as needed (Figure 5-3). All material is natural, locally available and renewable.

5.1.4.4 Removal of Branches and Fallen Trees

Removal of fallen trees and branches is usually done by hand. The collected wood is used by locals or workers for domestic fuel. Fallen branches and trees are from older plantings that can hinder access within the plantation.

5.1.4.5 Replanting of Old Rubber Trees

Depending on the spacing and condition, old trees are removed and replaced by new bud-grafted stumps after 30-40 years of production. A bulldozer is used to push old rubber trees and lift out as many of the trees as possible in order to reduce the incidence of root disease in the new plantation. Old trees are left to lie in their rows and naturally disintegrate. A cover crop (normally *Pueraria Phaseolides*) is planted after the felling, and the area is prepared for replanting, planting and

maintained. In order to ease tapping, reduce the slope the tapper has to climb and counter erosion, new plantings are now being set out in lines that approximate the contour of the land.

5.1.5 Fire Control

During the fire season (January through March) and throughout the dry season, plantation fires are a major problem. During that time, every vehicle on the plantation is equipped with basic firefighting equipment. Moreover, the plantation's management has one person in charge of fire-watch around the clock seven days a week during the fire season. The company also has a trailer mounted tank and pump on stand-by that can be pulled to major fires.

5.2 FACTORY

The primary raw material processed at the factory is natural rubber, originally a liquid (coagulated latex) from rubber trees (*Hevea Brasiliensis*). Natural rubber as raw material is a plastic material which hardly can be used for any production without being processed and transformed into an elastic material. The latex is composed of 30-40% pure rubber, 3-5% non-rubber and the rest is water. Secondary raw materials include caustic soda (NaOH) and hydrated lime [Ca(OH)₂]. The coagulated latex goes through a process that transforms it from liquid to solid (Figure 5-6 & Figure 5-7). In this process, different chemicals are added and mechanically mixed into the rubber and a heating process (vulcanising) will finally transfer the compound into an elastic material. The production process consists of cleaning the rubber from impurities, blending coagulum, granulation, milling, drying, packaging and quality assurance.

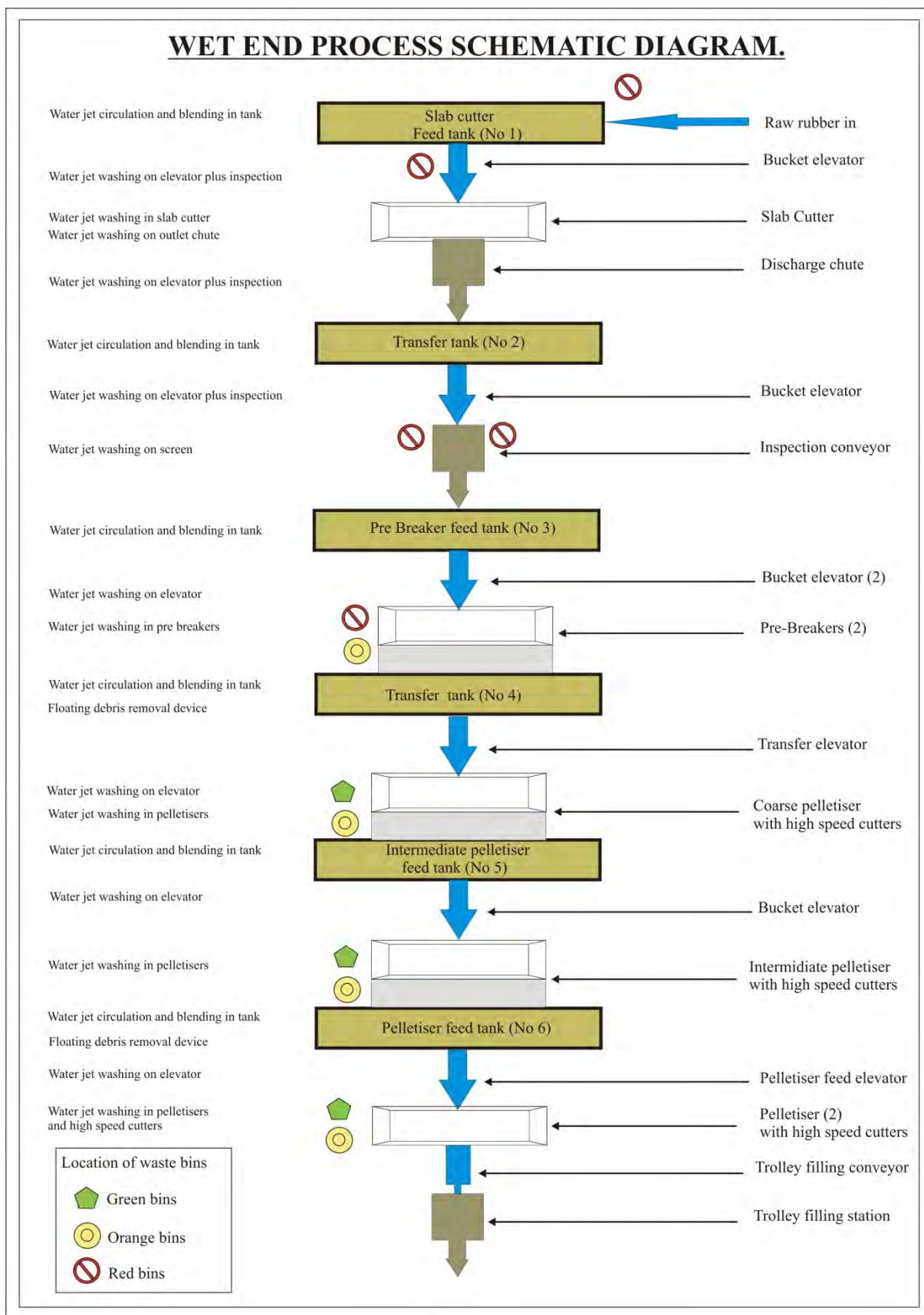


Figure 5-6: Wet end process schematic diagram. (Source: SRC, 2008)

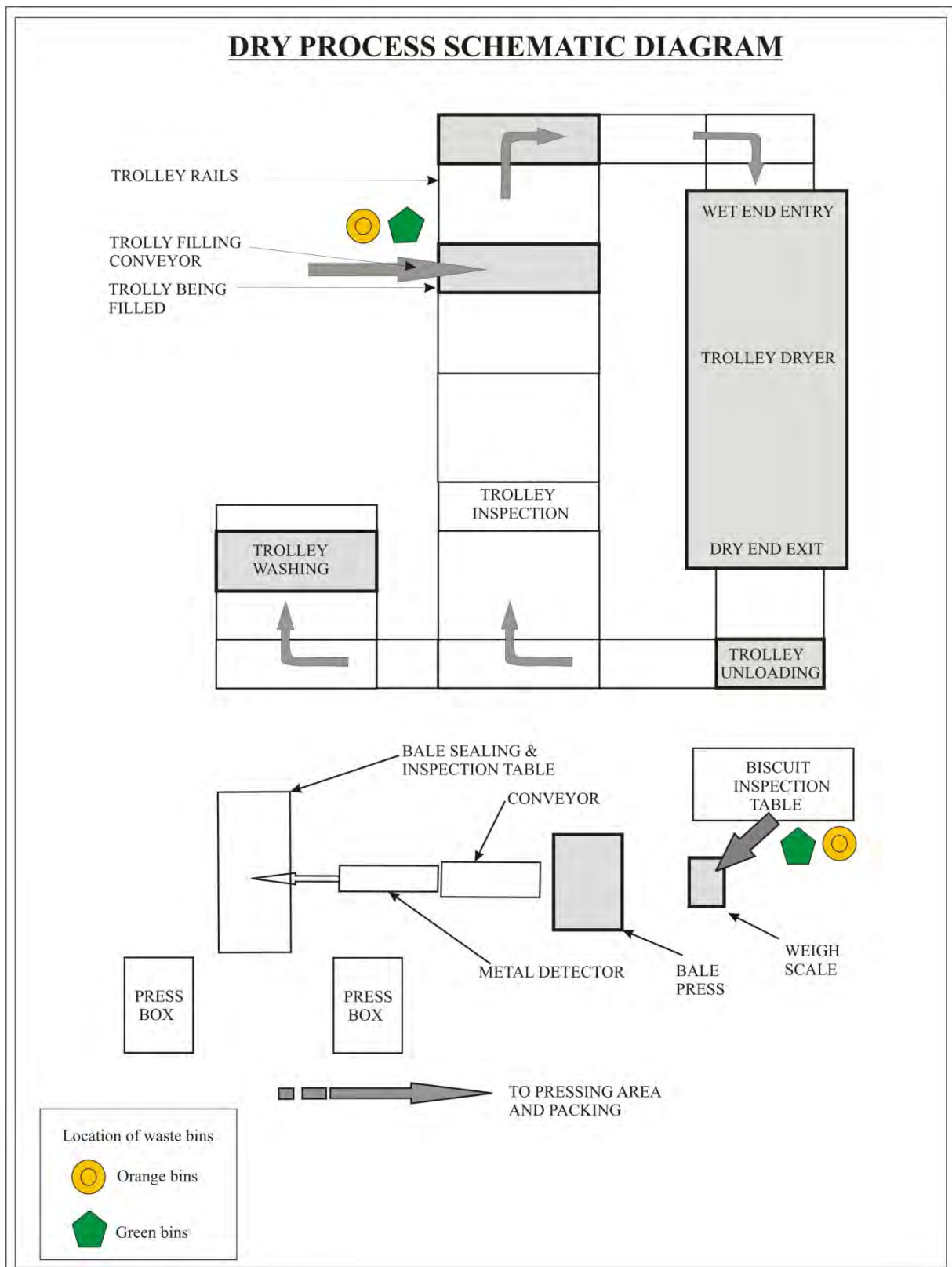


Figure 5-7: Dry process schematic diagram. Source: SRC, 2008.

5.2.1 Reception and Storage

Coagulum received at SRC factory is weighed at the weighbridge (Figure 5-8) and inspected before unloading into the storage bunkers and any defective rubber is rejected. The rubber is mainly inspected to ensure the following:

1. The rubber is clean and free from contaminants such as tree lace, leaves, sand, stones, metal strings, wood, polypropylene and any material that is not rubber.
2. The rubber must be fresh; if serum is dripping, purchase may be delayed until dripping is stopped.
3. Rubber must not have been kept in water and covered with green slime.
4. Rubber has not undergone significant oxidation or other external discoloration.
5. Rubber is not badly colored internally.

If these conditions are not met, the rubber is rejected. Meanwhile, accepted rubber is weighted and stored in the rubber bunkers (Figure 4-6). The base and walls of these bunkers are made of concrete. The staffs of the weighbridge identify each storage location and maintain records of amount and type of rubber and dates of opening and closing. Each location (bunker) has a signboard to carry information to correlate with the records related to bunker number, contents (C/L or Slab), weight (wet tons), opening date and closing date.



Figure 5-8: SRC's weighbridge located at the factory's site.

5.2.2 Treatment

When needed, the coagulum is collected by dumpers on a "first in – first out" basis (Figure 5-9) and loaded into reception water tanks from where it proceeds through a series of cutters and washers to clean and break it into small pieces (**Insert photos in appendix showing the different stages of the process**). In a continuous process, the coagulum proceeds through a series of creppers and shredders that create increasingly finer particles. These are then dried, packaged and stored for shipment. The main chemicals used during this process are hydrated lime and caustic soda. The hydrated lime is used to reduce the cohesion o the finer rubber particles immediately prior to the drying cycle, while the caustic soda is used to clean the drying trays.

However, before the rubber is issued to production it must be inspected by the loading staff as follows:

1. rubber is loosened and spread on the bunker floor for examination

2. all slab over 500 mm size is cut open for inspection
3. all contaminants are removed and collected in red bins
4. at least one red bin is to be in place at every bunker that is being opened
5. cleaned rubber is loaded into metal buckets and then into the dumper
6. attention shall be paid to polythene string, stones, metals, wood and other non-rubber materials, all of which are to be removed
7. excessive foreign matter shall be reported to the weighbridge superintendent

During the treatment process at SRC, the coagulum goes through 6 tanks before drying in the dryer. At tanks 1 & 2, the rubber goes through the slab cutter, tank 3 is the pre-breaker feed tank, tank 4 is the pre-breakers and transfer tank, tank 5 is the coarse and intermediate pelletisers tank, and tank 6 is the fine pelletisers tank.



Figure 5-9: Collection of coagulum. Note that basic occupational safety equipment such as masks are not used by the workers.

5.2.3 Slab Cutter (Tanks 1 & 2)

The slab cutter is a primary size reducer. The rubber is mainly blended and cleaned in tanks 1 & 2 where the slab cutter exposes the internal dirt and wet jets on the elevators and in the machine remove further dirt. The following procedures are to ensure a successful operation of the slab cutter:

1. Clean water must be added to the tanks and at the correct levels.
2. The elevator must be fed with rubber which will have to be maintained at sufficient quantity.
3. The slab cutter must start before the feed elevator, and the transfer elevator must be running whenever the slab cutter is working.
4. The operator of the slab cutter must:
 - a. Ensure that rubber feed to the bucket elevator is good.
 - b. Keep pump screens clean and see that circulation jets are on.
 - c. Inspect each bucket for dirt, which must be removed.
 - d. See that tank 1 & 2 overflows are flowing correctly.
 - e. Ensure that the elevator jets are fully on.
 - f. Ensure that tank 2 circulating jets are fully on.
 - g. Ensure that rubber pieces from the slab cutter are not larger than 250mm
 - h. Inspect every slab cutter feed bucket and remove dirt as it is seen.
5. The first tank must be emptied and cleaned on a shift basis.
6. The second tank must be emptied and cleaned on a daily basis.

If significant amount of foreign matter is found in the tanks when cleaning, the management is informed for investigation.

5.2.4 Pre-Breaker Feed Tank (3), Pre-Breaker and Transfer Tank (tank 4)

The capacity of tank 3 is large enough so that tanks 1 & 2 may be cleaned without interruption of the process. The rubber from the slab cutter is washed and blended in tank 3. The pre-breakers in tank 3 and 4 are secondary size reducers and expose rubber for further cleaning. An inspection conveyor is mounted over tank 3 where two checkers are located to remove dirt and defective rubber. Meanwhile, tank 4 takes rubber from the pre-breakers for washing and blending before directing it to the coarse pelletiser via the transfer elevator. During this stage, it is essential to ensure the following

1. Both tanks 3 & 4 are filled with clean water and to the correct level.
2. Filter screens must be clean and in position.
3. Circulation pumps must run continuously.
4. All water sprays on buckets elevators and pre-breakers must be fully operational.
5. Adequate feed of rubber to the pre-breaker and clean pump screens should be ensured by the pre-breaker operator.
6. The operator of the pre-breaker must also inspect each bucket load and remove any found dirt.
7. Tanks 3 & 4 are to be cleaned at least once a week.

All visible dirt is removed by the checkers assigned to the inspection conveyor.

5.2.5 Coarse and Intermediate Pelletiser and Tank 5

Crumb from tank 4 is delivered to the coarse pelletiser through a bucket elevator. The coarse pelletiser produces crumbs that are cut with a high speed cutter before discharge to tank 5. A second bucket elevator takes crumb from tank 5 and feeds it to the intermediate pelletiser. Tank 5 is equipped with water circulating jets to blend and clean rubber.

1. The pelletisers must start before the bucket elevator.
2. The bucket elevators must stop before the pelletiser.
3. The water jets on the bucket elevators must be fully on.
4. The water jets on the pelletisers must be fully on.
5. Crumbs from the coarse pelletiser must not exceed sizes of 1.5 cm in diameter.

Crumbs from the intermediate pelletiser must not exceed sizes 1.1 cm in diameter.

5.2.6 Fine Pelletisers and Tank 6

Crumbs from the intermediate pelletiser are directed into the tank 6. Tank 6 has a circulating pump and water jets to circulate, blend and wash the rubber. Bucket elevators take crumb from the tank to the pelletisers. Each elevator is equipped with water jets. Crumb produced by the fine pelletiser is discharged on to a moving distribution conveyor. The distribution conveyor must run at all times when the pelletisers are running, and the pelletiser must start before the bucket elevator while the bucket elevators must stop before the pelletiser.

1. The water wash jets must be fully on.
2. The auxiliary water input jets must be on.

The maximum crumb size shall not exceed a diameter of 0.57 cm.

5.2.7 Drying

A dryer capable of drying three tons of rubber per hour by passing hot air through a deep bed of rubber pallets. The dryer takes filled trolley of wet granules of rubber from the filling station and passes them through heating sections where two gas-oil burners provide heat and are regulated to provide a constant temperature of 118 °C. Trolleys are pushed into the dryer on a timed cycle. The two dryer heating sections are independently temperature controlled. Fans circulate air for combustion, cooling and exhaust in order to maintain a constant flow of air in the dryer. The air is drawn

from outside the factory, enters through the cooling and exits through the exhaust chimney at the wet end. At the end of the preset time, a pusher mechanism at the exhaust end of the dryer starts running. The operator then pushes a new trolley in and ejects a trolley of dried rubber from the cooling end of the dryer. On ejection, the temperature of the dried rubber must be less than 50 °C.

5.2.8 Trolley Filling Station and Wet End Dryer Feeding

The trolley is fed by a conveyor that takes crumb from the pelletiser to the filling station. Trolleys are placed under the conveyor and crumb is discharged into the trolley. Trolleys are filled and levelled by operators. After filling, the trolleys are pushed to the dryer wet end pusher station to await entry to the dryer.

5.2.9 Handling of Biscuits from Trolley to Pressing Station

Dried rubber biscuits emerge in the trolley at the end of each timed dryer cycle (Figure 5-10). The biscuits are unloaded from the trolley and placed on inspection table (Figure 5-11). After inspection the biscuits are made up into a standard 35 kg weight for pressing into bales. The inspection process includes the following criteria:

1. Every biscuit is inspected on every face for any deviation from standard.
2. Every biscuit is cut open in two places for internal inspection.
3. Defective rubber is rejected and reported to supervision.
4. When cutting rubber for inspection, only vegetable oil is used as lubricant.
5. Magnifying glasses (loupes) are used for detailed inspection.
6. Loose rubber is removed from the trolley and incorporated in bales.
7. The internal temperature of biscuits is measured (Figure 5-12) and recorded every 30 minutes, and rubber with an internal temperature over 45 °C is not pressed until cooled.

8. Only rubber passing inspection is weighed for bales on digital scales to an accuracy of 35 kg +/- 40 grams. The weigh scales are tested with calibrated weights every two hours.
9. Correctly weighed rubber is passed for pressing.



Figure 5-10: Dried rubber biscuit emerging from the dryer.



Figure 5-11: Dried rubber biscuits being unloaded from the dryer's trolley. Note the lack of use of safety equipment by workers.



Figure 5-12: Internal temperature of biscuits being measured.

5.2.10 Bale Press Operation and Control

After weighing the rubber biscuits are put into a 100 ton press (Figure 5-13), from which the bales are ejected after a timed cycle and then pass through a metal detector to the inspection and bagging table.

1. Each bale shall weigh 35 kg +/- 40 grams.
2. Press cycle time is determined by Technical Manager.
3. After pressing the bale is ejected onto a conveyor that feeds it to the metal detector.
4. Lubricate the press chambers only with vegetable oil applied with a rubber detector.

5. The feed conveyor and metal detector conveyor must be running with the press is operational.
6. The metal detector must be tested twice per shift, using the calibrated test piece.
7. Any bale that fails a metal detection test shall be carefully examined to locate the metal piece.
8. If metal is found all efforts must be made to locate and eliminate the source.
9. When a bale reaches the packing table it is to be carefully inspected.
10. A minimum of one bale in six is to be cut for internal inspection. If any defect is found, then previous and next bales are to be cut. If more defects are found, all bales are to be inspected until the process is free of defects.
11. All defective bales are to be rejected.
12. The external and internal temperature for every trolley cycle should be recorded.
13. Bales must not be packed if their temperature exceeds 50 °C.
14. When cutting bales, only vegetable oil shall be used.
15. Bales that pass inspection are sampled.
16. Only bales that pass inspection are bagged.



Figure 5-13: Pressing machines at SRC's factory.

5.2.11 Trolley Washing Procedure

All trolleys are cleaned on a regular basis in the trolley washing station. Washing procedure includes the following:

1. The designated trolley is placed in the washing station
2. Internal dividers and bottom panels are removed and placed in the soaking tank that contains solution of caustic soda in water.
3. The water/caustic soda solution is equivalent to 10 kg of caustic soda for a full cleaning tank of water.
4. Dividers and bottom panels are soaked for a minimum of one hour.
5. Side and end panels are to be brushed with a solution of caustic soda and water, great care being taken to ensure that all crevices are well soaked.
6. On completion of soaking, each part of the trolley assembly is to be brushed and washed with clean water to remove all traces of dirt.

7. No trace of caustic soda shall remain on any part of the trolley.
8. On completion of washing, all trolley components are to be re-assembled.

The wheels of the trolley are lubricated before returning to it the line.

5.2.12 Packaging

The dried rubber from the dryer are removed from the pan and pressed into rectangular bales. After passing inspection and sampling procedures, every bale is packed into a polythen bag which carries a print indicating the grade of rubber that is produced. The open end of the bag is heat sealed. Plastic materials used for packing of Salala rubber conform to specifications in table below.

Table 5-3: Specifications for plastic packaging materials. Source: SRC, 2007.

Item	Size	Specification
Bale bag, Weala 10 white/brown	350 + 2 mm x 150 mm x 1000 mm Thickness 4/100	Point VICAT 80C+/-10 C, fuse point < 109C
Bale bag, Weala 20 white/brown	350 + 2 mm x 150 mm x 1000 mm Thickness 4/100	Point VICAT 80C+/-10C, fuse point < 109
Bale bag, Plain	350 + 2 mm x 150 mm x 1000 mm Thickness 4/100	Point VICAT 80C+/-10C, fuse point < 109
Interleaf, PEBD standard	1450 x 8500 mm Thickness 14/10	Fuse point 105 – 118 C
Shrink wrap bags, PEBD standard	1585 + 2 mm x 525 mm x 1800, Thickness 16/100	Fuse point 105 – 118 C
Pallet base sheet, PEBD standard	1500 x 1800 mm Thickness 16/100	Fuse point 105 – 118 C
Container base sheets. PEBD standard	300 meter x 3 meter. Thickness 10/100	Fuse point 105 – 118 C

When the bale has been bagged it is placed in a pressing box former with a pallet placed in the base of the former. Before starting to fill the former with bales an interleaf sheet of polythene is put on the bottom of the pallet in a double thickness, consisting of base plus interleaf. The first layer of bales is then put in the former.

Before the second bale layer is commenced the interleaf is folded over the first layer so that there is no contact between successive layers of bales. The interleaf is placed so that it covers the wide side of the pallet stack. Every pallet bears a lot number for identification in two places.

Six successive layers of bales are built up to form a pallet load of 36 bales with the last fold of the interleaf covering the top layer. Operators entering the press box to load rubber must not wear shoes and must be careful to avoid contamination of the rubber and bale bags.

When the pallet load is completed, the assembly of pallet, rubber and pressing box is moved to the pressing area where a load is placed on top of the rubber bales and left for sufficient time to compress the bales into conformity with the final pallet size.

On completion of pressing the former is removed and the rubber is covered by a shrink-wrap polythene cover. The shrink-wrap is shrunk into position by means of a hot air gun. It is essential to avoid making holes in the shrink-wrap and/or causing the shrink-wrap to adhere to any of the bale bag material. In case of packaging for Michelin, the same procedure is followed except that the pallet is re-useable. When pressing is complete, the rubber bales are put into metal storage frames to await loading into the shipment container.

Pallets are loaded at 16 per container. Michelin rubber is loaded at 648 bales per 20 ft container, in a pattern approved by Michelin.

6 ENVIRONMENTAL IMPACT ASSESSMENT AND ANALYSIS

Impact identification involves documenting all possible events that could lead to a hazardous incident. It is a systematic process listing potential causes and consequences. Reference is also made to propose operational and organizational safeguards (and their basis) that would prevent any possible hazardous events from occurring, or should they occur, that would mitigate the impact on the plant, its equipment, people and the surrounding environment. This process enables the establishment, at least in principle, of the adequacy and relevancy of proposed safeguards.

Environmental resources are vulnerable to any type of human alterations especially that they are subject to depletion. The role of environmental legislation hence, focuses on regulating such activities in a manner promoting environmental sustainability for future generations. EIAs and EMPs are the main tools developed by legislators worldwide in order to control the adverse environmental impacts produced by human interferences; unfortunately, such measures were adopted in Liberia only recently.

Therefore, the aim of the following impact assessment is to shed the light on the potential environmental risks associated with the interaction of the SRC's facilities (as a whole) with the surrounding environment. Since SRC's activities are divided into the operation of the rubber plantation where rubber trees are grown, tapped and the latex is coagulated and the operation of the factory where the rubber is processed by cleaning from foreign material and dirt, drying and packaging it to be exported. Therefore, two separate impact assessments will be prepared. This objective is usually achieved through the preparation of a matrix including the main impacts produced by the different project's activities **(Insert Impact Identification**

Matrix). Moreover, the likely significance and type of these will be evaluated based on professional judgment as well as experience from similar facilities abroad as reported in the literature.

6.1 ENVIRONMENTAL IMPACT ASSESSMENT AND ANALYSIS OF THE SRC'S PLANTATION

Considered an important commodity in Liberia, natural rubber represents a source of foreign exchange and income generation for a significant proportion of the population. The specie *Hevea Brasiliensis* was first imported into Liberia from Brazil at the end of the 19th century (Gouyon, 2003). The rubber industry debuted as a small-scale operation in Liberia. Ever since, it has progressively expanded and currently accounts for a significant portion of the country's exports (UN, 2006). Rubber exports in Liberia had increased rapidly from 19.4 to 57.4 million USD between the years 1997 to 2002 respectively, despite the falling international prices (UN, 2006).

According to the literature, rubber plantations play a relatively significant role in boosting environmental quality through: 1) regulating the micro-climate especially in humid tropics; 2) contributing to biodiversity preservation (although diversity might be limited); 3) carbon sequestering (approximately 11.5 tonnes/ha/yr); 4) reducing of soil erosion when well managed; 5) regulating of water flows and 6) significantly producing of biomass (a 33-year old *Hevea* trees' forest produces on average 387 to 568 tonnes/ha/y of biomass) (Gouyon, 2003; UNCTAD/IRSG, 1997).

Nevertheless, this sector is threatened to collapse as mismanagement of the rubber plantations will lead to the depletion of natural resource (UN, 2006). In fact, issues that can be associated with the management of a rubber plantation primarily include Soil quality deterioration, water and air pollution, impact on biodiversity, solid waste management and occupational health.

For this purpose, this section will be discussing the environmental problems faced at the SRC plantation; however recommendations for better management practices will be discussed separately in the following section.

6.1.1 Impact on Soil Quality

According to literature, tropical soils are more prone to human interferences and are usually more difficult to restore as compared to the temperate regions' soils (Lal, 1990; Zhang, 2005). Severe deterioration of the soil quality in these regions is anticipated, especially when poor management practices are observed. At this level, it is highly important to understand and identify the negative environmental impacts generated by the SRC's rubber plantation in order to reverse degradation.

The SRC's rubber plantation covers a concession area of 8500 ha situated in the Dining-Ta Clan and Gibi District in Margibi County. The land is mainly divided into 2790,83 ha and 714,14 ha of mature and immature Hevea trees respectively (Table 6-1 & Table 6-2).

Table 6-1: Mature area: distribution of the surface per clone. Source: SRC.

Clone-ID	Surface (ha)	% per clone
Harbel-1	1096,43	39,29
LCB-510 / PR-107	821,4	29,43
GT-1	274,6	9,84
Chemaera-30	86,5	3,10
PB-86	29,5	1,06
PB-5/51	64,3	2,30
RRIM-600	31,9	1,14
RRIM-623	92,5	3,31
RRIM-628	96	3,44
Clonal Garden	33,6	1,20
Various	61	2,19
BD-5	40,6	1,45
Seedlings	62,5	2,24
TOTAL	2790,83	100,00

Table 6-2: Immature area: distribution of the surface per clone.

Clone-ID	Surface (ha)	% per clone
Harbel-1	113,96	15,96
LCB-510 / PR-107	211,05	29,55
GT-1	108,96	15,26
AVROS-2037	4,1	0,57
RRIM-600	6,92	0,97
RRIM-623	162,58	22,77
Harbel-10	106,57	14,92
TOTAL	714,14	100,00

There is strong evidence that long-term rubber farming is the leading cause of soil degradation, namely loss of organic matter and nutrients, soil acidification, as well as compaction of surface soil (Zhang, 2005; Zhang et al, 2006; Shorrocks 1965; He 1994), especially when coupled with poor management and over-intensive farming practices (UNCTAD/IRSG, 1997).

Farming practices adopted at a rubber plantation play a major role in depleting soil nutrients, namely tapping frequency and planting density (IRRDB). Increased tapping frequency is the leading cause behind soil nutrients depletion. In fact, Hevea trees convert nutrients from the soil, and carbon dioxide from the atmosphere, into organic carbohydrates known as rubber latex. Over-taping speed up the uptake of nutrients to replace those already lost throughout the process. Unless nutrients are replenished through fertilizers' application, this procedure will only lead to soil quality deterioration (Zhang, 2005). This is exactly the case at the SRC's plantation where sap tapping is performed on a relatively high frequency, namely on daily basis, whereas the recommended frequency is equivalent to twice a week (Sonetra, 2001; IRRDB). On the other hand, planting density is also considered an issue when it comes to nutrients preservation. Planting density should not exceed 500 trees/ha if soil quality is to be preserved (IRRDB). In the case of the SRC plantation, the planting density at the old plantation is equivalent to 178 tree/ha while that at the new plantation amounts to 556 tree/ha. Although SRC management had undertaken important measures to preserve the plantation through replacing

old trees by immature ones, the density adopted will eventually pose a risk on the soil quality.

Soil compaction is another frequent problem faced at rubber plantations where compaction could be observed due to the use of heavy machinery for the collection of tapped latex (Zhang, 2005). Fortunately, this is not the case at the SRC's plantation where collection is performed manually.

"Hevea is relatively insensitive to soil-type, but higher yields and disease resistance can be expected if it is grown on highly fertile soils" (IRRDB). Different types of fertilizers are being used at the plantation as an attempt to overcome the soil quality degradation problem and increase productivity. Insecticides, herbicides and fungicides are also used to fight insects and diseases (Table 6-3 & Table 6-4). Soil analysis to determine the nutrients' content and the chemical residues of the plantation soil was not performed during this study due to the lack of resources at SRC. However, it's important to note that abuse of biocides and fertilizers will compound the previously mentioned soil degradation problems (Murdoch University 2000).

Table 6-3: List of Chemicals Used at the Plantation

Fertilizers	Insecticides	herbicides	fungicides
NPK 12/12/17/2	Dursban	Glyphosate (Kalach)	Sumi 8
NPK 15/15/15/6/4		Garlon	Bayfidan
Rock Phosphate		2,4 – D	Mancozeb
Urea			Banko 500
Dolomie (MgCO3)			
Potassium Chloride (KCl)			

Table 6-4: Application Rates of Biocides and Fertilizers

Fungicides	Dithane 80%	mancozeb	1425 kg
	Banko 500	chlorothalonil	980 liter
	Carbendazim Flowable 500 SC	carbendazim	90 liter

	Sumi8		1500 kg
Herbicides	Kalach 360 g/l	glyphosate	2640 liter
	2,4-D	2,4-D	500 liter
	Garlon	triclopyr	150 liter
	urea (46 % N)	N	70 ton
Fertilizer	rock fosfate	P	160 ton
	KCl	K	35 ton
	Dolomie	Mg	50 ton

Soil erosion can be detrimental to the plantation development and to the surrounding environment mainly due to the organic matter/nutrients and pesticides/herbicides losses. Soil erosion can also have detrimental effects on nearby water bodies (Merrington et. Al., 2002). Erosion is intimately linked to the cultivation practices. The magnitude of soil erosion is directly related to weather conditions (i.e.: rainfalls, storms, etc...) and geology (i.e.: land sloping), and it might contribute to subsequent sedimentation of surface water bodies (Merrington et. Al., 2002). More details on the soil erosion problem will be included in the impact on water resources analysis.

In an attempt to control soil erosion, only two different practices were observed at the SRC's plantation, especially where re-planting is taking place. The first practice consisted of applying a land cover at locations where mature trees are being removed waiting for the new trees to be planted. While second practice involves setting out new rubber trees in lines that approximate the contour of the land. As much as these initiatives are important to control erosion, if not coupled with additional conservation measures they will not reach the expected outcome. In fact, adopting efficient preventative measures will not only enhance the soil quality and protect environmental resources, but it will also play an important role in enhancing productivity and reducing cost incurred during application of agrochemicals.

Last but not least, although acidification is a natural process, it can be triggered by rubber farming especially in high rainfall regions. This process is induced by unbalanced nitrogen cycling (Figure 6-1) (Department of primary industries, 2008).

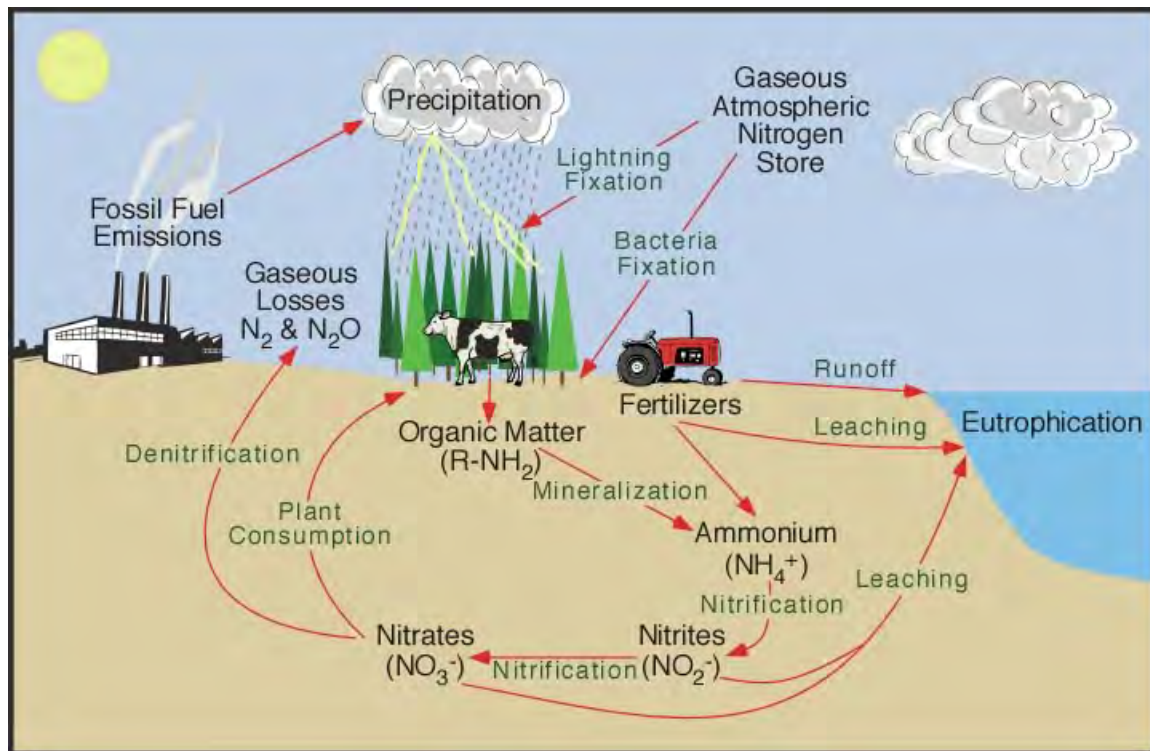


Figure 6-1: Nitrogen Cycle (Pidwirny, 2006).

In other words, during periods of rainfall, nitrogen is washed down in the soil where it is converted into nitrate by soil microorganisms. In this form, nitrate ions will be available for plant uptake. However, excess nitrate ions in soil, as a result of inappropriate fertilization, will either leach down below the root zone leading to acidification of the subsoil or run-off to nearby water bodies leading to eutrophication (Merrington, 2002). Unless this issue is given enough attention, acidification of topsoil, and more seriously, subsoil will eventually lead to (Department of primary industries, 2008; Merrington, 2002):

- Increased nitrate leaching into water aquifers;
- Increased contamination of surface water bodies, leading to eutrophication;
- Reduced productivity of the plantation;

- Reduced options for intercropping (as only acid-tolerant plants can grow well in these conditions);
- Reduced vegetative cover, leading to accelerated run-off and erosion;
- Declining pH of streams; and
- Decreased land values.

Best management practices to reduce the impact of soil degradation will be discussed in details in the Environmental Management Plan Section.

6.1.2 Impact on Water Resources

Although exhaustion of water resources at the plantation is not beneficial for business sustainability, the impacts of the SRC rubber plantation on water resources are numerous. Identifying the critical points within the plantation management practices will enable stakeholders to control resources degradation and increase productivity.

The transfer of eroded soil particles from the rubber plantation into adjacent water courses can have a detrimental impact on water quality. There are two different types of impacts that can be triggered by eroded particles namely transient and cumulative impacts. In fact, the former type is entirely of physical nature while the latter is associated with chemical pollutants.

Under the physical impacts, particulate material (PM) is of main concern. Following erosion, PMs mainly of inorganic nature are transported and deposited in water bodies. The adverse impact of these PMs on aquatic ecosystem is not yet identified, however, oxygen depletion and high levels of chemical pollutants are usually detected during periods of high suspended sediment concentration (Merrington et. Al., 2002). These two environmental changes alone can disturb the natural balance and threaten the sustainability of affected ecosystems.

When it comes to chemical pollution, pollutants might include macronutrients, mainly phosphorus, and pesticides. Abnormal increase in phosphorus concentration in fresh water will induce eutrophication, also known as algal bloom. Environmental issues associated with eutrophication can be summarized by the following (Merrington, 2002):

- Disturbance in the aquatic food chain due to changes in the species composition of algal communities;
- Increased fish mortality caused by deoxygenating water (resulting from algae and weeds decomposition);
- Impairment of the amenity value of water due to surface algal bloom; and
- Production of toxins in the water by some algal species.

Although experimental evidence on the impacts of pesticides on aquatic ecosystems is still restricted, the transfer of pesticides through to eroded sediments is of high significance, especially when in waters destined for drinking purposes. In fact, three of the main agrochemicals used at the plantation, namely dursban, glyphosate and garlon, are considered potential water pollutants. Excessive use of these chemicals combined with soil erosion, will lead to a relatively significant contamination of the water bodies close to the plantation.

According to the European standards, maximum admissible concentrations for potable water shouldn't exceed 0.1 µg/L for a single pesticide and 0.5 µg/L for all pesticides (Merrington, 2002). Unfortunately, water testing for pesticides level was not performed within the study area due to the lack of laboratories in Liberia that can perform such analyses. However, although determining the contribution of the SRC plantation to the water pollution is difficult, assessing the magnitude of the water pollution problem will support the necessity of controlling soil erosion from the plantation.

The monitoring of pesticides in water as well as other significant water parameters will be emphasized in the monitoring plan. SRC will have to consider this matter as a priority in order to ensure safe environmental practices on both their plantation and the factory where fertilizers and pesticides are expected to be applied to the existing nursery.

Besides the disturbance of the aquatic ecosystem and the reduced use of water resources, settling of suspended sediment resulting from soil erosion will affect the storage and flow capacities of streams, lakes and reservoirs, adversely affecting water supplies and increasing flood potential (Merrington et. Al., 2002; UNCTAD/IRSG, 1997).

Soil erosion is not considered the only water polluting factor. In fact, the main effluent generated by the rubber plantation consists of rubber serum produced as a consequence of coagulation. During coagulation the addition of formic acid to the sap triggers proteins biodegradation reactions leading to the formation of a clear, slightly yellowish liquid with a distinctive malodour, commonly known as serum (Sonetra, 2001; WIPO, 2004). The rubber serum is an organic compound containing proteins, amino acids, carbohydrates (polyhydric alcohols, myoinositol and quebrachitol) and various plant growth substances including a number of inorganic cations such as calcium, magnesium, sodium, potassium and phosphorus (Sonetra, 2001). At the SRC plantation, the serum produced at the coagulation point is left to drain (Figure 5-3). No collection system is installed, and the serum can easily leach into the soil or runoff into nearby water bodies. In fact, once the serum, rich in organic material, reaches water bodies and in the presence of dissolved oxygen, bacterial populations found in the water columns will initiate the decomposition into carbon dioxide, nitrate and water. A high BOD/COD level in the plantation's effluent will magnify the nitrate accumulation problem discussed earlier leading to eutrophication or dramatic algal bloom (US EPA, 1997).

Contamination of groundwater and wells in the plantation is also possible due to the use of chemical including pesticides, herbicides and fertilizers. It is often impossible to cleanup groundwater contaminated by pesticides and the contamination may last for several years. Most of the camp residents (if not all) rely on the existing wells for drinking water; currently, such wells are only being tested for content of E. Coli and Fecal Coliform and are not being tested for content of pesticides, and in all instances the wells are located within the plantation close to fields on which pesticides have been applied. Therefore, groundwater supplying the wells may contain pesticides that have been leached from the fields by rain and irrigation water. Many factors determine whether a pesticide will leach to groundwater (Table 6-5), including pesticide properties, soil characteristics, site conditions, and management practices. The pesticides most susceptible to leaching are those with high solubility in water, low adsorption to soil, and long-term persistence. The risk of contamination is high when these pesticides are applied to sites with sandy soils, shallow depth to groundwater, and either a wet climate or extensive use of irrigation. Table 6-6 lists some pesticides that are susceptible to leachate to groundwater.

Table 6-5: Factors indication greatest likelihood of groundwater contamination by pesticides.

Factor	Remarks
Pesticide properties	High solubility Low adsorption persistence
Soil characteristics	sand and gravel low organic matter content
Site conditions	shallow depth to groundwater wet climate or extensive irrigation depressions or flat areas where water collects
Management practices	poor timing with respect to climate overapplication (rate too high or application too frequent)

Table 6-6: Pesticides susceptible to leachate to groundwater (Trautman, N. et al, unknown date, <http://pmep.cce.cornell.edu/facts-slides-self/facts/pest-gr-gud-grw89.html>)

Chemical Name	Common Trade Names
Acifluorfen	Blazer, Tackle

Alachlor	Alanex, Alanox, Alatox, Bronco, Lasso, Nudor
Aldicarb	Temik
Aldrin	Aldrex, Aldrite, Altos
Ametryn	Ametrex, Evik, Gesapax, Trinatox
Atrazine	Aatrex, Atratol, Bicep, Conquest, Extrazine, Marksman
Bromacil	Hyvar, Krovar
Carbofuran	Furadan
Chloramben	Amiben
Chlorothalonil	Bravo, Daconil, Exotherm Termil
Cyanazine	Bladex, Conquest, Extrazine
Dalapon	Dalapon, DPA
DCPA (Dimethyltetra- chloroterephthalate)	Dacthal
Diazinon	Knox Out, Basudin, Dazzel, Spectracide, and others
Dicamba	Banvel, Marksman, Weedmaster
2,4-Dichloro- phenoxyacetic acid	Envrert, Landmaster, Plantgard, Salvo, Tordon, Weedar, Weed-B-Gon, Weedone, and others
1,3-Dichloropropene	D-D 92, Telone II Soil Fumigant
Disulfoton	Di-Syston
Diuron	Karmex, Krovar
Endosulfan	Thiodan
Ethoprop	Mocap
Fenamiphos	Nemacur
Fluometuron	C-2059, Cotoran, Cottonex
Fonofos	Dyfonate
Hexazinone	Velpar
Linuron	Gemini, Lorox
Malathion	Cythion, Malamar, Vegfru, Zithiol, and others
Methamidophos	Lanate, Lanox, Methomex, Nudrin
Methomyl	Lanate, Lanox, Methomex, Nudrin
Methyl parathion	Penncap-M
Metolachlor	Bicep, Dual, Turbo
Metribuzin	Canopy, Lexone, Sencor, Turbo
Oxamyl	Vydate
Parathion	Alkron, Phoskil, Soprathion, Thiophos, and otherz
Picloram	Grazon, Tordon

A long-term monitoring plan of groundwater is a necessity in order to ensure safe drinking water, as well as keeping pesticides out of groundwater through careful storage, use and disposal practices.

Best disposal practices for the produced serum will be discussed later in the report.

6.1.2.1 Water Quality and Effluent Discharge Analysis

Water quality was analyzed using the In-Situ method. This method of analysis was conducted by Earthtime Hydrogeologist using *In-Situ Multi Parameter Troll 9500 Probe* (Appendix). The main parameters that were obtained using the Troll 9500 include:

- Turbidity
- Conductivity
- pH
- DO
- ORP
- Temperature

However, important parameters such as BOD, COD, Total Phosphorous, Total Suspended Solids (TSS), oil and grease, and Total Nitrogen, could not be analyzed due to lack of local capable laboratories.

Water was analyzed in six wells with at least one well in each camp in the plantation (Table 3-4 & Table 6-7). Water in the Bolo River located at the outskirts of the plantation was analyzed as well as water in the Kporlaryah that is crossing in the plantation. Figure 3-11 shows the different locations at which the in-situ analyses took place within the plantation. The process was conducted on both the 8th and the 10th of July, 2008 (Figure 6-2).



(a)



(b)



(c)



(d)



(e)



(f)

Figure 6-2: *In-situ* analysis activities at the plantation's wells and other water bodies. (e) *in-situ* analyses at the Kporlaryah stream within the plantation; (f) *in-situ* analyses at the Bolo River on the outskirts of the plantation.

6.1.2.1.1 Results and Interpretation

Appendix B represents results of water analysis conducted in-situ for surface water bodies and groundwater on the plantation's sites. Table 6-7 summarizes the results as reported by the Troll 9500 probe in Appendix B.

6.1.2.1.1.1 Wells

At least one well from each camp was tested (Table 6-7). Wells tested at the plantation include: Well 1, Well 3, Well 4, Well 9, Well 11, Well 13 and Well 18 (Table 6-7). Table 3-4 also indicates the corresponding name for each well given by SRC's plantation. The location of each well in the plantation is displayed in Figure 3-11.

pH

Generally, pH values in all wells tested on the plantation are below drinking water standards (6.5 – 8) and tend to be acidic as the highest value is 5.93 for Well 11 (Figure 6-3). Wells 3 and 8 show critical pH values of 4.70 and 4.72 (Figure 6-4), respectively. Although pH usually has no direct effect on consumers, it is one of the most operational water quality parameters (WHO, 2006).



Figure 6-3: Variation of pH at the tested wells within the plantation.

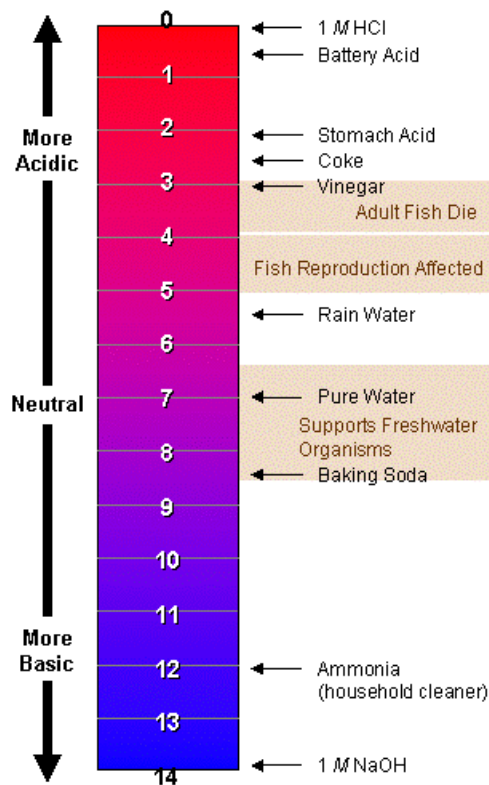


Figure 6-4: pH scale indicator.

Temperature

Temperature usually impacts the acceptability of a number of inorganic constituents that may affect taste. Cool water is generally more palatable than warm water, as high water temperature enhances the growth of microorganisms and increase taste, odour, colour and corrosion problems (WHO, 2006). Among all the wells tested at the plantation, Well 11 has a low temperature value (26.74 °C) when compared to the other wells on the plantation that have temperature ranging between 28 °C and 28.62 °C (Figure 6-5).

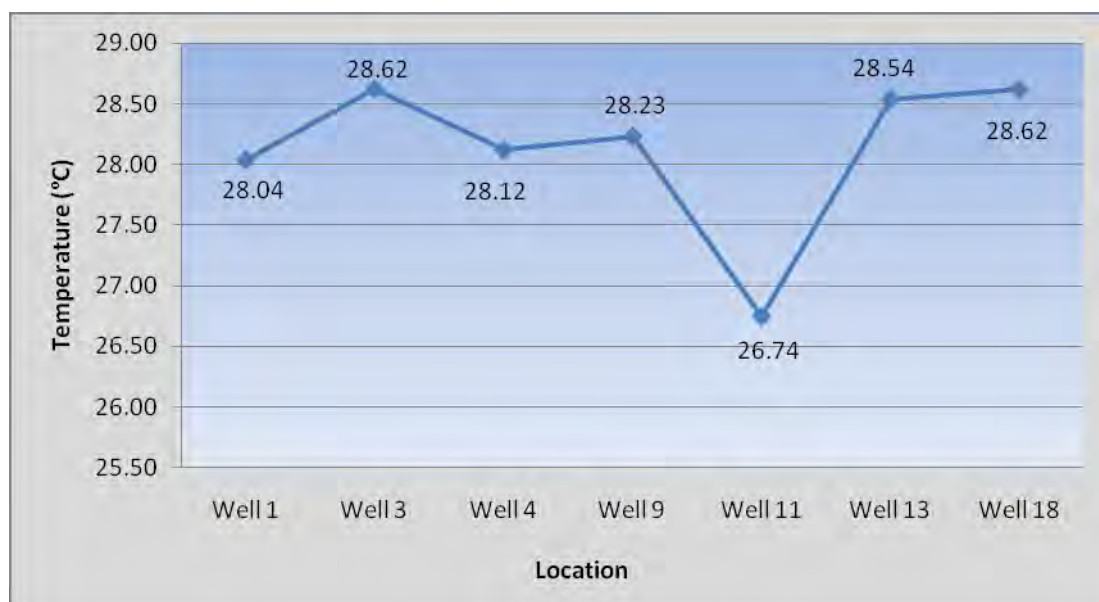


Figure 6-5: Variation of water temperature for wells tested at the plantation.

Total Dissolved Solids (TDS)

TDS values also vary from one well to another (Figure 6-6) where the minimum TDS value observed is 48.03 in Well 4 and the maximum value 276.44 in Well 18 that are located in camps 5 and 2, respectively. TDS value in Well 18 indicates that the water falls within the average tap water range (Figure 6-7), while water in wells 4 and 11 fall within the ideal drinking water range, and water in wells 1, 3, 9, and 13 show that the water has similar characteristics to spring or typical aquifer water. However, this is not an indication that the water is safe for drinking and free of

contamination. Tests for E. Coli and Fecal Coliform as well as other important parameters such as heavy metals have not been conducted.



Figure 6-6: Variation of TDS values (mg/l) for wells within the plantation.

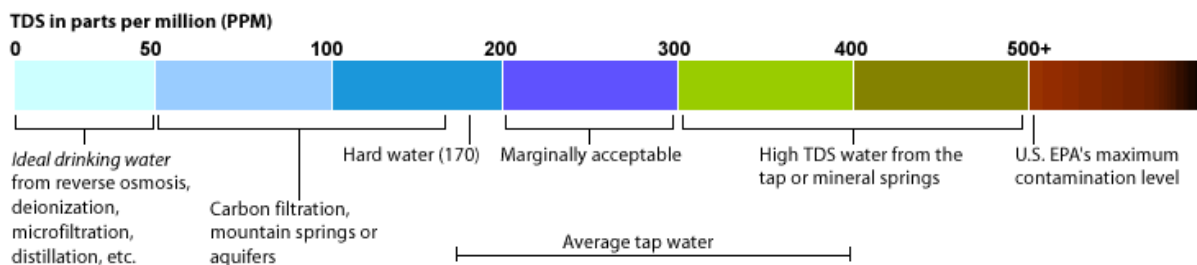


Figure 6-7: TDS scale in parts per million (ppm).

Table 6-7: In-Situ water analyses for both the factory and the plantation.

Date	Id	Location	Temperature (°C)	Turbidity (FNU)	ORP (millivolts)	pH	DO (micrograms/L)	Conductivity (mg/L TDS)
8/7/2008	Well F1	Factory	28.01	1.54	259.21	4.78	5922.21	49.79
10/7/2008	Well 1	Camp 5 Staff Bungalows	28.04	0.00	232.58	5.79	8643.25	57.99
10/7/2008	Well 3	Camp 1	28.62	0.00	285.65	4.70	6675.04	82.72
10/7/2008	Well 4	Camp 5	28.12	0.00	242.72	5.59	9751.59	48.03
10/7/2008	Well 9	Clinic	28.23	0.00	228.70	5.65	6430.30	61.05
10/7/2008	Well 11	Camp 4	26.74	0.00	228.05	5.93	8446.67	49.34
10/7/2008	Well 13	Camp 3	28.54	0.00	198.90	5.45	10406.55	82.81
10/7/2008	Well 18	Camp 2	28.62	0.00	252.50	4.72	7120.05	276.44
8/7/2008	Effluent Pond	Factory	27.20	33.23	74.88	6.87	6044.50	72.64
8/7/2008	Intake Yia Creek	Factory	25.59	13.48	64.88	7.77	10468.50	16.26
8/7/2008	Outlet into Yia Creek	Factory	25.62	14.60	63.20	6.95	10102.90	17.18
8/7/2008	Tank 1	Factory	26.12	448.17	-44.17	6.71	3326.83	153.49
8/7/2008	Bolo 1	Bolo River (Plantation's outskirt)	24.90	31.20	174.17	5.71	9421.83	9.08
10/7/2008	Kporlaryah 1	Kporlaryah Stream (Plantation)	25.90	0.00	223.25	5.55	12623.25	7.58

6.1.3 Solid Waste Management

Each facility found at the vicinity of plantation produces different types of solid waste (SW) which is practically disposed off differently. However, the waste with the most significant impact is often related to pesticide containers and obsolete, expired, and pesticides. Table 6-8 summarizes the different types of solid wastes produced at the SRC plantation, in addition to their disposal methods and the related environmental impact.

Table 6-8: Different Types of Solid Wastes Produced at the Plantation, their disposal methods and the relative Environmental Impacts

Organic	Tree residues (wood, leaves, etc...)	<ul style="list-style-type: none"> ▪ Left for natural decomposition ▪ Collected by workers for personal use 	+	<ul style="list-style-type: none"> ▪ Prevent soil erosion hence water pollution ▪ Compensate nutrients loss from soil ▪ Reduce the need for fertilization
Inorganic	Tools (old tapping knives, old cutlasses and old sprayers)	<ul style="list-style-type: none"> ▪ Reused in the field for other purposes or as spare parts 	+	<ul style="list-style-type: none"> ▪ Reduce the volume of solid waste produced at plantation
	Plastic bags (the woven PE type)	<ul style="list-style-type: none"> ▪ Reused as containers to mix fertilizer 	+	<ul style="list-style-type: none"> ▪ Reduce the volume of solid waste produced at plantation
		<ul style="list-style-type: none"> ▪ Reuse for sand transfer during dams' construction ▪ Reused for crop collection 	+	
5 liters hard plastic canister	<ul style="list-style-type: none"> ▪ Reuse for fertilizer application 	-	<ul style="list-style-type: none"> ▪ If not washed thoroughly, might lead to fertilizers' contamination with chemical residues ▪ Reduce the volume of solid waste produced at plantation ▪ If not washed thoroughly, chemical residues might contaminate the latex increasing the chemical loading into the processing effluent 	
	<ul style="list-style-type: none"> ▪ Reused to poisoning solution's application 	+		
	<ul style="list-style-type: none"> ▪ Reused for latex collection 	-		

200 liter metal drum	<ul style="list-style-type: none"> ▪ Reused as containers for oil 	-	<ul style="list-style-type: none"> ▪ If not washed thoroughly, oil can be contaminated with chemical residues
Paper bags	<ul style="list-style-type: none"> ▪ Open dumping 	-	<ul style="list-style-type: none"> ▪ Missing to recycle paper bags will require destroying more trees to produce new bags

According to the stakeholders, most of the inorganic waste produced at the plantation originates from agrochemicals' containers. These are mostly washed and then reused for other purposes. Although reusing wastes has a significant impact on reducing the produced solid waste volumes hence the cost of their disposal, special care should be awarded to containers' washing. In the case of SRC, the water used to wash biocide containers is directly discharged into swamps. Consequently, chemical pollution is anticipated in the swamps, which might also lead to ground water contamination. This type of pollution will probably affect biodiversity through the disturbance of the swamps' ecosystem. The later issue will be further discussed within the impact on biodiversity analysis.

6.1.4 Impact on Air Quality and Odors Emissions

The adverse impacts generated by the rubber plantation on the air quality are considered of lower significance as compared to soil and water deterioration levels. Nevertheless, it's essential to adopt a holistic approach when it comes to environmental protection.

Air quality impacts of rubber cultivation are directly related to "the clearance of primary rainforests" (UN, 2006). In fact, primary rainforests are considered major players in the carbon sequestration process, which is essential for limiting climate change. Clearance of such forests and replacing them with immature rubber trees will reduce the level of sequestration at least until trees' maturation. Recommended

measure aimed at improving carbon fixation will be discussed later in the Environmental Management Plan Section.

In addition, unplanned fertilization at the plantation might lead to high levels of nitrogen leaking from the soil back into the atmosphere mainly in the form of Nitrogen dioxide. The main sources of these emissions are microbial nitrification and de-nitrification (Figure 6-1). Nitrogen dioxide is considered a primary criteria pollutant, which once introduced to the atmosphere will result in acid rain in the presence of water and oxygen and the formation of tropospheric ozone in the presence sunlight and Volatile Organic Compounds (VOCs) (Cooper et.al., 2002). Although the agricultural sector is not considered the major source of nitrogen oxides as compared to the industrial and transport sectors, this issue is worth mentioning. In addition, acid rain and tropospheric ozone formation are classified as global air pollution problems, thus they might not have a direct impact on the plantation or it's neighborhood. Nevertheless, the impacts of these pollution problems have direct effect on fauna and flora in addition to the damage it can produce to physical structures and structures of cultural importance (Cooper et.al., 2002).

Another issue to be considered within the SRC plantation is the emission of putrid malodors. In fact, the serum produced during latex coagulation process has the tendency of emitting bad odors. At the SRC's plantation there are no drainage or collection systems installed for the serum collection, but instead, the foul-smelling liquid is left to leach uncontrolled leading to the intensification of the problem.

6.1.4.1 **Dust Emissions**

6.1.5 **Impact on Biodiversity**

As mentioned earlier, Hevea trees were introduced at the plantation of SRC after the

clearance of the primary forest and vegetation already existing on site. This activity had led to a temporary loss of habitats and local biodiversity (UNCTAD/IRSG, 1997). Knowing that SRC's management had adopted clone rubber farming, mainly consisting of mono-specific plantations of high yielding clonal varieties, diversity in fauna and flora became limited.

In addition, clone rubber farming is known to require intensive use of chemical inputs (Gouyon, 2003). Consequently, different types of agrochemicals are being used at the rubber plantation, five of which are known to have significant impact on the ecosystem. Table 6-9 and Table 6-10 will summarize the impact of these chemicals on biodiversity.

Table 6-9: List of the some of the Agrochemicals used at the plantation having an Adverse Impact on Biodiversity

Name of Agrochemical	Ecotoxicity	Reference
Glyphosate (Kalach)	<ul style="list-style-type: none"> ▪ Destruction of habitats and food sources for some birds and amphibians leading to population reductions 	Pesticides News, 1996
Mancozeb	<ul style="list-style-type: none"> ▪ Toxicity to aquatic organisms 	PAN Pesticide Database, 2008
2,4-D	<ul style="list-style-type: none"> ▪ Slightly toxic to small mammals on an acute oral basis ▪ Toxic to terrestrial plants (it is more toxic to dicots than to monocots) 	USEPA, 2005
Chlorothalonil	<ul style="list-style-type: none"> ▪ Very ecotoxic in the aquatic environment ▪ Ecotoxic in the soil environment ▪ Ecotoxic to terrestrial vertebrates 	FAO, 2005
Carbendazim	<ul style="list-style-type: none"> ▪ Highly toxic to aquatic life ▪ Ecotoxic in the soil environment ▪ Low acute toxicity for birds 	Pesticides News, 2002

Table 6-10: List of Aquatic Organisms Affected by Mancozeb Pollution coupled with the Noted Effect (PAN Pesticide Database, 2008)

Organism Group	Effects Noted
Amphibians	Development, Growth, Morphology, Mortality, Population
Fish	Mortality
Fungi	Development, Population, Reproduction

Molluscs	Intoxication
Phytoplankton	Growth, Physiology, Population
Zooplankton	Intoxication, Mortality

It is also worth mentioning that the plantation is surrounded by a number of swamps. Swamps are classified “among the most productive ecosystems in the world” (US EPA, 2006). They appear to host a large variety of living organisms namely some microbes’ species, plants, insects, amphibians, reptiles, birds, fish, and mammals. The complex relationship established between these different organisms is defined by food webs (US EPA, 2006). Any disturbance of this natural balance will eventually lead to a serious distortion of these life cycles. This is exactly the case at the plantation where biocides’ containers are washed for reuse; unfortunately the generated effluent water is discharged directly in nearby swamps and rivers. This practice will probably intensify the impact of the agrochemicals on the swamps ecosystem.

6.1.6 Occupational health safety

Major health risks encountered at the plantation originates from the different chemicals handled by the workers. As previously mentioned, agrochemicals are important components of the SRC’s rubber plantation management. Formic acid is also used at the plantation during the coagulation process. Handling these chemicals, especially during transport, storage, application and disposal, can pose major health risks on the plantation workers unless precautionary measures are adopted. The following Table 6-11 will summarize the different chemicals used at the plantation and the related health hazards.

Table 6-11: Summary of the Different Types of Chemicals Used at the Plantation and the Related Health Impacts

Name of chemical	Health Impact
Dursban (CNN, 2000)	▪ Neurological effects in children
Glyphosate (Pesticides News, 1996)	▪ Acute toxicity can lead to congestion of the lungs and increased breathing rate

	<ul style="list-style-type: none"> ▪ Chronic toxicity results of kidney damage and reproductive effects
Garlon (Cox, 2000)	<ul style="list-style-type: none"> ▪ Acute toxicity causes nervous system effects, weakness, stomach irritation and minor damage to liver and kidneys ▪ Chronic toxicity can lead to minor damage to liver and kidneys
2,4-D (USEPA, 2005)	<ul style="list-style-type: none"> ▪ 2,4-D is toxic to the eye, thyroid, kidney, adrenals, and ovaries/testes. ▪ Neurological effects
Sumi 8	Not Available
Bayfidan	Not Available
Mancozeb (PAN Pesticide Database, 2008)	<ul style="list-style-type: none"> ▪ Carcinogenicity, ▪ Reproductive and developmental toxicity, ▪ Neurotoxicity, ▪ Acute toxicity such as soar throat, skin rash, eye redness, diarrhea, nausea and vomiting
Banko 500	Not Available
Chlorothalonil (FAO, 2005)	<ul style="list-style-type: none"> ▪ Acute inhalation toxicant ▪ Skin sensitizer ▪ Suspected human carcinogen ▪ Target organ systemic toxicant ▪ Eye corrosive
Carbendazim (Pesticides News, 2002)	<ul style="list-style-type: none"> ▪ Carcinogenic effects ▪ Mutagenic effects ▪ Reproductive effects
Formic Acid (OSHA)	<ul style="list-style-type: none"> ▪ Acute toxicity leads to corrosion of the skin, eyes, and mucous membrane of the mouth, throat, and esophagus and may be associated with complications such as cardiovascular collapse and ischemic damage to the heart, liver and kidneys, swelling of the airway, and respiratory distress) ▪ Ingesting causes ulceration of the gastrointestinal tract, resulting in perforation and peritonitis and late scarring of structures of the gastrointestinal tract which, in turn, produces obstructions that require surgical repair ▪ A worker splashed in the face with formic acid developed respiratory distress and difficulty in swallowing, and died within 6 hours ▪ Splashes of formic acid in the eye have caused permanent clouding of the cornea, with loss of visual acuity. ▪ Chronic toxicity (damage to the kidneys and sensitization dermatitis)

Careful handling of agrochemicals is advised at the SRC rubber plantation in order to reduce the related adverse health impacts. In fact, lack of protective personal equipment use was observed at the plantation during field visits, especially during

biocides' application, leading to an increased occupational risk (Figure 6-8).



Figure 6-8: (a-c) Workers on plantation poorly equipped with personal protective equipment; (d) a container of formic acid placed near a coagulation location with no labeling or appropriate storage.

Other types of occupational health risks can be related to physical injuries due to field work (Table 6-12). These are considered of minor risk as compared to chemical exposure.

Table 6-12: List of Physical Injuries

Bush fire	High during short dry season
Snake bite	Low 4 – 4 cases per year- not known if hospital stocks anti venom
Cuts from slashing/weeding	High but relatively rare considering the size of workforce
Burns	High during new clearing bit incidents are rare

Injured or diseased workers are usually referred to the clinic located within the SRC

plantation. The clinic should be well equipped in order to assimilate all type of occupational health risks encountered by the works.

6.2 ENVIRONMENTAL IMPACT ASSESSMENT AND ANALYSIS OF SRC'S RUBBER PROCESSING FACILITY

Liquid latex is highly unstable and tends to degrade shortly after tapping. 90% of the latex produced worldwide is converted into stable easier to handle, store and process dry rubber (Gouyon, 2003). The SRC rubber plantation is considered the main supplier of coagulated latex of SRC factory where latex undergoes a chain of processes resulting of a stabilized rubber product ready for export and further processing.

There are a number of environmental concerns associated with the operation of a rubber manufacturing facility. These include, water consumption and pollution, energy consumption, disturbance of the surrounding ecosystems, air and odor emissions, wastewater and solid waste generation and occupational health (Figure 6-9 and Figure 6-10). Unless environmental management practices are adopted at the SRC's factory, environmental degradation is inevitable.

For the purpose of alleviating the adverse impacts, the following section will consist of identifying the different risks posed by the rubber processing facility on the environment and public welfare. The different environmental and health issues mentioned earlier will be grouped under different titles, namely impact on water resources, impact on air quality, impact on ecosystem and biodiversity, impact on landscape and visual amenity and impact on human health, for the purpose of simplifying the structure of the report. Environmentally sound management practices will be discussed in details later in the report, in the environmental and social management plan section.

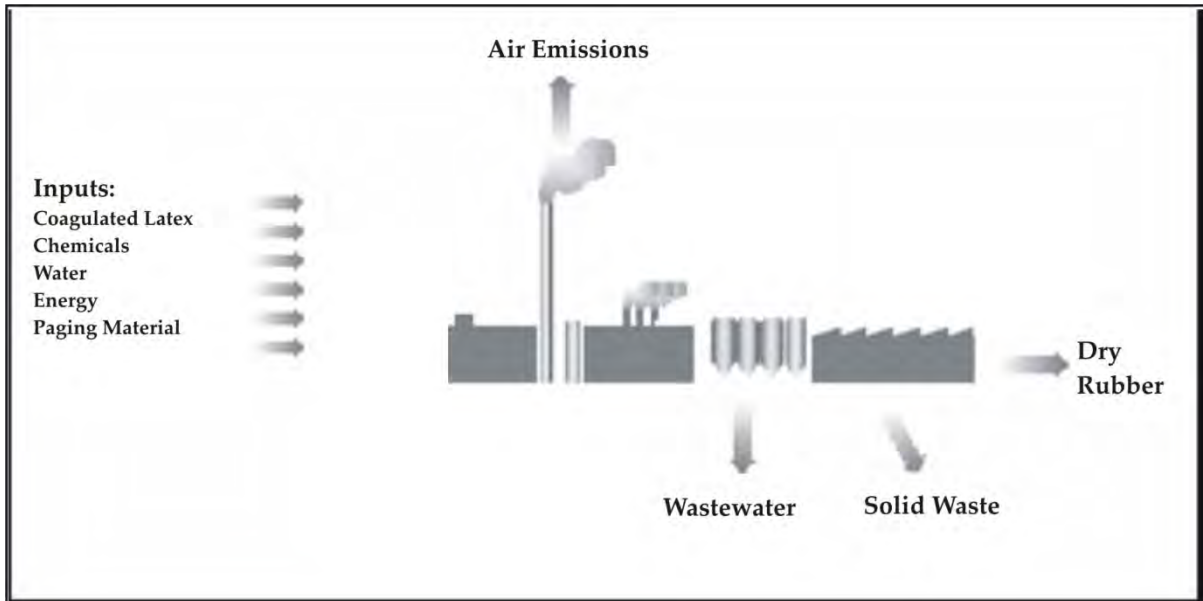


Figure 6-9: Environmental Impacts Generated by a Typical Rubber Drying/Stabilizing Facility

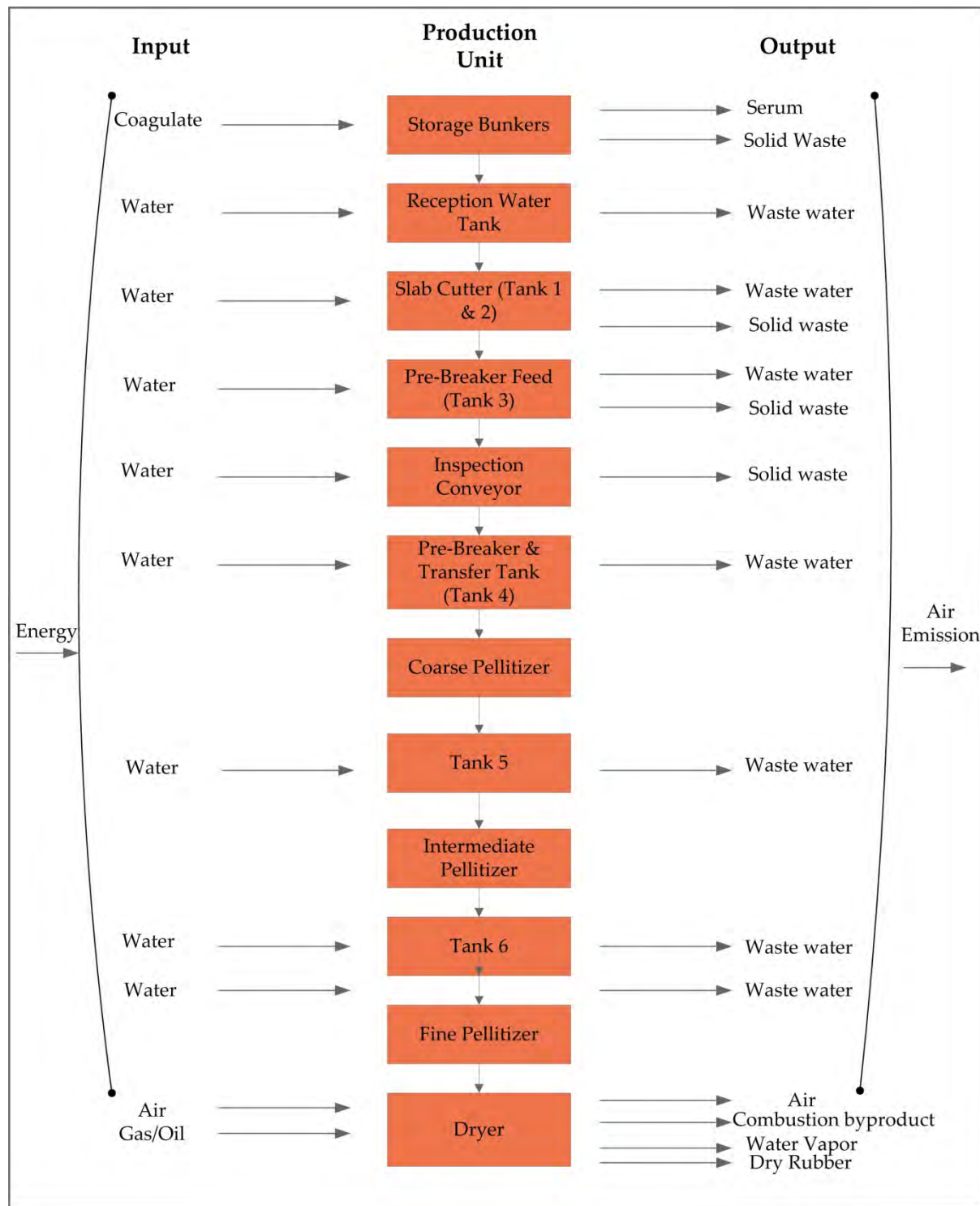


Figure 6-10: Rubber production process and the related inputs and outputs.

6.2.1 Impact on Water Resources

Water resources located within or nearby SRC's rubber production facility are prone to deterioration unless good management practices are adopted. In fact, there are

two main classes of environmental impacts associated with SRC's operations namely water consumption patterns and water pollution.

6.2.1.1 Water Quality and Effluent Discharge Analysis

Water quality at the factory, the nearby Yia Creek, and the effluent pond was analyzed using the In-Situ method. This method of analysis was conducted by Earthtime Hydrogeologist using *In-Situ Multi Parameter Troll 9500 Probe* ([Appendix](#)).

The main parameters that were obtained using the Troll 9500 include:

- Turbidity
- Conductivity
- pH
- DO
- ORP
- Temperature

However, important parameters such as BOD, COD, Total Phosphorous, Total Suspended Solids (TSS), oil and grease, Total Nitrogen, Total Coliform and E. Coli could not be analyzed due to lack of local capable laboratories.

Water was analyzed in one well within the factory (Table 3-4), the nearby Yia Creek, the effluent pond and in Tank 1 (Table 6-7). Figure 6-15 shows the different locations at which the in-situ analyses took place within the factory. The process was conducted on the 8th of July, 2008 (Figure 6-12).

Water in the nearby Yea Creek adjacent to the factory was also analyzed at two different locations; the intake point where water is pumped into the factory for process use and the outlet point few meters after the effluent are discharged from the effluent pond (Figure 6-15).

It should be noted that monitoring water quality for such an operation existing on a bank of river/creek should be performed at different intervals of time; i.e. seasonal monitoring, in order to detect pollution variation. This was not applied during the preparation of this report. Thus, the obtained results only represent the water quality at the sampling days and do not reflect general water quality of the creek. However, some analyses strictly represent the effluent discharge of the factory as they were conducted within the effluent pond (Figure 6-13 & Table 6-7). Water from the effluent pond is discharged through drainage into the Yea Creek (Figure 6-13).

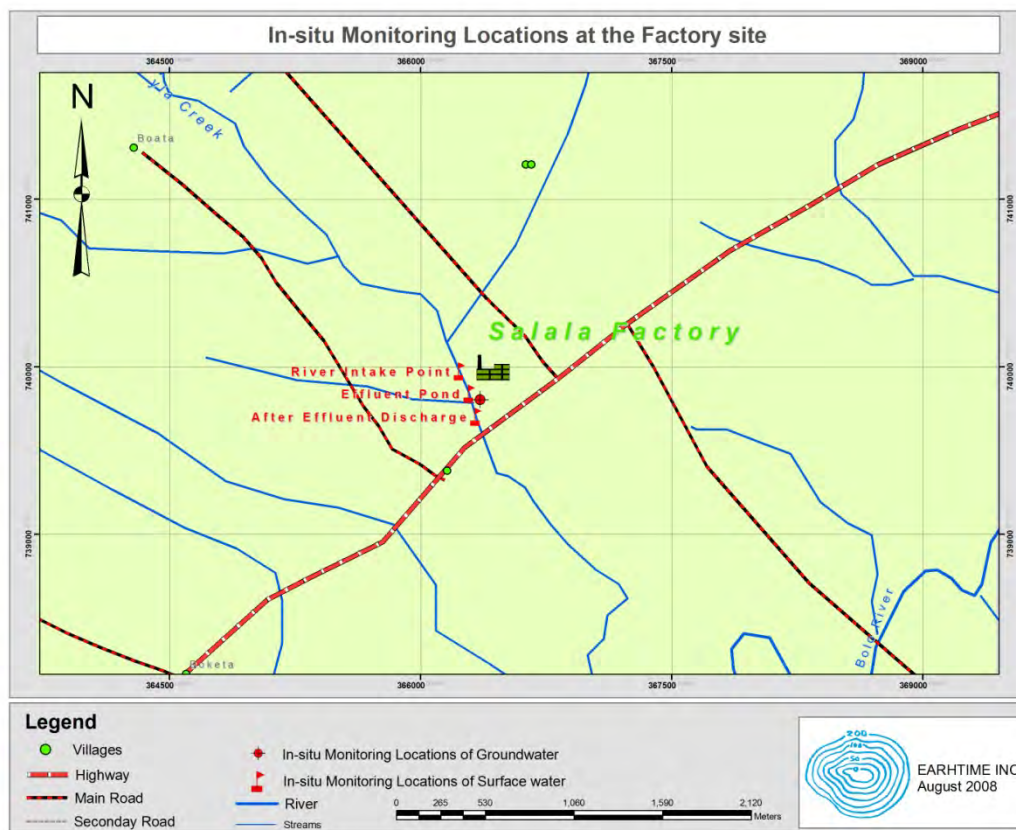


Figure 6-11: Sampling locations at SRC's factory's site.



(a)



(b)



(c)



(d)



(e)

Figure 6-12: In-situ analysis activities at the factory's site.



(a)



(b)



(c)

Figure 6-13: (a) Effluent pond at SRC's factory; (b) outlet from effluent pond; (c) effluent drainage leading to the Yea Creek.

6.2.1.1.1 Results and Interpretation

6.2.1.1.1.1 Wells (Well f1)

During the visit to the site, Earthtime's Hydrogeologist was informed that water from Well F1 is being used by the workers of the factory for drinking purposes. In the following paragraphs, some parameters are shown not to meet acceptable drinking water standards, and it is strongly recommended to abandon using this well for drinking purposes.

Total Dissolved Solids (TDS)

The TDS value (Table 6-7) of the water in the factory's well (Well F1) is not objectionable as it is 50 mg/l (50 ppm) (Figure 6-7). WHO standards advice

maximum contamination level (MCL) of 500mg/liter (500 parts per million) for TDS. When TDS levels exceed 1000 mg/l it is generally considered unfit for human consumption. High TDS level is an indicator of potential concerns. Most often, high levels of TDS are caused by the presence of potassium, chlorides and sodium.

pH

pH values obtained at Well F1 is 4.78 (Table 6-7). pH values exceeding 11 are considered as basic (high content of Ammonia) while pH values lower than 5 affect aquatic life (Figure 6-4). **The pH value of water in Well F1 indicates that the water is harmful and should not be consumed by humans.** It is recommended to establish a long term monitoring scheme for this well in order to identify the source of contamination.

Turbidity

The turbidity value in the Well F1 is 1.54 FNU (Table 6-7) whereas allowable value for drinking water standard range between 0.3 and 1 FNU with many drinking water utilities striving to achieve levels as low as 0.1 FNU. The turbidity value in this well is not satisfactory and it is not recommended to use the water for drinking purposed.

6.2.1.1.1.2 Surface Water

The Yea Creek in addition to the effluent pond are the two main surface water bodies that were tested in-situ (Table 6-7). Water was analyzed at two main locations within the Yea Creek while one sample was taken at the effluent pond. The two locations at the creek include the river intake point (where water is pumped to the factory for rubber processing) and the outlet point which is located few meters after water is discharged from the effluent pond (Figure 6-11). Figure 6-14 shows the

difference in values obtained for the different parameters for the Intake Point, the effluent pond and after the outlet to the Yia Creek from the effluent pond.

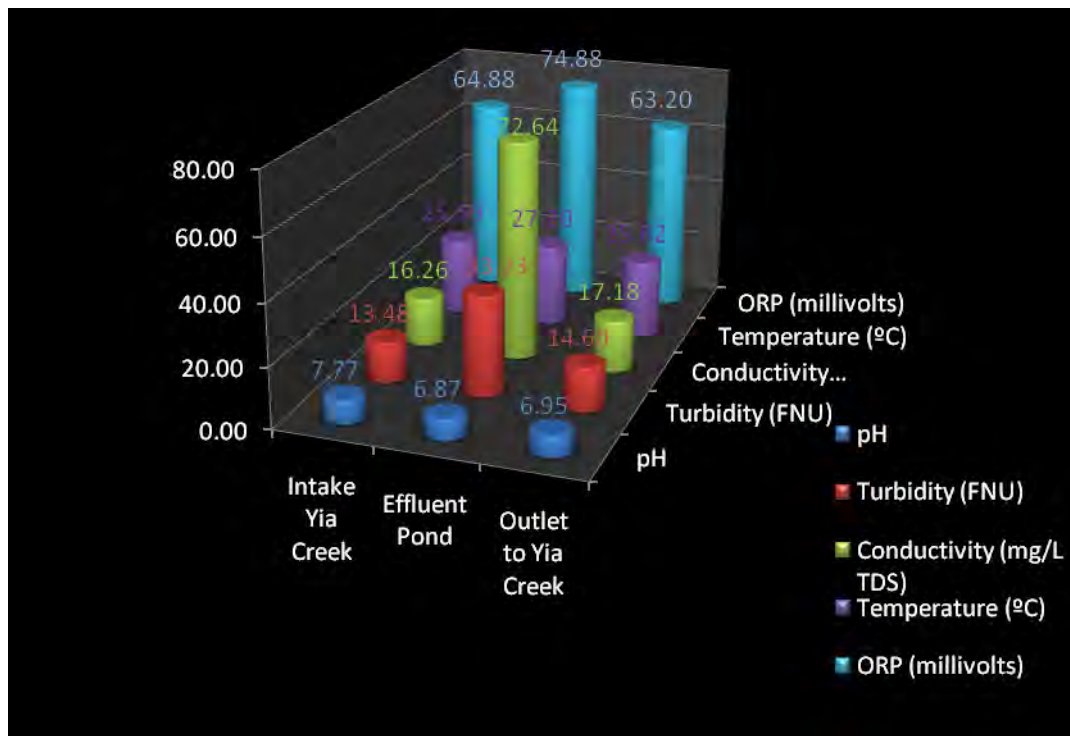


Figure 6-14: Comparison of water quality between the intake point (Yea Creek), effluent pond and Outlet point (Yea Creek).

Analytical results revealed that water quality in the creek is not affected in terms of conductivity (TDS), pH, ORP, turbidity, and temperature values (Table 6-7).

Total Dissolved Solids (TDS)

Even though the conductivity (TDS) value of the effluent pond (72.64 mg/l) appears to be higher than that at the intake point in the Yea Creek (16.26 mg/l), the value does not seem to remain high at the outlet point in the Yea Creek (17.18 mg/l). Moreover, the TDS value in the effluent pond remains within acceptable range (Figure 6-7).

pH

pH values obtained at the intake point and the outlet point are 7.77 and 6.95, respectively while the pH value in the effluent pond is 6.87 showing slight variation between the three locations (Table 6-7). The pH value for water at the intake point tend to be basic while pH values for the outlet and the effluent pond appear to be close to neutral (Figure 6-4).

Turbidity

As mentioned earlier allowable drinking water standards for turbidity values range between 0.3 and 1 FNU. Higher turbidity values indicate high Total Suspended Solids (TSS). The turbidity value of the effluent discharge from the factory in the effluent pond is 33.23. This value is higher than those at the intake point and the outlet point, which are 13.48 and 14.60, respectively. The slight difference between the turbidity values at the intake point and the outlet point could be due the contribution of effluent discharge from the effluent pond into the Yea Creek.

Temperature

There is also a slight difference in temperature values between the intake point, the effluent pond and the outlet point; the values are 25.59 °C, 27.20 °C and 25.62 °C, respectively. The higher temperature value in the effluent pond could be due to the fact that the water in the pond is generally stagnant; however, this could be contributing to the slight increase in temperature between the intake and the outlet points.

6.2.1.2 Water Consumption

Water consumption patterns are highly significant at typical rubber processing facilities. Clean water is used in large volumes during the rubber processing, especially during pre-drying stages where latex is continuously washed for impurities' removal. Water used during the rubber primary processing is directly drawn from the Yea Creek located adjacent to the SRC facility. Annual water consumption at WRC facility amounts to 70 to 80 m³ per hour (How much per ton of rubber produced???)

In the absence of data concerning the water consumption patterns at the WRC, secondary data in typical rubber processing facilities will be used, as it is critical for improving water resources' management at the WRC. According to the literature, for each kilogram of block rubber in TSR units almost 25 L of clean water is consumed (Wouapi et.al, 2006). Incentives for controlling and reducing water consumption patterns are non-existing at the WRC facility mainly because water resources are still conceived as inexhaustible free good. This old paradigm is considered misleading.

The problems generated from such high water consumption are not only related to the depletion of water resources at the WRC but it also leads to high production of acidic and organically loaded wastewater. In fact, "rubber processing generates on average effluent twenty-five to forty times more than the volume of rubber produced" which is equivalent to 25 to 40 m³ of water used for each metric ton of rubber produced (Wouapi et.al, 2006; Department of Industrial Works, 2001). The properties of such effluent vary greatly depending on the end product, namely on the grade of rubber produced. Information associated with the quality of the WRC discharges was not available due to the lack of laboratory resources at the facility. Secondary data was used in this study in order to understand the impact of TSR production at the WRC on the water quality (Table 6-13).

Table 6-13: Properties of the Effluent Generated during TSR Production in Comparison to the World Bank Standards

pH (S.U.)	4.5	6-9
Total Solids (mg/L)	6000	50
Suspended Solids (mg/L)	15000	Not Available
BOD (mg/L)	6000	Not Available
COD (mg/L)	4000	250
Ammoniacal Nitrogen (mg/L)	500	10
Total Nitrogen (mg/L)	800	15

According to the previous table, effluents from typical rubber processing facilities are relatively acidic, rich in organic matter and suspended solids as compared to the World Bank Guidelines. Therefore, untreated discharges into surface water bodies will rapidly lead to the deterioration of the physical, chemical and biological quality of the receiving water.

The only effluent treatment process applied at the WRC consists of directing process effluent into evaporation ponds, where wastewater is left for 16 days retention time before being discharged in the Yea River. Two evaporation ponds were identified within the WRC facility, one of which is currently being used for effluent discharge while the other is already closed due to saturation. Both of evaporation lagoons were constructed with disregard to environmental considerations. In other terms, although they were established in locations where the water table is relatively high, no protective lining material was used to prevent leaching into the ground water table. In addition, these lagoons were located at proximity (only few meters) of the Yea Creek, which accentuated the river pollution level especially during flood season.

(What do they do with sludge??? Do they trap rubber and recycle/reuse it?).

Evaporation ponds usually play a role in enhancing settlement of suspended solids

present in wastewater, however, this practice is not considered sufficient for water pollution control, knowing the composition of the WRC effluent.

During field visits, a black coloration of the receiving water was observed. This phenomenon is expected to decrease the levels of light penetration into the water thus limiting photosynthesis of bottom vegetation. Photosynthesis plays a major role in balancing to oxygen levels in the water necessary for a sustained aquatic life. In addition, limited vegetative growth in the water will probably weaken the balance of the aquatic food chain, leading to limited populations' growth.

The acidity of the WRC effluent has detrimental effect on the receiving water quality. First, it will trigger the acid leaching of toxic metals from nearby soil and second it will induce fish death (Cooper et.al, 2002).

Furthermore, nitrate accumulation is anticipated in the Yea River due to high BOD/COD content of the untreated effluents. According to the literature, high levels of organic matter in water bodies will trigger bacterial decomposition in the presence of dissolved oxygen into carbon dioxide, water and nitrate leading to nitrate accumulation (US EPA, 1997). High nutrient levels in the water, namely nitrate, will accelerate the growth of algae in the water leading to oxygen depletion. Dissolved oxygen is vital for aquatic ecosystem's growth. Lack of adequate levels of dissolved oxygen will result of death or limited growth of aquatic populations (Wouapi et.al, 2006; US EPA, 1997). Oxygen depletion will reduce water quality value for other uses like drinking and swimming, and might also cause the release of obnoxious odors during the dry season (Wouapi et.al, 2006).

Calcium hydroxide is used during the rubber processing to reduce the cohesion of the fine rubber particles immediately prior to the drying cycle. Thus, calcium hydroxide is expected to be present in the process effluent discharge in the Yea River. According to the literature, calcium hydroxide doesn't present any adverse

impacts on aquatic ecosystems; on the contrary it plays an important role in hindering eutrophication through binding to phosphorus present in water (Washington State Department of Ecology, 2005).

6.2.1.3 Wastewater Management

On the other hand, wastewater produced at WRC does not consist only of process wastewater, it also includes sewage waste, equipment cleaning effluent, runoff from process and materials staging areas (including serum), and miscellaneous activities including wastewater from laboratories, equipment maintenance shops, etc...(World Bank, 2007).

According to the WRC management, sewage waste generated from residential and office complexes are usually collected in septic tanks which are periodically emptied by the Liberian Water and Sewage Corporation. The septic tanks commonly available in Liberia are open bottom. Knowing that the water table is high in the study area, potential leaching and contamination of the ground water with sewage should be anticipated.

Oil waste from workshop, vehicles and generators are usually collected and sold to locals. Recycling oils is a good management practice adopted by WRC, however collection methods devised for this type of hazardous waste should be given enough consideration in order to prevent accidental spills. Finally, runoff and equipment cleaning waters are collected and transferred to the evaporation ponds before later discharge in the Yea Creek. This type of effluent potentially contains organic matter from serum and washed soil, oils and caustic soda from equipment cleaning. Once discharged in the Creek, three major pollution problems can be expected namely eutrophication, oil and chemical pollution. These problems will have major impacts on the designated water uses in addition to the impact on biodiversity. The latter impact will be discussed fully in the impact on biodiversity analysis.

Obviously, effluents from the WRC facilities require further treatment to reduce the water quality degradation and aquatic ecosystems disturbance. Suggestions for wastewater treatment strategies that can be adopted by the WRC management will be discussed later in this report.

6.2.2 Impact on Air Quality

Primary rubber manufacturing involves two main processes, to be exact cleaning and drying the rubber. Electrical and fuel energy are the types of energy sources respectively used in each of these processes.

During the cleaning process, machines are used to grind, shred and cut the rubber into small sized particles in order to increase the water contact surface during washing. Cleaning is essential for the production of high grade rubber, however it requires significant amounts of electrical energy (Department of Industrial Works, 2001). According to the literature, electrical power consumption can reach up to 600 kW per ton of TSR produced (Wouapi et.al, 2006). In the case of WRC, private generators are used to produce the necessary electric power for process operation.

During the drying process, on the other hand, heat is generated through the combustion of diesel oil and distributed throughout the dryer by electric fans. Rubber drying usually involves removing humidity from the rubber content after being cleaned. Heating also facilitate storage of processed rubber by preventing biological deterioration (Department of Industrial Works, 2001). According to the literature, fuel consumption of diesel/thermal fluid heater ranges from 50 to 60 L per ton TSR produced (Wouapi et.al, 2006). **Data available for WRC shows that fuel consumption during rubber processing can reach 31,000 L/week.**

“Research has found that fuel consumption incurs one of the most variable costs for Block Rubber Industry” (Department of Industrial Works, 2001). Consequently,

adopting energy efficient practices will not only promote environmental health, it will also reduce the economic costs associated with high energy consumption. Such practices will be discussed later in this report.

Energy production, both in the form of heat or electric power, involves fuel combustion, which will result of the air pollutant release. Table 14 summarizes the different emissions released during fuel combustion and their impacts on human health. However the impact of these on biodiversity will be discussed later in the related part.

Table 14: List of Pollutants Generated as a Result of Fuel Combustion and the Related Health Impact (Cooper et.al, 2002; USEPA,2008)

Name of Pollutant	Type of Pollutant	Health Impact
Nitrogen oxides (NO _x)	Primary Criteria Pollutant	<ul style="list-style-type: none"> ▪ Eye and nose irritation; ▪ Pulmonary edema; ▪ Bronchitis; ▪ Pneumonia; ▪ Pulmonary fibrosis; ▪ Emphysema; and ▪ Increases the frequency of lower respiratory tract illness in children;
Sulfur dioxide (SO ₂)	Primary Criteria Pollutant	<ul style="list-style-type: none"> ▪ Bronchoconstriction; ▪ Eye, nose and throat irritation; ▪ Stimulates mucus secretion; and ▪ Chronic bronchitis
Carbon monoxide (CO)	Primary Criteria Pollutant	<ul style="list-style-type: none"> ▪ Fatigue; ▪ Headaches; and ▪ Intoxication
Particulate matter (PM)	Primary Criteria Pollutant	<ul style="list-style-type: none"> ▪ Bronchitis; ▪ Asthma; ▪ Emphysema; ▪ Pneumonia; and ▪ Cardiac disease
Carbon dioxide (CO ₂)	Greenhouse Gas	<ul style="list-style-type: none"> ▪ Adverse effects due to exposure to extreme temperature variations (i.e.: Prolongation of the disease transmission seasons, dehydration, etc...); ▪ Reappearance of climate sensitive diseases (i.e.: malaria, dengue fever, yellow fever, and encephalitis, and cholera, etc...)
Methane (CH ₄)	Greenhouse Gas	

Name of Pollutant	Type of Pollutant	Health Impact
Volatile organic compounds (VOCs)	Lead to Ground-level Ozone formation in presence of NO _x	<ul style="list-style-type: none"> ▪ Formation of ozone might lead to: <ul style="list-style-type: none"> ○ Severe eye and nose irritation; ○ Reductions in lung functions; and ○ Lung aging

Although fuel combustion can induce the release of PM into the atmosphere, these releases are considered minor when compared to emissions caused by the continuous incoming and out coming heavy duty vehicles for transport of raw or stabilized rubber. In fact, major roads connecting the WRC facility to the main road paved, however those connecting the plantation with the facility are not. Consequently, the transport of coagula from the plantation to the processing facility can be the source of high PM release into the atmosphere.

Emissions level produced by the WRC facility are not included in this report due to the lack of resources. Consequently, the level of WRC's contribution to ambient air quality deterioration in the study area is not well determined. However, understanding the magnitude of the air pollution problem created should be sufficient for initiating pollution control incentives. Air pollution abatement practices will be discussed later in this report.

6.2.3 Impact on Biodiversity

According to what was previously mentioned in this report, primary rubber manufacturing generates significant amounts of pollutants simultaneously discharged in different environmental media (such as air and water). Living organisms relying on these media for survival are the main victims of environmental pollution.

Effluent discharges in the Yea creek with minimal treatment had induced water black coloration, nitrate accumulation, increased acidity of water and chemical/oil

pollution. Each of these water related problems has an independent adverse impact on aquatic ecosystems. The following Table 15 lists the different adverse effects produced by each water pollution problem.

Table 15: List of Water Pollution Problems Induced by WRC Operation and the Related Impacts

Problem	Direct Impact	Ecological Impact
Black water coloration and Oil pollution	Prevent light penetration, Oxygen depletion	<ul style="list-style-type: none"> ▪ Reduced photosynthesis; ▪ Disturbance of the aquatic food chain due to changes in the species composition of algal communities; ▪ Increased fish mortality caused by deoxygenating water
Nitrate accumulation	Eutrophication, Oxygen depletion (Merrington, 2002)	<ul style="list-style-type: none"> ▪ Algal bloom ▪ Disturbance of the aquatic food chain due to changes in the species composition of algal communities; ▪ Increased fish mortality caused by deoxygenating water (resulting from algae and weeds decomposition); ▪ Production of toxins in the water by some algal species
Acidity	Change in water pH (Cooper et.al, 2002)	<ul style="list-style-type: none"> ▪ Increased fish mortality
Sodium hydroxide pollution	Chemical Pollution (ATSDR, 2002)	<ul style="list-style-type: none"> ▪ Induce mortality in crustaceans, fish, insects, mollusks, nematodes and flatworms, and zooplankton. ▪ Induce physiological changes in crustaceans ▪ Induce reproductive effects on marine benthic communities ▪ Lead to intoxication in zooplankton

Terrestrial ecosystems in the study area are prone to degradation due to ambient air quality deterioration. The different pollutant emitted during the rubber primary processing generates a wide range of adverse effects on fauna and flora. The following Table 16 will only summarize the major pollutants produced during the WRC operations and the associated ecological impacts.

Table 16: List of Air Pollutants Produced by WRC Facility and the Related Impacts (Cooper et.al., 2002)

Pollutant	Ecological Impact
Nitrogen oxides (NO _x)	<ul style="list-style-type: none"> ▪ Necrosis in broad leaved plants ▪ Retardation of vegetative growth
Sulfur dioxide (SO ₂)	<ul style="list-style-type: none"> ▪ Chlorosis (loss of chlorophyll) in green plants ▪ Plasmolysis (tissue collapse of many leaf cells) ▪ Acid deposition leads to reduction in growth of 6 hardwood species

Environmental goods, similar to any other public goods, are usually abused and depleted irresponsibly. Damages imposed on the environment are not accounted for as a production cost, but instead burdens are shared by the general community. Apparently, sensitive ecosystems are highly exposed to deterioration as a result of the WRC operations. Management adjustments are essential at this point for sustainable development. Recommendations for better management practices will be included in the environmental management plan.

6.2.4 Impact on Human Amenity and Health

Deterioration of the environmental quality is directly reflected in adverse health outcomes. Each pollution problem discussed earlier in this report, whether air pollution or water pollution, was directly linked to negative health impacts expected to affect neighboring communities.

Occupational health risks are also significant in the rubber processing industry; however these only affect employees directly involved in the production process. Occupational health risks usually vary between physical hazards and dust/chemical inhalation. The following Table 17 lists the different hazards encountered during the production process and the related sources.

Table 17: Occupational Health Hazards and the Associated Sources

Type of Hazard	Source
Physical Hazards	<ul style="list-style-type: none"> ▪ Same-level fall hazards due to slippery conditions (through the use of water in production and cleaning) and the use of machines and tools ▪ Grinders, shredders and conveyors are potential hazards and may catch fingers, hair, and clothing. ▪ Repetitive work including cleaning ▪ Poor work postures caused by inadequate workstation and process activity design ▪ Manual rubber inspection for impurities can cause injuries ▪ Exposure to heat from dryer
Dust/chemical Inhalation	<ul style="list-style-type: none"> ▪ Organic dust arising from rubber grinding and handling of calcium and sodium hydroxide ▪ Caustic acid burns

Occupational hazards can be avoided through the adoption of the appropriate prevention measures. A full discussion of such measures will be discussed later in this report.

6.2.5 Impact on landscape and Visual Amenity

Visual impact of the factory is low and restricted to a few hundred meters from any direction as the compound is surrounded by high vegetations and trees.

6.2.6 Noise Emission

SRC workers are exposed to noise rising from transport of raw materials and finished products as well as from process and utility machinery. The main sources of highest noise at SRC are the power plant, and processing plant. The Noise levels were obtained at SRC and discussed in the following sections.

6.2.6.1 Noise Level Monitoring Equipment

Noise levels were recorded using an integrating sound level meter type 407780 manufactured by Extech Instruments. Extech Model 407780 is a rugged integrating sound level meter that provides comprehensive data for environmental noise measurements. The A-scale and the slow response method were used in order to approximate the frequency response of the human ear because it represents the response of the human ear when listening to ordinary every day sound. A calibrator is available to calibrate the instrument and ensure accurate noise measurements. The noise level meter indicates at each location the maximum (Lmax), minimum (Lmin) and average sound level (Leq) in addition to date and time recorded during the sampling period.

6.2.6.2 Noise Level Monitoring Methodology

Four (4) monitoring locations were selected and denominated from L1 to L4 (Table 6-18). At these locations, noise level was monitored continuously (Appendix F). The selection was done taking into consideration location and time where the highest noise levels are expected to be present and with respect to the source of the highest noise level (power plant and processing plant). The five locations at which the noise was monitored are listed and described in Table 6-18. Measurements at all locations, were taken both during the operation of the processing plant (factory) and the Caterpillar 850kVA-generator (refer to Table 4-11) in the power plant.

Table 6-18: Brief Description of Sampling Locations

MONITORING DATE	STARTING TIME	ENDING TIME	SAMPLING REFERENCE	SAMPLING LOCATION	BRIEF DESCRIPTION
01/07/08	11:24:00	12:23:55	L1	MAIN ENTRANCE GATE	DURING OPERATION; LOCATED FEW METRS FROM PROCESSING PLANT, AND ABOUT 50m FROM

					POWER PLANT.
01/07/08	13:50:00	14:49:55	L2	PROCESSING PLANT (FACTORY)	LOCATED BEHIND POWER PLANT. SEPARATED BY A CONCRETE WALL.
08/07/08	10:19:00	11:18:55	L3	POWER PLANT	LOCATED FEW METERS AWAY FROM BUNKERS.
01/07/08	15:02:00	16:01:55	L4	NEAREST RESIDENTIAL UNIT	LOCATED 300M FROM FACTORY PLANT & 400M FROM POWER PLANT

6.2.6.3 Results & Interpretations

Comparing locations (Table 6-19), considerable high levels were recorded during the production process in the processing plant (factory) where noise level temporarily exceeded 85 dbA, while the highest noise level was measured in the generator's rooms and appears to be between 100.4 and 106.2 dBA (Table 6-19). The maximum and the minimum values indicated in Table 6-19 are temporal and could be due to instant events and do not reflect the permanent noise level with or without operation. Meanwhile, the average values indicated in Table 6-19 reflect the noise level within the facility at the corresponding locations. These values were obtained by calculating the average of readings measured at the various locations. These readings are presented in Appendix F. Therefore, the average values can be considered as indicative noise levels at the various locations within the factory's facilities. Accordingly, the noise level at the processing plant (87.4 dBA) ranges between moderate and very loud (Figure 6-16), while that at the power plant falls within the very loud category as indicated in Figure 6-16. At other locations such as the entrance gate, and outdoor the residential units, noise levels range from moderate to quiet, respectively. The increase in noise levels at these locations (the maximum and minimum values in Table 6-19 are temporal and are attributed to

vehicles, especially heavy duty vehicles transporting raw materials and finished products inside and outside the factory's compound.

Even though noise pollution during operation from both the processing plant and the power plant could have negative impact mainly on the employees working within these facilities, the open nature of the site is sufficient to minimize noise propagation and promote dampening thus reducing any significant impact on the public. In other words, noise pollution at SRC is limited to the processing plant and the power plant and represents the main source of noise at SRC's compound.

Table 6-19: Temporal Maximum and Minimum On Site Noise levels at various locations (maximum and minimum values based on values in Appendix F).

Location	Monitoring Duration (hr)	Recorder Number	Maximum Value (dBA)	Minimum value (dBA)	Leq (dBA)	Average ⁶ value	Remark
Main Gate Entrance (L1)	1	720	86.1	69.3	75.3	75.4	During Operation
Processing Plant-Factory (L2)	1	720	88.3	83.8	84.7	87.4	During Operation
Power Plant (L3)	1	720	106.2	100.4	102.6	102.6	During Operation
Nearest Residential unit (L4)	1	720	82.9	41.7	62.7	56.1	During Operation
Plantation's Entrance Gate	1	720	76.3	34.9	55.5	63.9	Crossing Vehicles are main source of noise

⁶ Average value was obtained by calculating the average of noise level readings at each location (Appendix F)

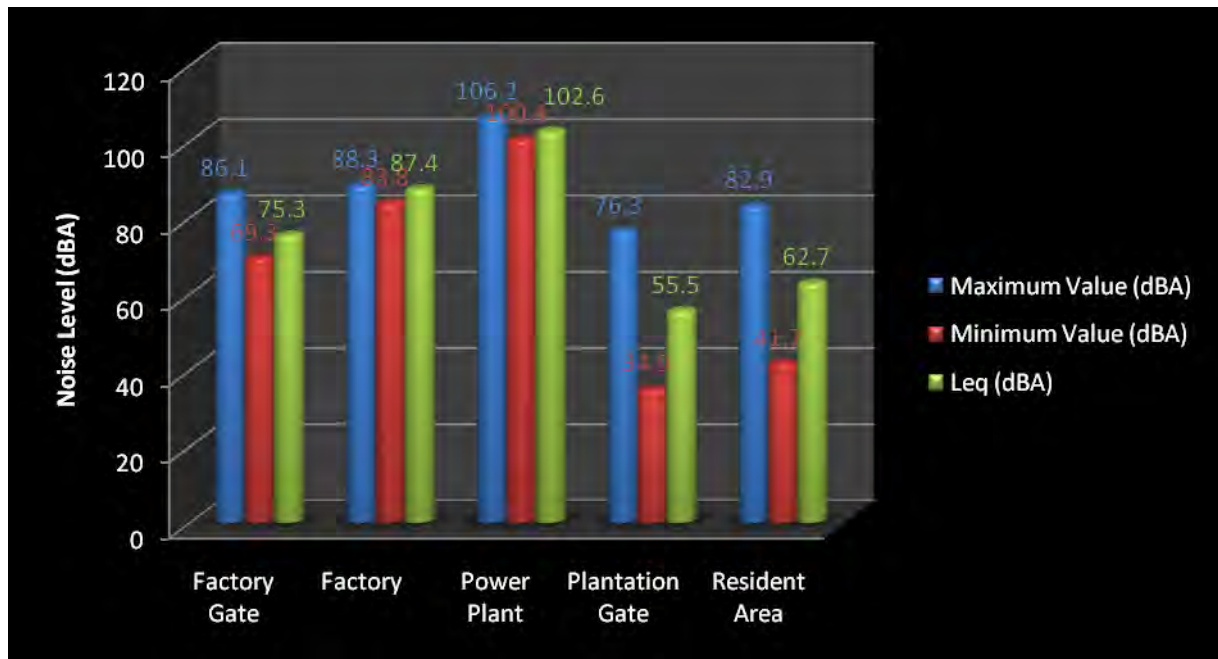


Figure 6-15: Noise level at various locations at SRC.

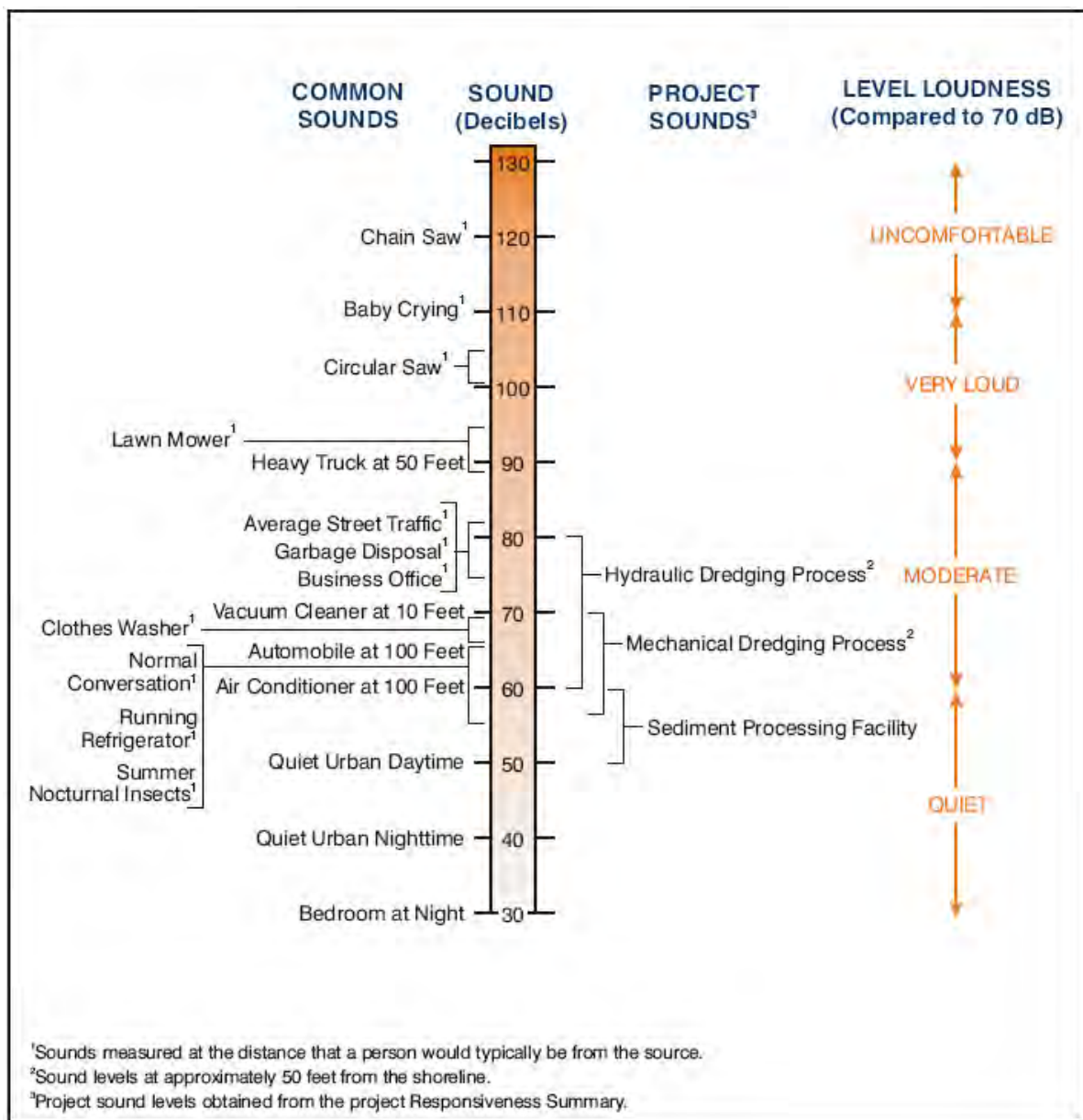


Figure 6-16: Figure adopted from Handbook of noise control, C. M. Harris, Editor, McGraw-Hill Book Co., 1979, and FICAN 1992.

7 SOCIAL IMPACT ASSESSMENT

SRC is planning to improve the current living conditions of the workers residing in the camps. This section presents the results of the socioeconomic survey undertaken by Earthtime Inc. upon the request of SRC as part of the ESIA site survey. The survey was conducted at the plantation site and covered 5 camps.

The assessed impact reflects local community, families and workers opinion, interest and objections related to services as well as utilities provided by Salala Rubber Company at the plantation site.

The purpose of the survey is to collect information about the major stakeholders of the study area, and to assess the public opinions, interests or objections related to the current living conditions of the camp residents.

7.1 SURVEY METHODOLOGY

The survey consisted of a socio economic screening of the camps within the plantation. It consisted of the following:

- A Desk Review including of an overview of the locations to be visited, the identification of the stakeholders and main contacts, and the preparation of the field visit and socio-economic site survey.
- Preparation of the necessary survey tools;
- Field visits to the project areas.

Earthtime team composed of two socio-economic surveyors and a senior socio-economist as well as one geographer and a GIS expert conducted field surveys and consulted with various stakeholders. The survey in the field encompassed the following:

- Establishing socio economic community profiles for the camps of interest, these included assessing existing infrastructure that include health facilities, schools, water supply systems, roads, current status of houses as well as market facilities;
- Filling out individual questionnaires for randomly selected male and female individuals reflecting their expectation of the above mentioned facilities. A representative baseline study was acquired through questionnaire application to collect potential socio economic impacts. The selection of the interviewed persons was based in a way to ensure that the selected individual is representative of the area, and that gender issues are accounted for;
- Identification of potential social negative and positive impacts;
- Critical observation, investigation, documenting, and evaluating potential socio economic impacts of the plantation;
- Assessment of potential social impacts on selected rehabilitation and construction activities to be implemented by SRC;
- Organizing consultations and holding meetings with concerned parties, stakeholders or public authorities that are related to the Project to address their main concerns and opinions about the project and to assess social positive and negative impacts of Salala Rubber Company activities. Consultation is a method of public involvement and participation in the conduct of social impact assessment. This procedure in accordance with the Environment Protection and Management Law Act 2002 of Liberia.

The survey in the field was performed as follows:

- Visit to the camps located within the plantation of SRC;
- Interviews with the Camp Masters;
- Interviews with the camp residents;
- Interviews with the school principals

- Interviews with the clinic administration.
- Visit and assess the status as well as the availability of the existing facilities such as health care centers, hospitals, schools, training centers, etc located in the plantation site.

Following the field survey, a thorough analysis of the collected information, questionnaires and appraisal was undertaken. This report presents the results and the synthesis of the field survey and its analysis.

Limitations and difficulties encountered during the field survey were mainly limited to lack of data available at SRC's plantation due to the neglect that was practiced by the previous management. Relevant information on the population growth in each camp and data related to number of residents above and below the age of 65 and 15 were lacking in some camps. However, it is to be noted that it was relatively intricate to identify stakeholders among the local community.

The purpose of the survey was to collect information about the major stakeholders of the study area, and to assess the public opinions, interests or objections in the camps of SRC's plantation. The socio economic survey mainly covered the camps within the plantation.

The purpose of the meetings:

- To gather information on potential negative and positive environmental and social impacts of the Salala Rubber Company activities on the local communities;
- To assess the environmental and social challenges facing local communities;
- To identify at the community level the capacity of Salala Rubber Company to implement social mitigation, monitoring and management plans;
- To seek information on the probability of involuntary displacement of people due to Salala activities;

- To identify, record, and analyze claims or grievances by community members relating to impacts of the activities that might have had on their lives, and to recommend specific actions that could support their compensation.

During these meetings, Earthtime team addressed the following issues:

- What are the goals and objectives of your project?
- What areas are involved in your project?
- What percentage of the camps population work within the Salala activity areas?
- What are the major concerns regarding Salala activity areas?
- What are the potential negative socio economic and environmental impacts of the Salala activity areas?
- What are the potential positive socio economic and environmental impacts of the Salala activity areas?
- Any other comments.

Interviews at various levels were conducted using structured questionnaires and focused group discussion method. The information sought was related to the following issues:

- Assessment of the potential social impacts on local communities of construction of schools, markets, clinics, rehabilitation of existing wells, etc;
- Prioritizing and identifying alternatives that may cause higher social impact under the proposed projects by Weala Company;
- Identification of capacity building needs in order to recommend actions to strengthen the actual status of the local community for sustained social compliance monitoring and development;
- Preparation of appropriate social management plan.

7.2 DESCRIPTION OF SOCIO-ECONOMIC CONDITIONS OF CAMPS

RESIDENTS AT SRC

The community profile of each Camp was analyzed based on information gathered through questionnaires and meetings with the Camp Masters, the camps residents SRC's management, and field visits.

7.2.1 Community Profile

The camp Masters were mainly interviewed in this process. There are five camps and each with two camp masters. Camp 3 and Camp 1 have one camp master who resides in camp 3. Camp 4, Camp 5 and Camp 2 have one camps master as well who resides in camp 4. The camps are distributed at several locations within the plantation's concession (insert table to show coordinates).

Each camp has a camp master and sub camp master (considered as the assistant of the camp master). Both are the major responsible figures for mediating disputes among the community members.

Camp 1 and Camp 4 are located within the central part of the plantation. Camp 2 extends in the northern section of the plantation, while Camp 5 is in the western section and Camp 3 is located in the southeastern part of the plantation (Insert map).

All camps are accessed by major roads that are unpaved and made of laterite.

Total population within the plantation appears to be xxxx (insert graph).

Total number of households in the plantation distributed among the camps is xxx (insert graph). General conditions of housing units in the camps can be considered below living standard conditions.

In terms of education, there are xxx school building with education level ranging from kindergarden till high school level.

One clinic serves the entire plantation population.

Generally, no tourism features or industrial activities were recorded or observed on the plantation's site and within the camps.

Few shops that provide below basic requirements are distributed among the camps within the plantation (inset Chart).

Utility services are generally poor within the plantation camps as no electricity is provided and the residents mainly rely on other sources of energy and light such as candles, kerosene, and charcoal. Camps encompassed no kitchens and basic sanitary facilities. Sewage water in all camps (except camp 4) is disposed on the ground surface open in the environment and without prior treatment. Solid waste is also disposed and burnt in spaces near the camps.

Wells equipped with basic hand pumps are the main source of water for the residents. In terms of security, the residents reported no major security issues; however, only one police station exists within the plantation and with no security center available in each camp.

Salala Rubber Company owns the majority of the houses within the five camps; very few houses are owned by the local camp residents. The total number of houses within the five camps is xxx (insert table).

Average income of laborers in the camp is U.S \$ 100.00. According to data provided by the camp masters, none of the workers within the plantation are below fifteen in age or above 65 in age. At least one member of each family works at the plantation. Women also participate in the workforce of the plantation. at least 12-16 individuals share a two bed room house.

Residents practice small scale farming activities such as self-gardens as local cultivation and to ensure daily food requirement. Among the grown cash crops are, rice, vegetables such as okra, peanuts.

No major cultural and archeological sites exist within the plantation. However, few religious houses including churches and one mosque exist within the plantation.

Table 7-1: Coordinates of the five (5) camps, the heads of each camp and location with respect to the plantation's entrance gate.

Name	Head of community	X	Y	Z	Remarks
Camp 1	Camp Master- Mr. James Fayiah	29 N 0375428	UTM 0736179	117 m	6 km east of plantation's main entrance gate
Camp 2	Camp Master Mr. Emanuel Smith	29 N 0374539	UTM 0737342	117 m	4.9 km east of plantation's main entrance gate
Camp 3	Camp Master Mr. James Fayiah	29 N 0377706	UTM 0734869	131 m	8.6 km east of plantation's main entrance gate
Camp 4	Camp Master Mr. Emanuel Smith	29 N 0375722	UTM 0736993	128 m	6.2 km east of plantation's main entrance gate
Camp 5	Camp Master Mr. Emanuel Smith	29 N 0372605	UTM 0735406	129 m	3.8 km SE of plantation's main entrance gate

Camp	Population		Workers from each Camps		No. of Households	No. of Shops
	Men	Women	Men	Women		
Camp 1	331	310	130	10	90	4

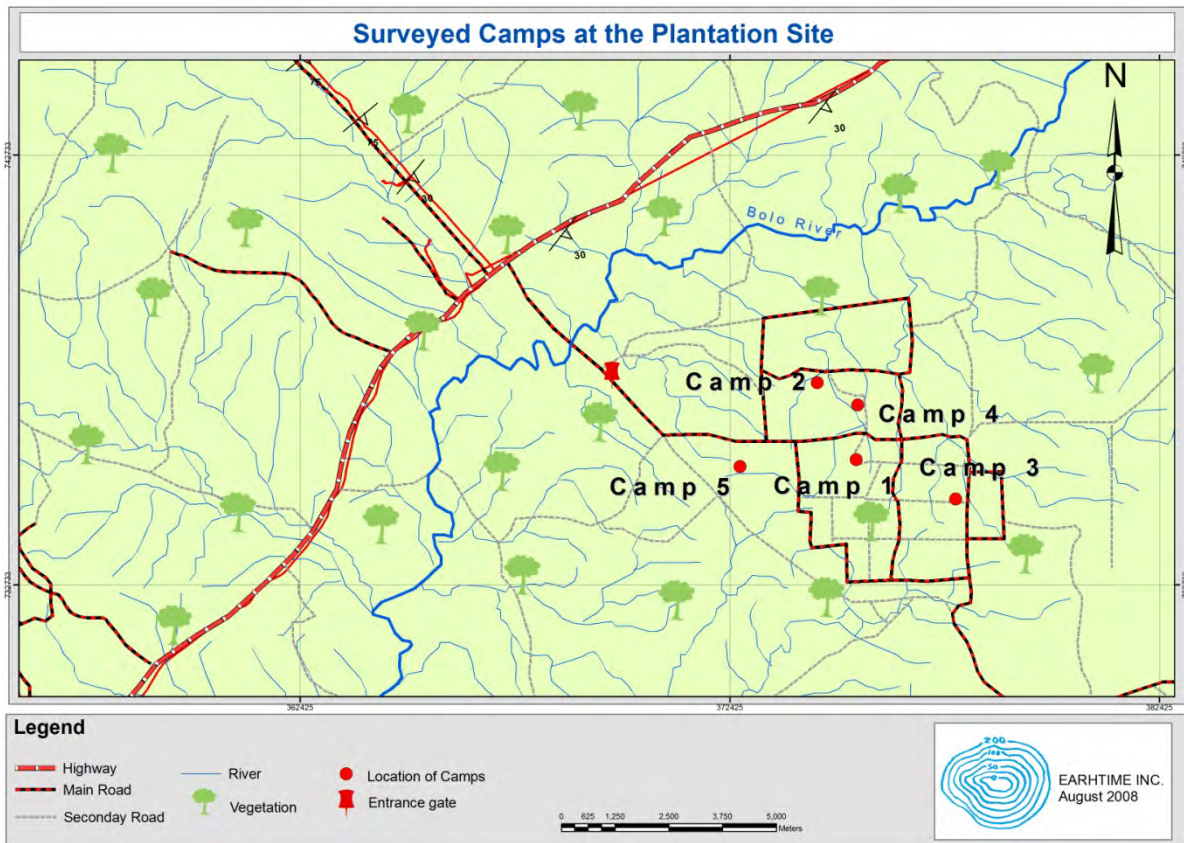


Figure 7-1: Location map of the camps and the plantation.

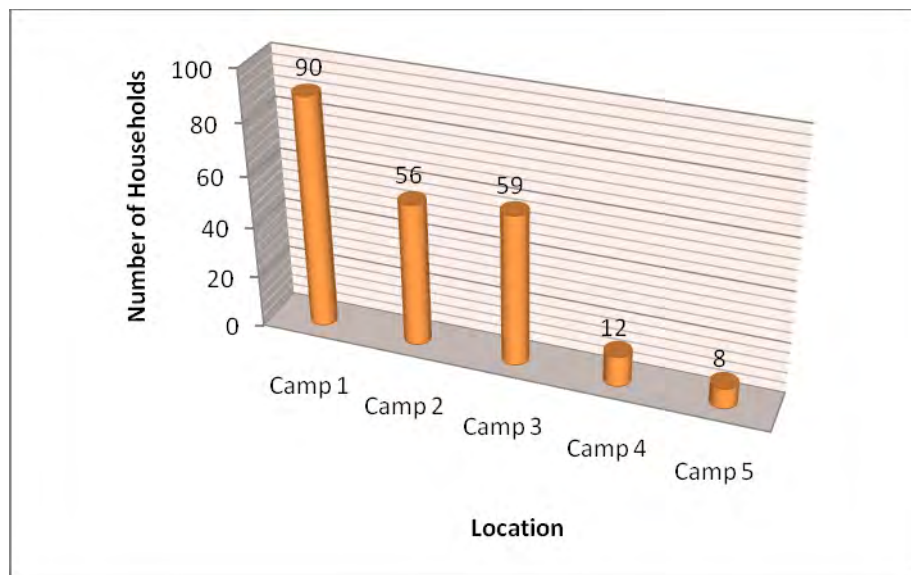


Figure 7-2: Number of households per camp.

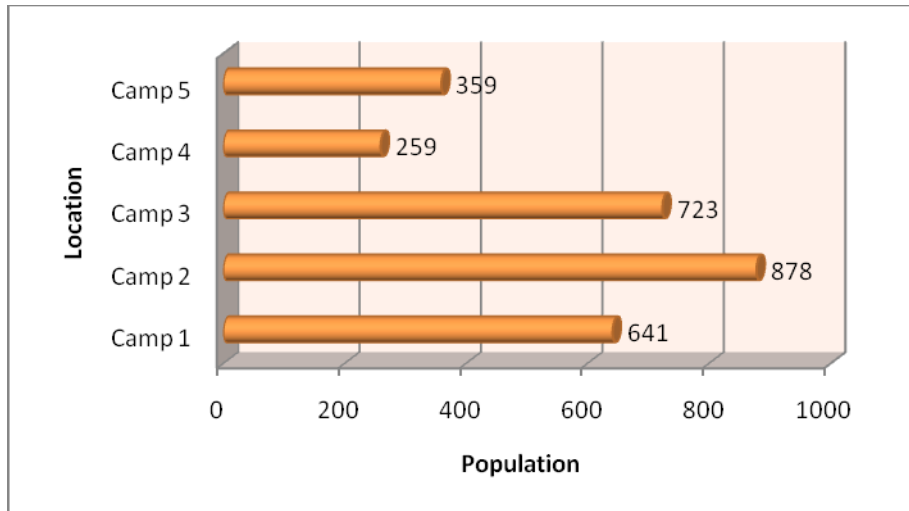


Figure 7-3: Population distribution in each camp.

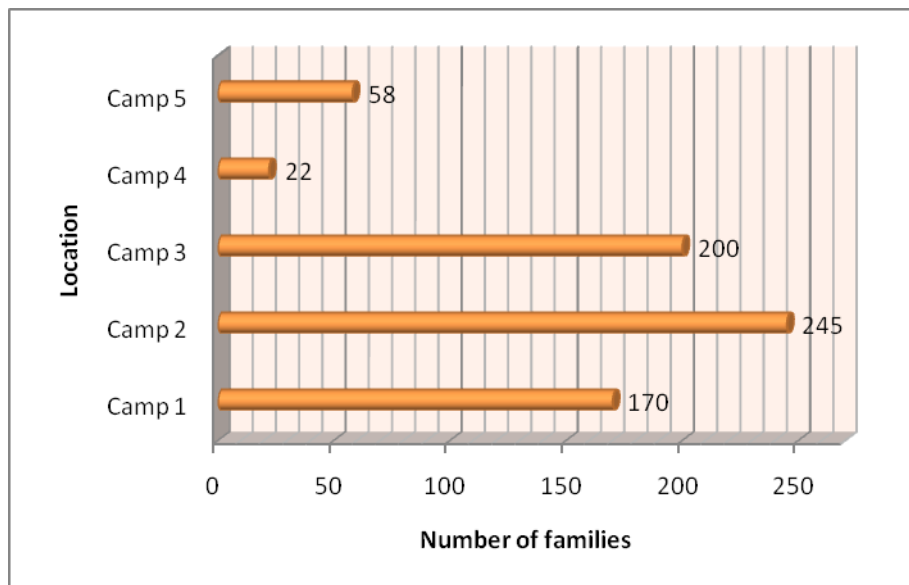


Figure 7-4: Number of families in each camp.

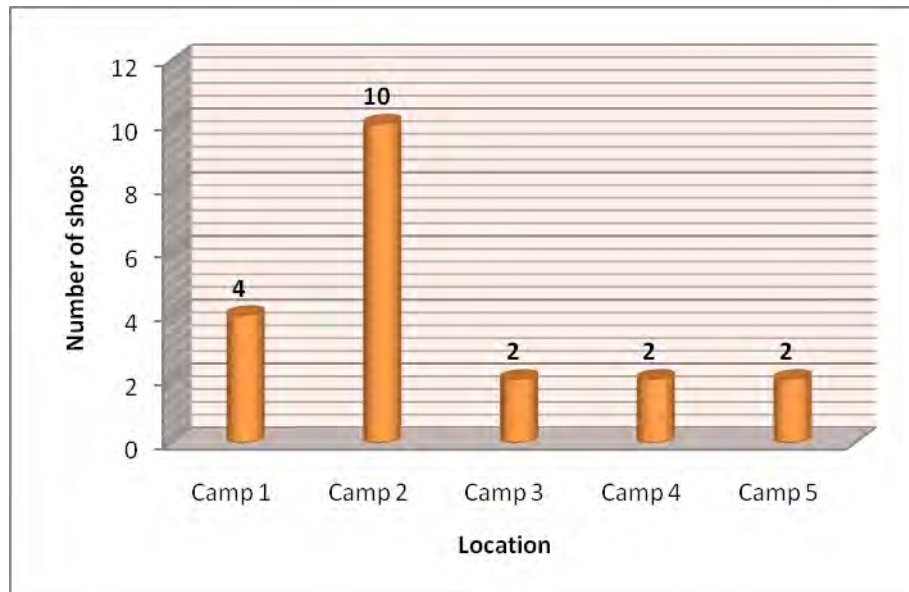


Figure 7-5: Number of shops per camp.

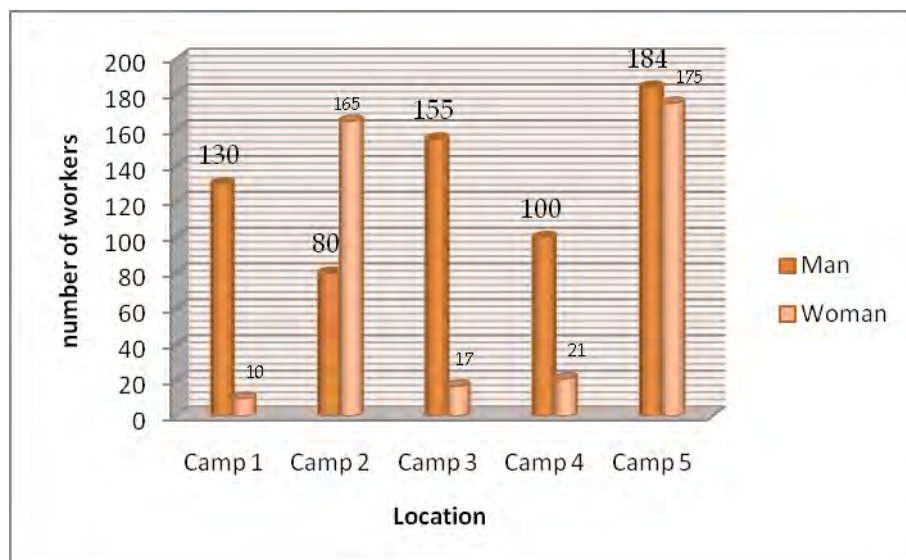


Figure 7-6: Number of workers by gender.

7.2.1.1 Camp 1

Camp1 is located in the central part of the plantation (*insert map*) at a distance of 6 Km east of the plantation’s main entrance gate (Table 7-1). The total population of this camp is 641 while the number of families residing is not recorded by the Camp Master. 331 peoples of the total population are males while 310 are females (Figure 7-7). The number of residents below 15 years of age is not known as well those

above 65 years of age. 140 resident of this camp work for SRC where 130 are male and only 10 of the workers are females.

Housing condition in the camp is below standard. There are 90 households that are fully occupied and overcrowded. Most houses are composed of two bedrooms with no basic facilities such as kitchen and toilets. Each house is occupied by at least two families and each room is occupied by the worker (generally tappers) and his/her family. Each family is between 4-8 individuals. In general, each of the two-bedroom house shelters between eight (8) to sixteen (16) people. The houses are owned by SRC and the residents do not pay rental fees.

In addition to the lack of basic facilities such as kitchen and toilets, the residents have no access to electricity and pipe borne water; kerosene lanterns are generally used to generate light and fuelwood and charcoal are the principal energy source for cooking. Some of the residents annexed additional rooms mainly as kitchens at their own expense. Most of the houses are built of mud and sticks. The roofs are often damaged and the sticks are damaged by termites. Some houses have collapsed walls. Houses are also affected by erosion due to heavy rainfall. Toilet and bathing facilities are built separately and near the houses while others are relatively far. Toilet facilities and usually exist separately in the camp.

There are three (3) wells within Camp 1 (Table 4-17), equipped with manual hand pumps and protected by cement covers. These wells are the source of domestic and drinking water. Water source for animals is from a nearby creek. Sources of water for irrigation are the wells a nearby creek.

There are no solid waste or wastewater disposal facilities. Solid wastes are usually dumped at a dump site close to the camp. Given the fact that the camp's houses lack toilet, kitchen and washing facilities, there are no wastewater septic tanks within attached to the houses. Water from toilets and bathing is absorbed by the soil into the ground.

There no security forces or police stations within the camp; also, fire fighting facilities do not exist within the camp. The only clinic in the plantation is located close to the camp. There is a school that is an annex of SRC School and provides daycare and primary classes.

Roads conditions are inadequate and during rainy season permanent pools of water are spread all over the camp's road thus providing a good environment for mosquito breeding.

There are no farming activities. Four (4) selling spots (referred to by the residents as shops) owned by some of the residents sell few basic goods, such as beer, canned sardine, biscuits, beans, batteries, and basic stationary. Goods that are unavailable locally are bought from shops located in Weala Town located several kilometers away from the plantation itself. Meanwhile, one of the camps residents manufactures aluminum cooking pots.

The only religious group within the camp is Christianity. There are two Churches. *Susu* is the only community group or organization within the camp. *Susu groups* are group of residents within the camp that organize themselves and contribute to save money on a monthly basis. The sum is then given to a member of the group.

Disputes within the camp are mainly settled in the presence of the Camp Master and his deputies. Other mediators within the camp include governor of the Pele Tribe (Pele Governor) and three Quarter Chiefs.

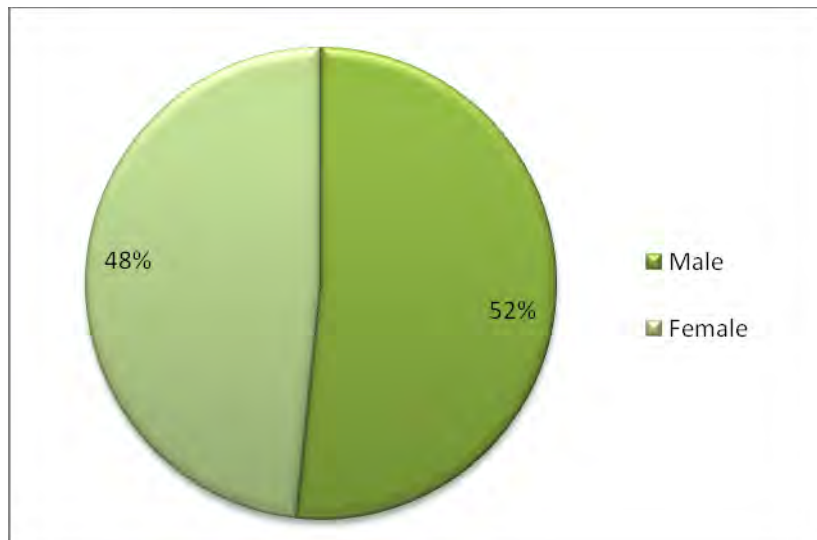


Figure 7-7: Percentage of males to females in Camp 1.



Figure 7-8: Toilet facility within Camp 1.



Figure 7-9: Selling spot within Camp 1.

7.2.1.2 Camp 2

Camp 2 is located in the northern section of the plantation ([insert map](#)) at a distance of 4.9 km east of plantation's main entrance gate (Table 7-1). The total population of this camp is 878 included in 245 families. 400 people of the total population are males while 478 are females (Figure 7-7). The number of residents below 15 years of age is 300 and those above 65 years of age are 30. 245 residents of this camp work for SRC where 165 are females and 80 are males.

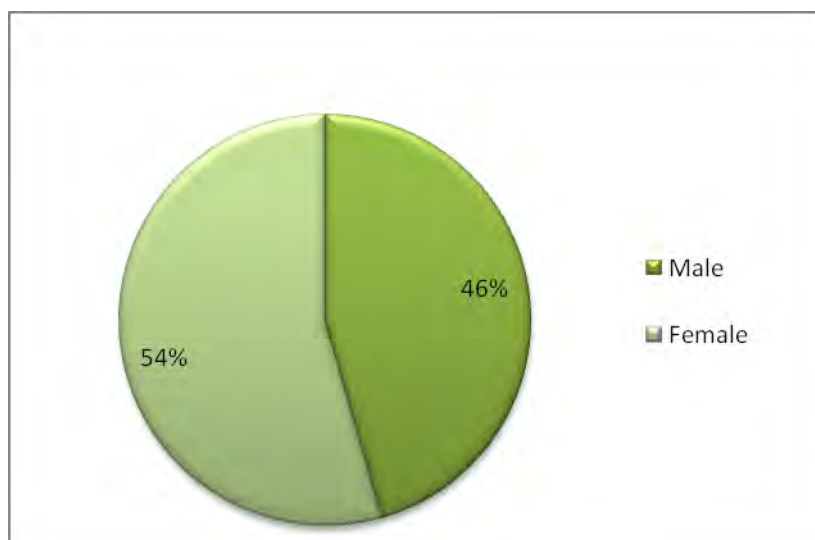


Figure 7-10: Percentage of male to female in Camp 2.

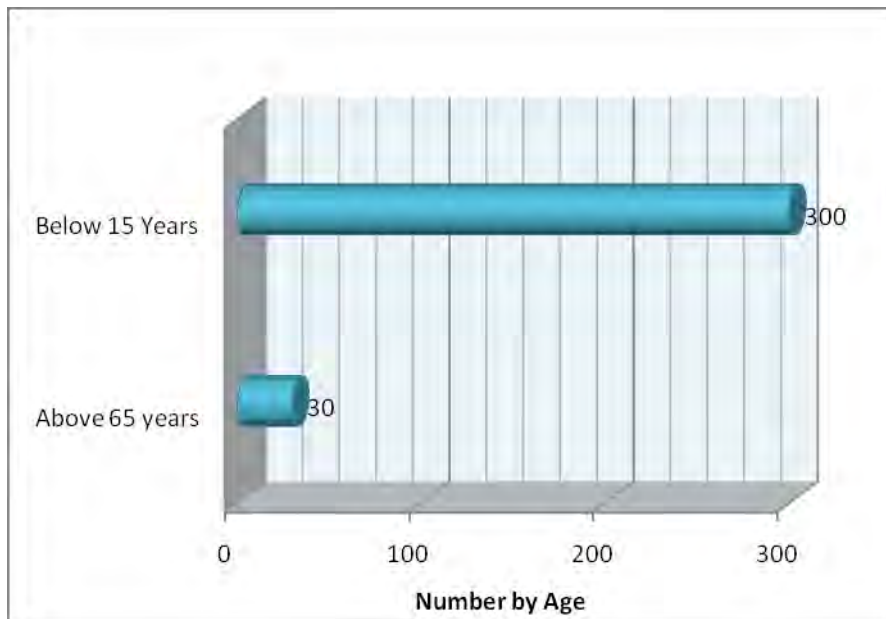


Figure 7-11: Percentage of population by age in Camp 2.

Housing conditions in camp 2 are below standards. There are 56 households that are fully occupied and overcrowded. Most houses are composed of two bedrooms with no basic facilities such as kitchen and toilets. Each house is occupied by at least two families and each room is occupied by the worker (generally tappers) and his/her family. Each family is between 6-8 individuals. In general, each of the two-bedroom house shelters between twelve (12) to sixteen (16) people. The houses are owned by SRC and the residents do not pay rental fees.



Figure 7-12: A two-bedroom house in camp 2.



Figure 7-13: Basic renovation for one of the houses in Camp 2.



Figure 7-14: One of the houses with broken wall within camp 2.

In addition to the lack of basic facilities such as kitchen and toilets, the residents have no access to electricity and pipe borne water; kerosene lanterns and candles are generally used to generate light, and fuelwood and charcoal are the principal energy source for cooking. Some of the residents annexed additional rooms mainly as kitchens at their own expense. Most of the houses are built of mud and sticks. The roofs are often damaged and the sticks are damaged by termites. Some houses have collapsed walls (Figure 7-14). Houses are also affected by erosion due to heavy rainfall. Toilet and bathing facilities are built separately either near or at far from the houses while others are relatively far. Toileting and bathing facilities exist separately in the camp. The residents of the camp share few inadequate toilets and bathrooms that are located at a distance from the houses (Figure 7-15).



Figure 7-15: Toilet and bathing facilities within Camp 2.

There are four (4) wells within Camp 2 (Table 4-17), equipped with manual hand pumps and protected by cement covers. These wells are the source of domestic and drinking water for the camp residents. Water sources for animals and irrigation in Camp 2 are the nearby creeks and the wells.

There are no solid waste or wastewater disposal facilities. Solid wastes are usually dumped at a dump site close to the camp. Given the fact that the camp's houses lack toilet, kitchen and washing facilities, there are no wastewater septic tanks attached to the houses. Water from toilets and bathing is absorbed by the soil into the ground.

There no security forces or police stations within the camp; also, fire fighting facilities do not exist as well as emergency medical services. There is no healthcare facility within Camp 2; therefore, residents have to seek healthcare in the clinic located in Camp 1 which is the only clinic within the plantation. The clinic is xxx km south of camp 2. There is a school that is an annex of SRC School and provides only daycare classes for 130 students.

Roads conditions are inadequate and during rainy season permanent pools of water are spread all over the camp's road thus providing a good environment for mosquito breeding.

Farming activities are limited to small scale agricultural activities such as self-gardens, and cultivating rice for daily food requirements. Ten (10) shops owned by some of the residents exist within the camp and sell few basic goods, such as beer, canned sardine, biscuits, beans, batteries, and basic stationary. Similar to Camp 1, goods that are unavailable locally are bought from shops located in Weala Town located several kilometers away from the plantation itself.

The religious groups within the camp are Christians and Muslims. There is only one church. *Susu* is the only community group or organization within the camp. *Susu groups* are group of residents within the camp that organize themselves and contribute to save money on a monthly basis. The sum is then given to a member of the group.

Disputes within the camp are mainly settled by the Camp Master and his deputy known as the Sub-Camp Master.

7.2.1.3 Camp 3

Camp1 is located in the southeastern part of the plantation (**insert map**) at a distance of 8.6 Km east of the plantation's main entrance gate (Table 7-1). The total population of this camp is 723 included in 200 families. 362 people of the total population are males while 361 are females (Figure 7-16). The number of residents below 15 years of age is not known as well those above 65 years of age. 155 residents of Camp 3 work for SRC where 17 are females and 138 are males. At least one member within each family existing in this camp works with SRC.

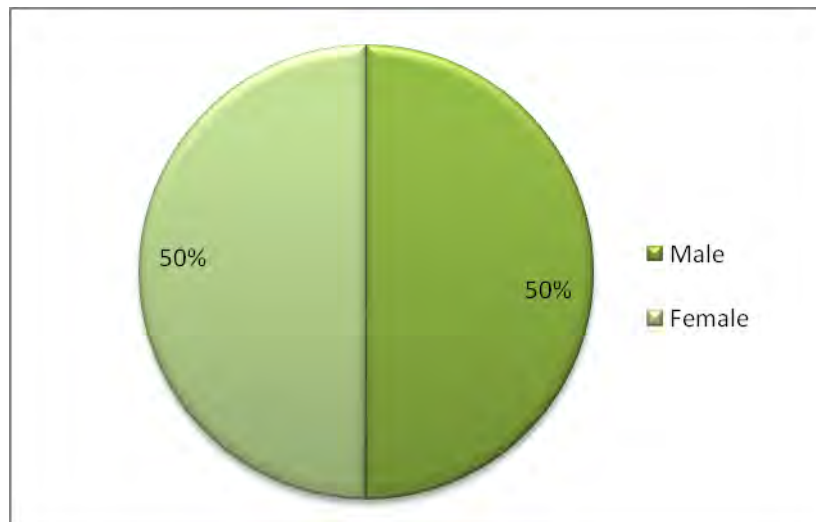


Figure 7-16: Percentage of male to female in Camp 3.

Housing condition in the camp is below standard (Figure 7-17). There are 59 households that are fully occupied and overcrowded. Most houses are composed of two bedrooms with no basic facilities such as kitchen and toilets. Each house is occupied by at least two families and each room is occupied by the worker (generally tappers) and his/her family. Each family is between 8-10 individuals. In general, each of the two-bedroom house shelters between sixteen (16) to twenty (20) people. The houses are owned by SRC and the residents do not pay rental fees.



Figure 7-17: Sample view of household condition in Camp 3.

In addition to the lack of basic facilities such as kitchen and toilets, the residents have no access to electricity and pipe borne water; kerosene lanterns are generally used to generate light and fuelwood and charcoal are the principal energy source for cooking. Some of the residents annexed additional rooms mainly as kitchens at their own expense (Figure 7-18). Most of the houses are built of mud and sticks. The roofs are often damaged and the sticks are damaged by termites. Houses are also affected by erosion due to heavy rainfall (Figure 7-17). Toileting and bathing facilities exist separately in the camp. The residents of the camp share few inadequate toilets and bathrooms that are located at a distance from the houses.



Figure 7-18: Note the added section to the house that is made of mud and sticks. This section serves as a kitchen for the household residents.

There are three (3) wells within Camp 3 (Table 4-17), equipped with manual hand pumps and protected by cement covers (Figure 7-19). These wells are the source of domestic and drinking water. Water source for animals is from a nearby creek. Sources of water for irrigation are the wells and a nearby creek.



Figure 7-19: A well in Camp 3 with cement cover.

There are no solid waste or wastewater disposal facilities. Solid wastes are usually dumped at a dump site close to the camp. Given the fact that the camp's houses lack toilet, kitchen and washing facilities, there are no wastewater septic tanks attached to the houses. Water from toilets and bathing is simply disposed into the environment without treatment or collection systems.

There no security forces or police stations within the camp; also, fire fighting facilities do not exist as well as emergency medical services. There is no healthcare facility within Camp 3; therefore, residents have to seek healthcare in the clinic located in Camp 1 which is the only clinic within the plantation. The clinic is xxx km west of Camp 3. There is a school that is an annex of SRC School and provides only daycare classes for 140 students.

Roads conditions are inadequate and during rainy season permanent pools of water are spread all over the camp's road thus providing a good environment for mosquito breeding.

There are four (4) farms within Camp 3 where farming activities are limited to small scale agricultural activities such as self-gardens, and cultivating rice, pepper, and

okra for daily food requirements. Two (2) shops owned by some of the residents exist within the camp and sell few basic goods, such as beer, canned sardine, biscuits, beans, batteries, and basic stationary. Goods that are unavailable locally are bought from shops located in Weala Town at several kilometers away from the plantation itself.

The only religious group within the camp is Christianity. There are two Churches. *Susu* is the only community group or organization within the camp. *Susu groups* are group of residents within the camp that organize themselves and contribute to save money on a monthly basis. The sum is then given to a member of the group.

Disputes within the camp are mainly settled in the presence of the Camp Master and his deputy (known as Sub-Camp Master). Other mediators within the camp include a Pasteur and a Quarter Chief.

7.2.1.4 Camp 4

Camp 4 is located in the central part of the plantation (**insert map**) at a distance of 6.2 Km east of the plantation's main entrance gate (Table 7-1). The total population of this camp is 259 included in 22 families. The number of males is 100 representing 39% of the total population, and the number of females is 159 representing 61% of the total population (Figure 7-20). The number of residents below 15 years of age is 85 and non of the residents exceeds 65 years of age (Figure 7-21). At least one member of each family works at SRC representing 8.1% of the camps residents. The number of workers by gender at SRC's facilities from this camp is not recorded by the Camp Master.

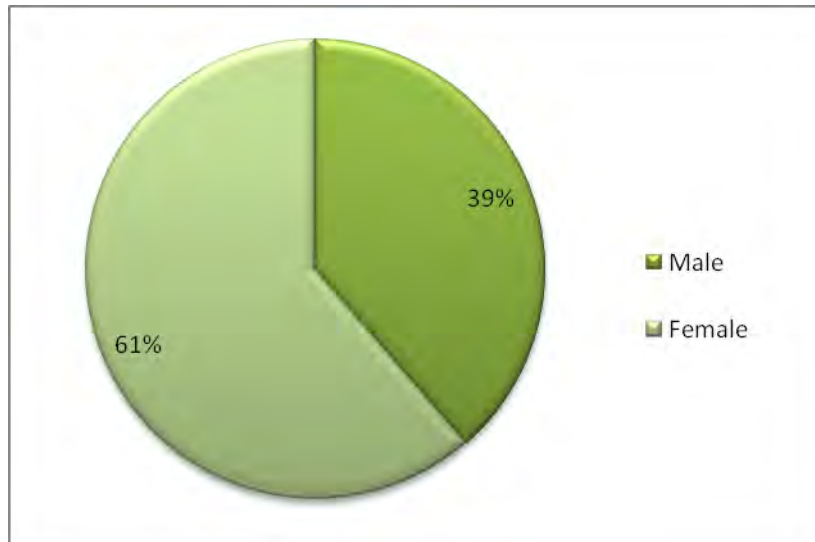


Figure 7-20: Percentage of male to female in Camp 4.

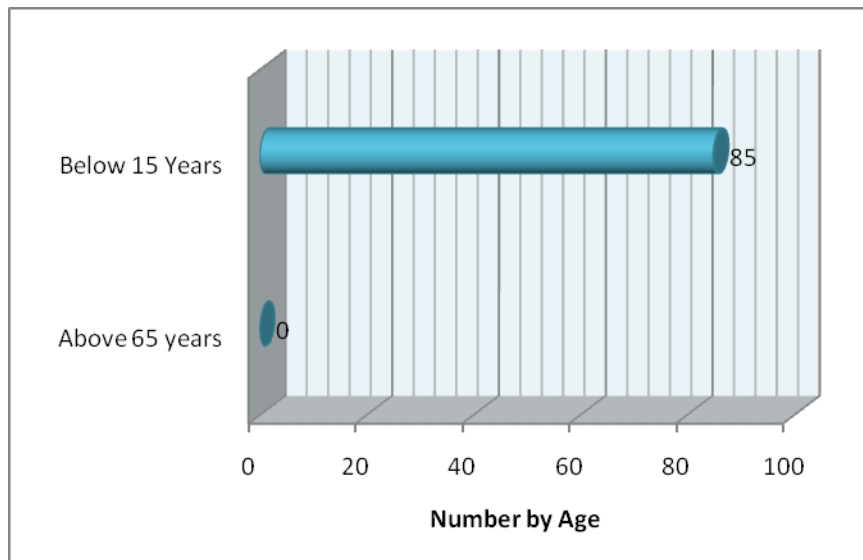


Figure 7-21: Percentage of population by age in Camp 4.

Housing conditions in the camp are generally good but require rehabilitation as indicated by the Camp Master. There are 12 houses within this camp. Even though each house in Camp 4 includes basic facilities such as a kitchen, a toilet and a bathroom, it does not include other major house units such as living room or dining room. Some of the houses are made of two (2) bedrooms while others of three (3) bedrooms. The two bedrooms house shelters two (2) separate families and the three bedrooms house shelters three (3) separate families. Each family is composed of at least 5 individuals. Therefore, houses of two rooms encompass ten people and

houses of three rooms shelter 15 people. The houses are owned by SRC and the residents do not pay rental fees.

However, similar to other camps the residents have no access to electricity and pipe borne water; kerosene lanterns are generally used to generate light and fuelwood and charcoal are the principal energy source for cooking. The houses are build of cement blocks.

There are two (2) wells within Camp 4 (Table 4-17), equipped with manual hand pumps and protected by cement covers (Figure 7-19). These wells are the source of domestic and drinking water. Water source for animals is from a nearby creek. Sources of water for irrigation are the wells and a nearby creek.



Figure 7-22: (a) Well 11 located close to the school; (b) Well #12 located within the camp.

There are no solid waste disposal facilities. Solid wastes are usually dumped at a dump site close to the camp. Wastewater from the houses is disposed and collected into septic tanks attached to the houses. These septic tanks represent a whole dug into the ground with no basic protection layers except for the top cover which is made of cement.

There no security forces or police stations within the camp; also, fire fighting facilities do not exist as well as emergency medical services. There is no healthcare

facility within Camp 4; therefore, residents have to seek healthcare in the clinic located in Camp 1 which is the only clinic within the plantation. The clinic is xxx km west of Camp 4.

SRC's main school building exists in Camp 4 providing daycare, primary and secondary classes. The school includes a total of 656 students where 130 students are in daycare classes, 486 students in primary classes and 40 students are in secondary classes.

Roads conditions are inadequate and during rainy season permanent pools of water are spread all over the camp's road thus providing a good environment for mosquito breeding.

Farming activities are limited to small scale agricultural activities such as self-gardens, and cultivating of few vegetables such as pepper and okra. Two (2) shops owned by some of the residents exist within the camp and sell few basic goods, such as beer, canned sardine, biscuits, beans, batteries, and basic stationary. Similar to other camps, goods that are unavailable locally are bought from shops located in Weala Town located at relatively far distance from the plantation itself.

The only religion in the Camp is Christianity and there is no church within the Camp. *Susu* is the only community group or organization within the camp. *Susu groups* are group of residents within the camp that organize themselves and contribute to save money on a monthly basis. The sum is then given to a member of the group.

Disputes within the camp are mainly settled in the presence of the Camp Master and his two deputies (known as Sub-Camp Master).

7.2.1.5 Camp 5

Camp 5 is located in the southern area of the plantation (**insert map**) at a distance of 3.8 Km east of the plantation's main entrance gate (Table 7-1). It is the nearest camp

to the main entrance gate. The total population of this camp is 359 included in 58 families. The number of males is 275 representing 77% of the total population, and the number of females is 84 representing 23% of the total population (Figure 7-23). The number of residents below 15 years of age is 80 and none of the residents exceeds 65 years of age (Figure 7-21). At least one member of each family works at SRC representing 16.1% of the camps residents. The number of workers by gender at SRC's facilities from this camp is not recorded by the Camp Master.

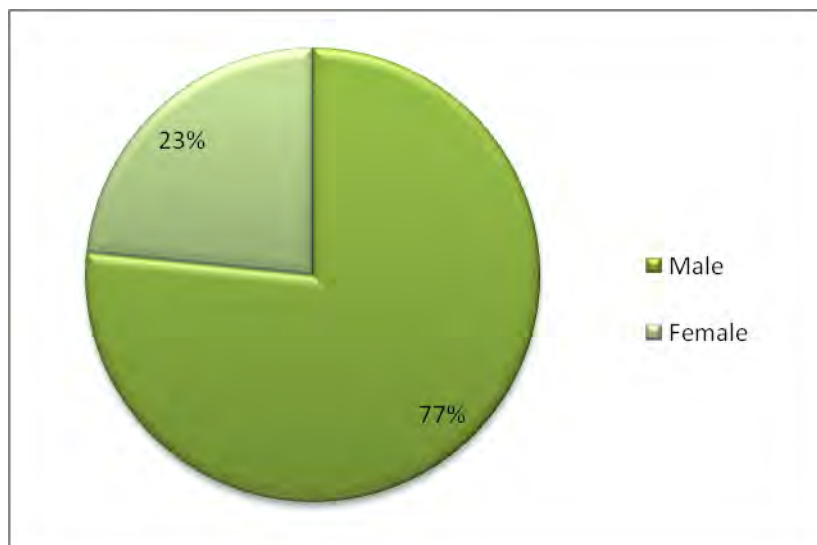


Figure 7-23: Percentage of male to female in Camp 5.

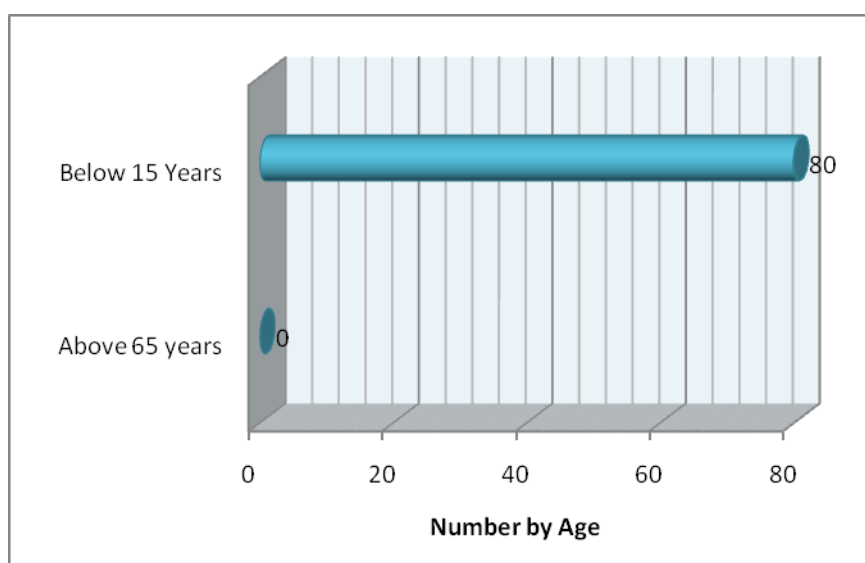


Figure 7-24: Percentage of population by age in Camp 5.

Housing conditions in the camp are below standard (Figure 7-17). There are 8 households that are fully occupied and overcrowded. Most houses are composed of six (6) bedrooms with no basic facilities such as kitchen and toilets. Each house is occupied by at least six families and each room is occupied by the worker (generally tappers) and his/her family. Each family is between 6-8 individuals. In general, each of the six-bedroom house shelters between twelve (12) to sixteen (16) people. The houses are owned by SRC and the residents do not pay rental fees.

In addition to the lack of basic facilities such as kitchen and toilets, the residents have no access to electricity and pipe borne water; kerosene lanterns and candles are generally used to generate light, and fuelwood and charcoal are the principal energy source for cooking. Toilet and bathing facilities are built separately either near or at far from the houses while others are relatively far (Figure 7-25). Toileting and bathing facilities exist separately in the camp. The residents of the camp share few inadequate toilets and bathrooms that are located at a distance from the houses (Figure 7-15).



Figure 7-25: Toilet and bathing facilities within Camp 5.

Similar to the rest of the camps the residents of Camp 5 have no access to electricity and pipe borne water; kerosene lanterns are generally used to generate light and fuelwood and charcoal are the principal energy source for cooking. The houses are built of cement blocks.

There are six (6) wells within Camp 5 (Table 4-17), equipped with manual hand pumps and protected by cement covers (Figure 7-26). These wells are the source of domestic and drinking water. Water source for animals is from a nearby creek. Sources of water for irrigation are the wells and a nearby creek.



Figure 7-26: Well with cement cover in Camp 5.

There are no solid waste or wastewater disposal facilities. Solid wastes are usually dumped at a dump site close to the camp. Given the fact that the camp's houses lack toilet, kitchen and washing facilities, there are no wastewater septic tanks attached to the houses. Water from toilets and bathing is simply disposed into the environment without treatment or collection systems.

There no security forces or police stations within the camp; also, fire fighting facilities do not exist as well as emergency medical services. There is no healthcare facility within Camp 5; therefore, residents have to seek healthcare in the clinic

located in Camp 1 which is the only clinic within the plantation. **The clinic is xxx km west of Camp 5.** There is a school that is an annex of SRC School and provides only daycare classes for 50 students.

Roads conditions are inadequate and during rainy season permanent pools of water are spread all over the camp's road thus providing a good environment for mosquito breeding.

Farming activities are limited to small scale agricultural activities such as self-gardens, and cultivating of few vegetables such as pepper and okra. Two (2) shops owned by some of the residents exist within the camp and sell few basic goods, such as beer, canned sardine, biscuits, beans, batteries, and basic stationary. Similar to other camps, goods that are unavailable locally are bought from shops located in Weala Town located at relatively far distance from the plantation itself.

The only religion in the Camp is Christianity and there is no church within the Camp. In addition to the *Susu*, *Kwapajeh* is another community group or organization within the camp. *Susu groups* are group of residents within the camp that organize themselves and contribute to save money on a monthly basis. The sum is then given to a member of the group. The *Kwapajeh* mainly includes those that practice farming activities within the camp.

Disputes within the camp are mainly settled in the presence of the Camp Master and his deputy (known as Sub-Camp Master).

7.3 ANALYSIS OF INDIVIDUAL QUESTIONNAIRES

The results were analyzed based on the questionnaires addressed to the residents of each camp based on random selection in order to highlight their opinion concerning basic matters such as living conditions, infrastructure, as well as services.

Seventy five (75) questionnaires were filled in the study area. The filled individual questionnaires consisted of a series of inquiries related to the socio-economic status of the surveyed person, and address his/her interest, objections or expectations from Salala Rubber Company. Information was collected for some demographic characteristics such as poverty status, marital status, and educational attainment. The results of this survey provided quantitative data on the demographic and socioeconomic characteristics of the surveyed population.

Out of the 75 respondents at the plantation site 42% were males and 33% were females (Figure 7-27: Percentage male to female of the surveyed population).

In terms of age, 63% of the respondents were in the active population range (26-46 years old), 17% of the surveyed people were between 18 and 25 year of age, 15% were between 47 and 65, 4% were below 17 while the lowest (1%) were above 65 years old (Figure 7-28: Age of surveyed population).

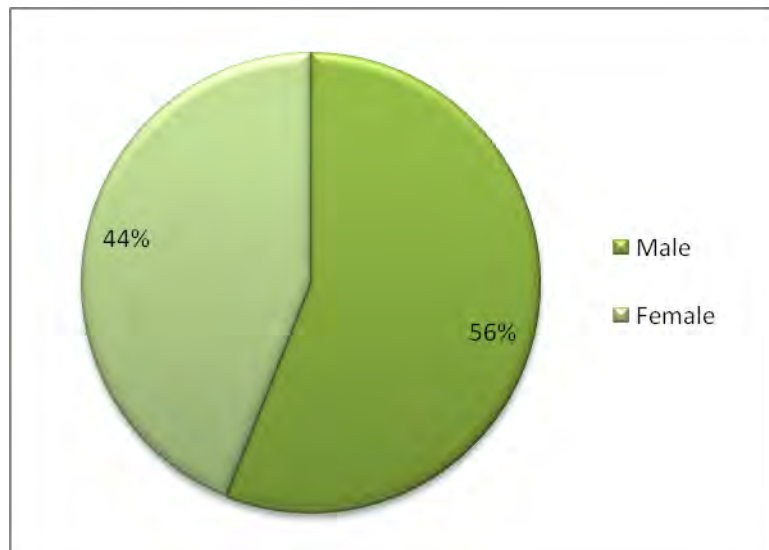


Figure 7-27: Percentage male to female of the surveyed population

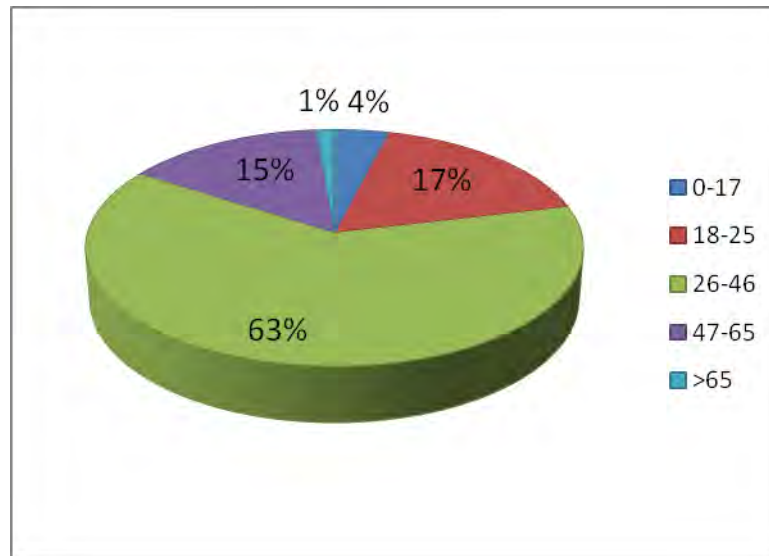


Figure 7-28: Age of surveyed population

In terms of education, questionnaires were distributed among people of different education levels, where 25% of the surveyed never attended a school before, 28% achieved the primary level, 18% the secondary level, and only 3% attended universities (Figure 7-29: Education level of the surveyed population).

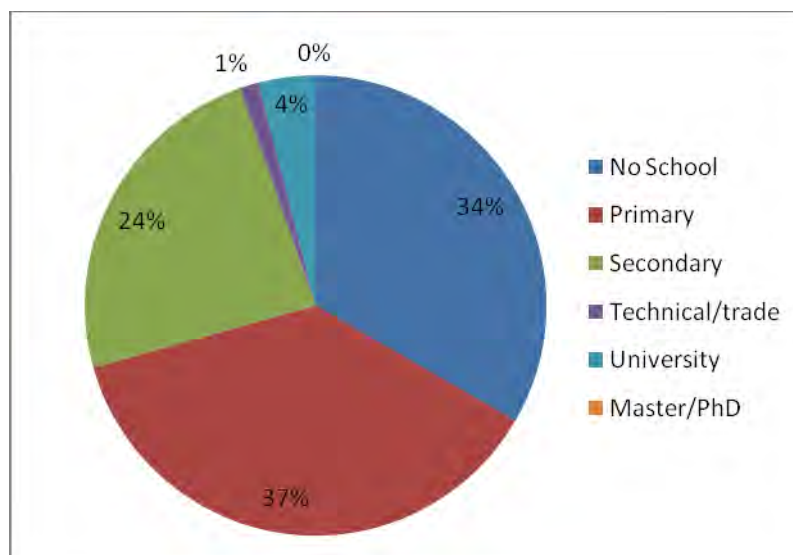


Figure 7-29: Education level of the surveyed population

Moreover, during the survey process 61% of the surveyed people at the plantation site were married and 13% were single (Figure 7-30: Marital status of the surveyed

population. Meanwhile, 59% of the surveyed individuals have a job (Figure 7-31), from which 55% are employed at Salala plantation facilities (Figure 7-32).

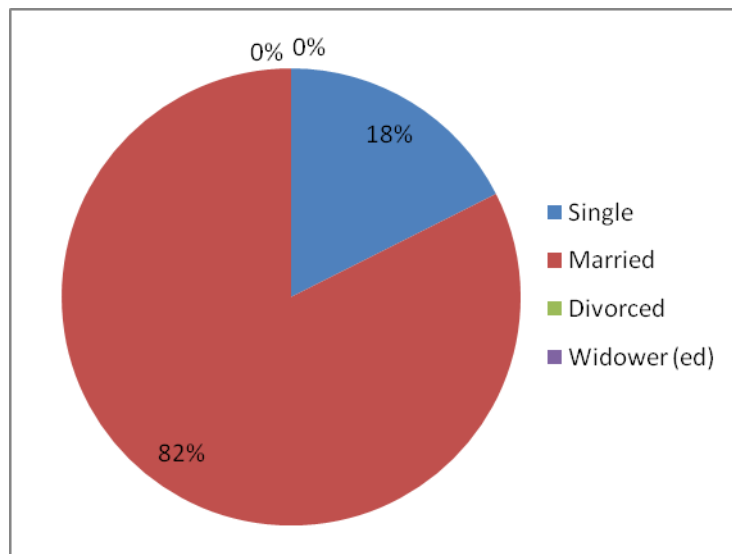


Figure 7-30: Marital status of the surveyed population

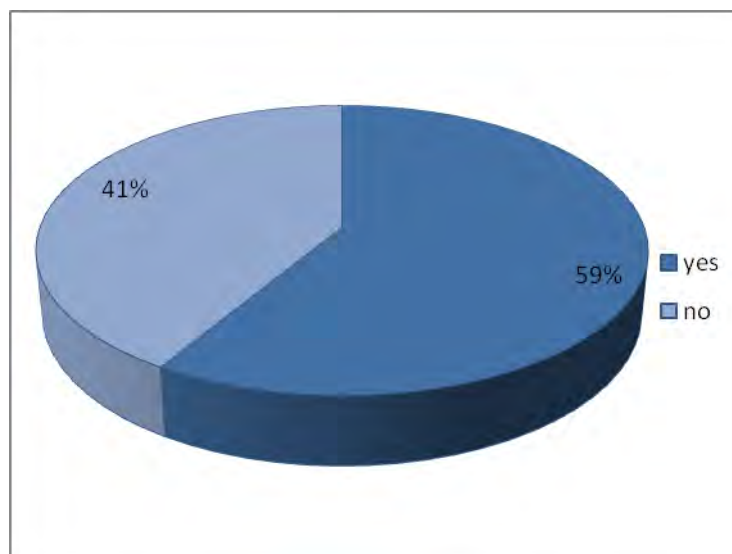


Figure 7-31: Employment of the surveyed population

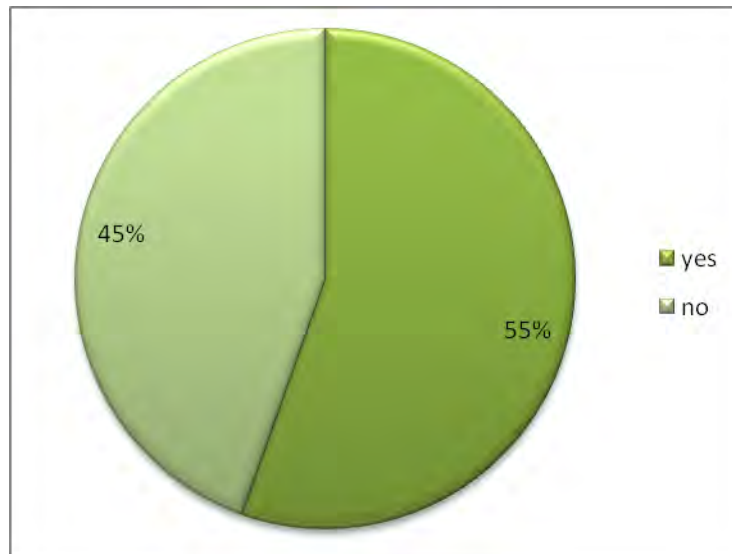


Figure 7-32: Percentage of surveyed population working at SRC

7.3.1 Housing Conditions as Expressed by Surveyed Individuals

Workers at Salala plantation are provided with free housing, regardless of the number of family members employed (Figure 7-33). Houses are composed mainly of two rooms made from mud and sticks with no electricity, running water, toilet facilities and kitchens. Surveyed residents highlighted that houses have never been refurbished and updated to modern safety standards.

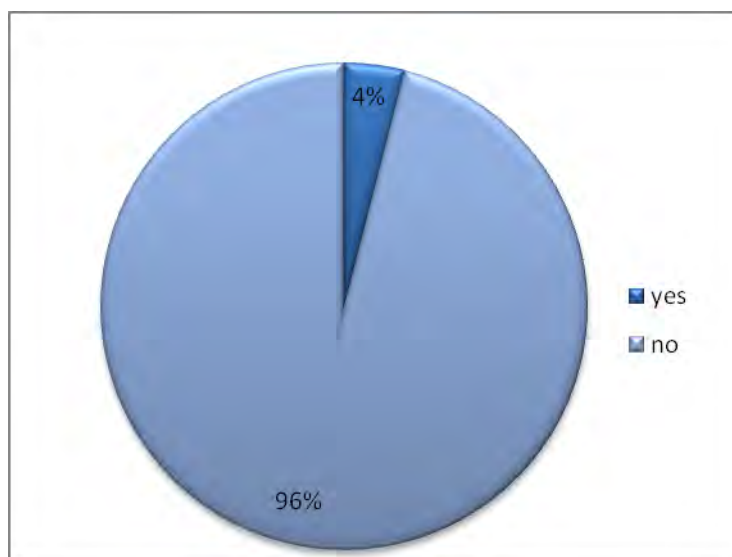


Figure 7-33: Does one of the household members own the house you live in?

According to interviewers each house encompasses only two units with the exception of Camp 4 and Camp 5, and each unit accommodates one family composed at least of 6 to 8 members (Figure 7-34: Percentage of surveyed population living in the same household)

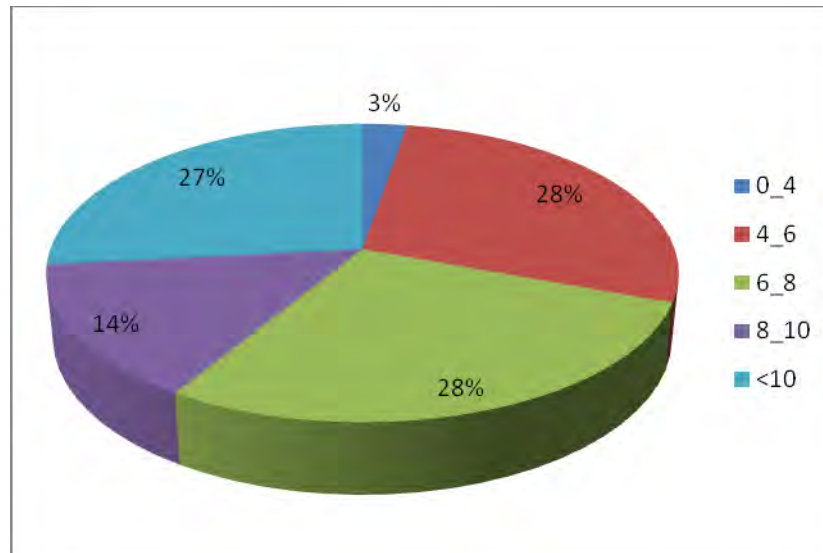


Figure 7-34: Percentage of surveyed population living in the same household

Based on information obtained through interviews with local residents and workers at Salala plantation, the houses provided have apparently not been renovated since they were built. No major improvements in the housing conditions were recorded during the field surveys or highlighted by the surveyed residents in the five camps at Salala Plantation (Figure 7-35: Community profile as rated by individuals)

The remainder of workers' families excluding management and their families live in deplorable conditions, with inadequate and insufficient space; adequate lighting and ventilation do not exist; local residents are subject to be affected by health risks. The houses in the 5 camps lack basic sanitary infrastructure such as adequate bathrooms, toilet and kitchens.

Local residents stated that they live in very small houses that are in desperate need of renovation, rehabilitation and some of them need complete demolition. The surveyed tappers complained to Earthtime’s team that the housing provided, being a single room of roughly ten square meters, was insufficient for his family of ten. However, housing for skilled laborers differs, depending on the position held in the company.

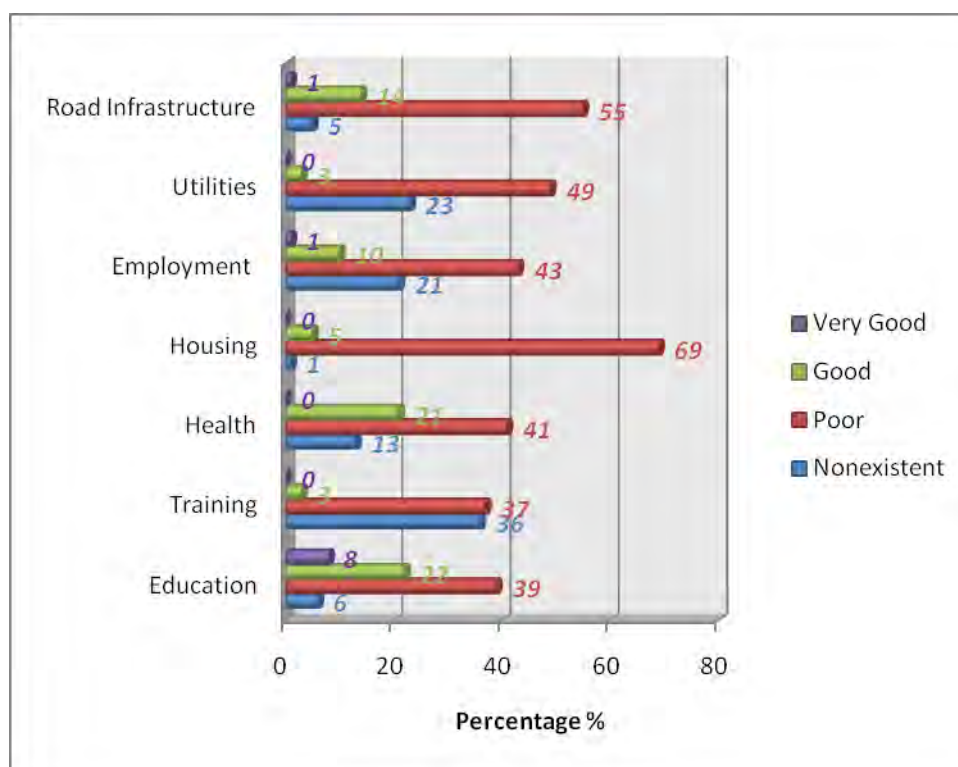


Figure 7-35: Community profile as rated by individuals.

In addition, and based on the analysis of the surveyed questionnaires, 69% of the surveyed local residents consider that the housing conditions within the plantation site is poor while 5% considered as good and 1% considerer it as nonexistent (Figure 7-35).

According to the assessment matrix (to be included in Appendix) of household infrastructure conditions prepared by Earthtime Inc. and filled by the camp masters; the size of the houses, number of rooms, water availability, personal hygiene, toilets

conditions, wastewater disposal, waste disposal, building material, ventilation, lighting and general hygiene status were rated as poor/old and nonexistent.

According to surveyed residents Salala should start housing renovations and demolition at the plantation site. Stakeholder investigation and consultation revealed that the renovations will need to go beyond repairs for some camps such as camp 1, 2, 3 and 5 in order to bring the housing situation in line with the requirements and standards of good living conditions and as well as the right to live in security, peace and dignity.

7.3.2 Health Care Infrastructure

The surveyed residents indicated that one clinic is operational and serves the entire population at the plantation site. It is responsible for the coordination and monitoring of health and welfare services in the plantation. The clinic is characterized by inadequate construction and very limited medical supplies with deplorable condition. The clinic does not have sufficient medical personnel or medical supplies to offer services for the population of the plantation (approx. 3000).

No cases of children affected by rubber- related activities have been reported. However, cases of diarrhea, fever, malaria and worms are frequent and adequate treatment is not always available due to lack of medicines. The pharmacy has a very limited range of medication are available to meet patient's need.

Unfortunately the clinic cannot treat patients with serious illnesses, which require them to travel over several kilometers to the nearest hospital for treatment.

Furthermore, the clinic has limited electricity supply; the only source of power is a small generator. Wastewater arising from the clinic is disposed into the environment without prior treatment as well as solid waste which might comprises

hazardous medical waste. Potable water is not available on the premises and the clinic relies on water taken from a nearby hand pump well.

The residents expressed dissatisfaction towards the response of the ambulance due to the lack of appropriate communication tools and the poor mobile network coverage. Therefore, they emphasized their need for an effective communication system in case of emergency.

On the other hand, 41% of the surveyed local residents consider that the healthcare infrastructure within the plantation site is poor while 21% considered as good and 13% considerer it as nonexistent (Figure 7-35).

According to the assessment matrix of existing health care facility (to be included in appendix) prepared by Earthtime Inc and filled by the responsible key personnel in the clinic, the clinic needs improvements in order to increase its capacity as well as rehabilitation work.

7.3.3 Educational Infrastructure

Schools are available within the plantation site. However, educational facilities provided by the corporation are inaccessible to many children due to the excessive distance of the facilities from their settlements.

According to the information gathered from the survey, six schools are available within the plantation site from which 3 provide secondary and primary levels and 3 provide daycares and kindergarten levels. The six schools accommodate 1550 students from which 585 students are at daycares level, 596 students are at primary level and 369 students at secondary level. A total number of 49 instructors serve the 1550 students at the various levels (Table 7-2).

Table 7-2.Schools within the plantation site

Location	Camp	Type	Existing services						Beneficiary
			Daycares		Primary		Secondary		
			Students	Instructor(s)	Students	Instructor(s)	Students	Instructor(s)	
Weala township, Maghribi County	Wea River, Side school	Concession	-	-	45	6	208	10	Local community & employees' children
SRC Plantation	Baypolu community annex 3	Concession	135	1	65	1	121	10	Local community & employees' children
SRC Plantation	Camp # 4 Central school	Concession	130	1	486	7	40	10	Local community c & employees' children
SRC Plantation	Camp # 2 Annex 1	Concession	130	-	-	-	-	-	Local community & employees' children
SRC Plantation	Camp # 3 Annex 2	Concession	140	2	-	-	-	-	Local community & employees' children
SRC Plantation	Camp # 5 Annex 4	Concession	50	1	-	-	-	-	Local community & employees' children

39% of the surveyed local residents consider that the educational infrastructure within the plantation site is poor while 22% considered it as good (Figure 7-35).

According to the assessment matrix (to be included in appendix) of existing educational infrastructure, buildings lack proper furniture, playgrounds, air-conditioning, science laboratory equipment, and lighting (Figure 7-36). Schools are exposed to noise and some classes are leaking during winter season. During the field survey, a room in one of the school's annex located in Camp 3 was used for the storage of chemicals and fertilizers (Figure 7-37).



(a)



(b)



(c)



(d)

Figure 7-36: (a-b) different views of school's condition in Camp 3.



Figure 7-37: (a-b) chemicals and tools stored in one of the rooms within the school of Camp 3.

7.3.4 Training

In terms of training related to skills enhancement and capacity building, 37 % of the surveyed residents considered that training at SRC is relatively poor, while 36% considered it nonexistent and 3% considered it as good (Figure 7-35).

7.3.5 Migration

The general migration flow from and to the plantation camps is insignificant. Last year, five families from camp 1 left the plantation, and five new ones joined the camp. In camp 2, four families left and ten families joined during the same year; eight families left and eight new ones joined camp 3. As for camp 4 and 5, no migration flow was recorded.

According to the camp masters, the main reason for leaving camps is attributed to end of service; meanwhile, newly employed family member is the main reason for joining camps (Table 7-3).

Significant seasonal changes in number of population that are related to the various plantations' activities do not occur. Therefore, local camp residents are not expected to will not face any kind of incremental demands.

Table 7-3: Migration flow

Camp Number	# of families joined the camp (last year)	# of families left the camp during (last year)
Camp 1	5	5
Camp 2	10	4
Camp 3	8	8
Camp 4	1	0
Camp 5	1	0
Reason	Newly employed family member	Pay off / end of service

7.3.6 Employment

According to surveyed individual, SRC is providing new employment opportunities every two months. At least one member of each family works for SRC. However, 43 % of the surveyed residents considered that employment generation and condition at SRC are relatively poor, while 10% considered it good, 21% considered it nonexistent and 1% consider it very good (Figure 7-35).

In terms of working hours, 68% of the surveyed laborers work from 8 to 10 hours, while 5 % work from 6 to 8 hours and another 5 % work from 10 to 12 hours. 8 % work for more than 12 hours (Figure 7-38).

None of the workers within the plantation site are below 15 years old and above 65 years old.

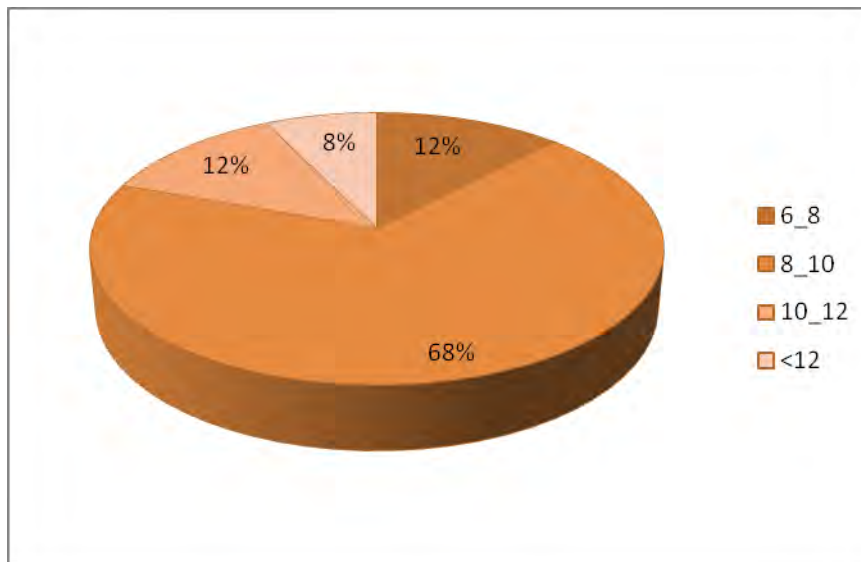


Figure 7-38: Number of working hours at SRC

7.3.7 Road Infrastructure

All roads within the plantation site are unpaved. 55% of the surveyed residents consider roads condition as poor and 14% evaluate them as good (Figure 7-39).



(a)



(b)



(c)



(d)

Figure 7-39: Road conditions in the camps.

7.3.8 Attitude of Surveyed Residents towards Salala Rubber Company

This section evaluates the attitudes of surveyed residents towards SRC activities in terms of positive and negative impacts targeting different sectors such as environment, health and safety, community service and land use & archeological resources. The attitude was classified into 3 categories; negative effects, no effects and positive effects.

7.3.8.1 Environment, Health and Safety

The first question addressed to the surveyed residents was concerned with the impact of Salala activities on the environment, health and safety services. Table 7-4 summarizes the number of answers provided for each category by the residents.

Table 7-4: Attitude towards SRC (environment, health and safety).

Activities	Negative effects	No effects	Positive effects
Health	6	43	26
Emergency Services	16	26	33
Noise	19	52	4
Crime and Delinquency	15	55	5
Environmental Impacts	18	50	7
Employment	17	35	23

The chart presented in Figure 7-40: Attitude towards SRC (environment, health and safety) shows the interviewees' opinion about the impact of SRC on the environment, health and safety services. It shows that the majority agree that SRC has no major effects. This indicates that SRC is not playing an effective role in considering the necessary environmental requirement for the camps. This applies to other aspects such as crime, noise, and health.

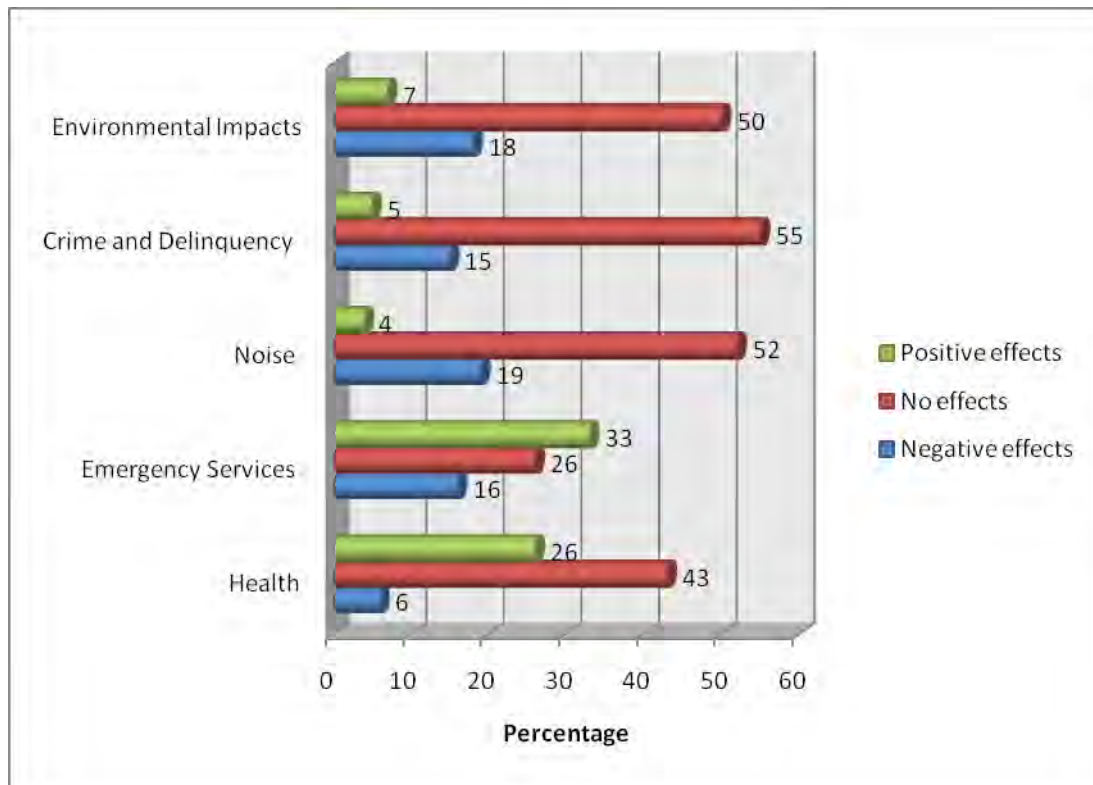


Figure 7-40: Attitude towards SRC (environment, health and safety).

7.3.8.2 Community Services

The second question was to determine the interviewees' position on the impact of SRCs' activities on the community services (Table 7-5: Attitude towards SRC's (community services)).

The chart presented in (Figure 7-41: Attitude towards SRC (community services)) shows the interviewees' various opinions about the impact of SRC on the

community services. It shows that the majority agree that SRC has no major positive effects except for income generation where the company plays a positive impact.

Table 7-5: Attitude towards SRC's (community services).

Activities	Negative effects	No effects	Positive effects
Income Generation	11	34	30
Utilities	23	36	16
Road Infrastructure	13	38	24
Housing	23	40	12
Education & Training	12	38	25
Health Care Infrastructure	8	42	25

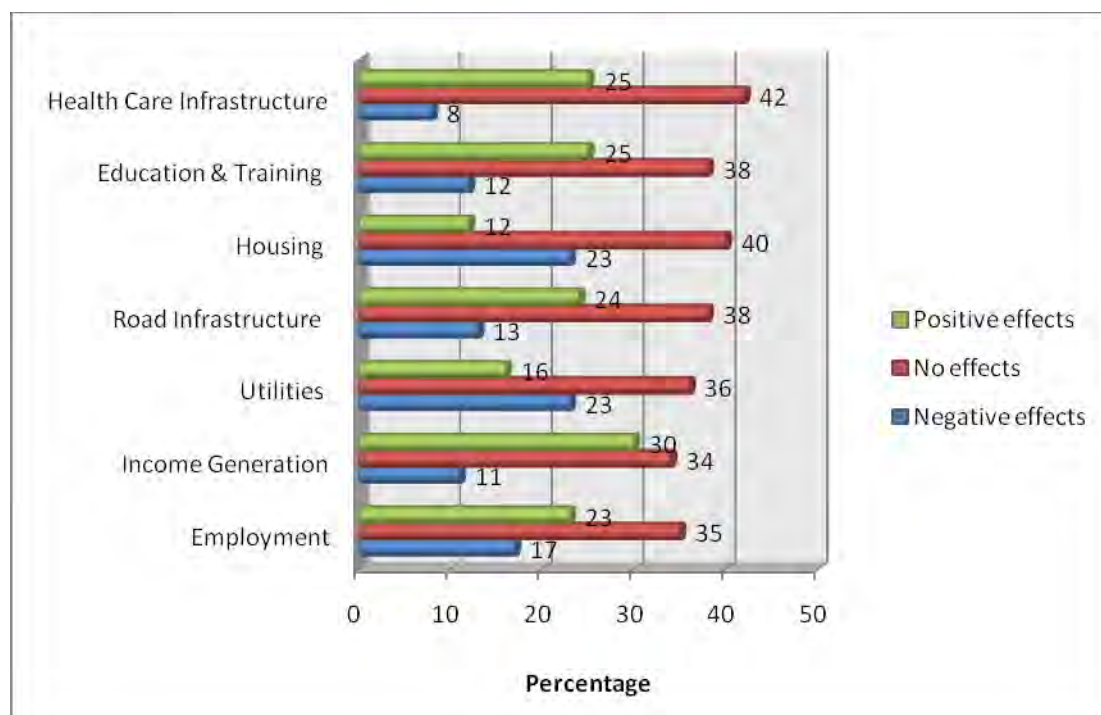


Figure 7-41: Attitude towards SRC (community services).

7.3.8.3 Land use resources & Archeological Resources

The third question was concerned with the impact of Salala activities on land use & archeological resources (Table 7-6: Attitude towards SRC (land use & archeological resources)).

The chart presented in (Figure 7-42: Attitude towards SRC (land use & archeological resources)) shows the interviewees' opinion about the impact of SRC on the land use & archeological resources. It shows that the majority agree that SRC has no negative effects.

Table 7-6: Attitude towards SRC (land use & archeological resources)

Activities	Negative effects	No effects	Positive effects
Land Use	15	51	9
Cultural Family Values	25	54	5
Religious or Cultural Sites	19	51	5
Archaeological Resources	13	55	7

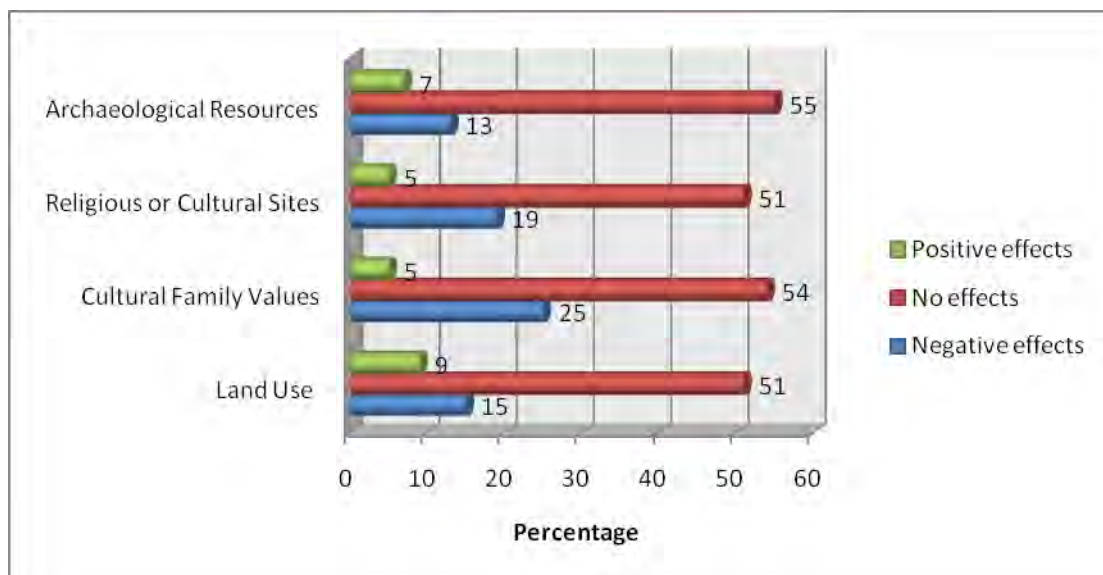


Figure 7-42: Attitude towards SRC (land use & archeological resources)

7.3.9 Expectations

Several important expectations from the residents were highlighted during the field survey, such as:

- Construct new houses.
- Improve educational system.

- Improve healthcare system.
- Increase number of wells.
- Construct sanitary facilities.
- Communication radios.
- Construct playgrounds/recreational infrastructure.
- Introduce Kitchens.
- Improve road networks condition.
- Increase salaries.
- Provide micro-credits funds.
- Introduce local farming activities.
- Construct Town halls.

8 ENVIRONMENTAL & SOCIAL MANAGEMENT PLAN

The proper implementation of a comprehensive environmental and social management plan (ESMP) will ensure that the both the plantation and the factory meet regulatory and operational performance (technical) criteria. This section discusses the objectives of the ESMP, sets the mitigation measures and plans, summarizes the impacts and their mitigations measures, and designs an environmental and social monitoring plan and record keeping and reporting process.

8.1 OBJECTIVES OF THE ENVIRONMENTAL MANAGEMENT PLAN

The environmental and social management plan (ESMP) will ensure that the performance of SRC will comply with all technical, regulatory, and institutional requirements. The ESMP is essential to ensure that identified impacts are maintained within the allowable levels, unanticipated impacts are mitigated at an early stage (before they become a problem), and the expected project benefits are realized. In the ESMP, the environmental objectives of SRC should be clearly stated, and communicated to all staff to provide the necessary cohesion between planning, engineering, collection and operation. The ESMP has clear targets and times as well as clearly allocated responsibilities among the different personnel working at the factory. The ESMP assists in the systematic and prompt recognition of problems and the effective actions to correct them. Table 8-1 describes the items that will help the management in achieving high environmental performance. These include understanding environmental priorities and policies, ensuring proper management at all levels of the project's operation, knowing the regulatory requirements, and keeping up-to-date operational information.

Briefly, the execution of the ESMP will facilitate efficient implementation of mitigation measures to minimize impacts, accident prevention, effective operation and maintenance of both the plantation and the factory, and proper training, awareness and information diffusion among the SRC's personnel.

Table 8-1: Environmental Awareness Checklist for Management.

<i>Item</i>	<i>Main Requirements</i>
ENVIRONMENTAL PRIORITIES AND POLICIES	<ul style="list-style-type: none"> • ENVIRONMENTAL OBJECTIVES ARE CLEARLY DEFINED • ENVIRONMENTAL ISSUES (SUCH AS THOSE RELATED TO AIR POLLUTION, EFFLUENT DISCHARGE AND SAFETY) ARE UNDERSTOOD
MANAGEMENT	<ul style="list-style-type: none"> • ENVIRONMENTAL AND SAFETY RESPONSIBILITIES ARE CLEARLY ALLOCATED • STAFF TRAINING PROGRAMS ARE DEFINED AND CARRIED OUT • MONITORING RESULTS ARE REGULARLY RECEIVED AND ACTED UPON
REGULATORY REQUIREMENTS	<ul style="list-style-type: none"> • POLLUTION REGULATIONS – AIR, WATER, AND SOIL STANDARDS ARE KNOWN • HEALTH REGULATIONS (WORKPLACE) ARE KNOWN • LOGISTIC REGULATIONS (HANDLING AND CARRYING) ARE KNOWN
OPERATIONAL INFORMATION	<ul style="list-style-type: none"> • ANALYTICAL PROCEDURES ARE UNDERSTOOD • MONITORING DATA ARE COMPILED AND SUBMITTED ACCORDING TO SCHEDULE • MONITORING DATA ARE CHECKED BY QUALIFIED PERSONNEL WITH APPROPRIATE RESPONSIBILITY

8.2 MITIGATION MEASURES

The mitigation plan identifies the actions that can be undertaken to minimize or eliminate the negative impacts while improving the positive impacts. The Impact Assessment section has shown the different negative and positive impacts of the project's operation. Nevertheless, actions to minimize the likelihood and significance of possible negative impacts are summarized in **Table**. Management at SRC is responsible for the implementation of these measures to avoid unnecessary impacts to take place.

8.3 SIGNIFICANCE OF MITIGATION MEASURES

Mitigation refers to the set of measures taken to eliminate, reduce, or remedy potential undesirable effects resulting from the proposed action, in this case SRC. Mitigation should be typically considered in all the operational stages of the facility, namely the plantation operations (including planting, tapping, coagulation, collection of coagulated latex, application of chemicals, etc.), and the factory (processing of rubber, management of effluent discharge, power plants, etc.).

Potential adverse environmental impacts induced by the operation of the plantation and the factory may include, as described in the previous section (a) health and safety concerns (b) air quality (c) generation of noise from traffic and operation of the power plant and processing plant (e) generation of solid waste (f) generation of effluent discharge (g) impacts on biodiversity and (h) soil quality degradation.

Mitigation measures should be monitored on a continuous basis in order to achieve the highest control with minimum risks. The supervisor engineer and the environmental officer are the main personnel to ensure that mitigation measures are employed in the right way.

The subsequent paragraphs describe the mitigation measures that should be followed to minimize the above-summarized impacts.

8.4 DESCRIPTION OF MITIGATION MEASURES

As identified earlier, potential adverse impacts of SRC may include degradation of soil quality, emission of gasses, noise generation, and production of effluents, health and safety concerns, and generation of solid waste. Proposed mitigation measures for the above-mentioned adverse impacts are discussed in the following paragraphs. **Section 8.10** summarizes such mitigation measures, their monitoring for actions affecting environmental resources and human amenity. Such measures should be set as primary conditions to assure a proper management of SRC as well as the implementation of the Environmental and Social Management Plan (ESMP).

In order to be applied efficiently, mitigation measures should be typically considered at the different operational stages of the SRC facilities (namely the operation of the plantation, coagulation, management of the camps, raw material storage, processing, packaging, and end product storage and transporting) and monitored on a continuous basis. Every single issue discussed earlier should be addressed and resolved, including water and energy consumption, wastewater and solid waste disposal, air and noise emissions and finally occupational safety. The supervisor engineer and the environmental officer are the main personnel to ensure that mitigation measures are employed in the right way.

The following section will discuss the mitigation measures and plans recommended by the study team and design an environmental monitoring plan paralleled with a record keeping/reporting process.

8.4.1 Mitigation Measures for the Plantation

Pollution abatement is essential for sustainability of resources and livelihoods. In fact, the rubber business is entirely dependent on the productivity of the rubber plantations. Therefore, it's very important for the SRC's management to consider preserving and restoring its resources for business sustainability.

For this purpose, the following section will be discussing the different measures to be adopted by the stakeholders in order to alleviate or even eliminate the adverse impacts generated by the rubber plantation. However, it's worth mentioning the soil preservation should be considered at the top of the priority list especially when erosion could have serious impacts on plantation growth, quality of nearby water bodies and agrochemicals use/expenses.

8.4.1.1 Mitigating Impacts on Soil Quality and Soil Preservation Practices

Preserving the soil quality at the SRC rubber plantation will require three main strategies namely reduction of erosion, control of soil nutrients loss and prevention of acidification. If these strategies are adopted, they will not only enhance soil quality but they will also have a similar effect on other environmental resources like water and air. Table 8-2 lists the recommended conservation measures based on the type of problem to be dealt with and environmental resource affected.

Table 8-2: List of Soil Preservation Measures (UNCTAD/IRSG, 1997, Zhang et al, 2006, UN, 2006 and Sonetra, 2001).

		TYPE OF PROBLEM			Environmental Resource Affected
		Erosion	Loss of Nutrients	Acidification	
CONTROL MEASURES	Practice Integrated Nutrient Management ⁷		x	x	Soil, air ⁸ and water
	Use barriers for runoff (i.e.: stone barriers, terraces, or drainage and diversion canals)	x			Soil and water
	Use plant cover for nitrogen fixation		x		Soil and water
	Increase the organic matter content in the soil by applying crop residues, compost or manure ⁹	x	x		Soil
	Consider adding lime to soil			x	Soil
	Apply adequate cultivation methods (such as dikes, ditches, intercropping ¹⁰ , shadow trees, shrubs or crop cover)	x	x		Soil and water
	Minimize the need for agrochemicals (through removing stumps of old trees, sufficiently diverse soil-covering plants, drainage in areas with high water level)		x	x	Soil and water
	Reduce the tapping quotas into three times per week		x		Soil

⁷ Integrated Nutrient Management involves the application of fertilizers based on the plant need and soil content in order to avoid nutrient depletion or accumulation

⁸ Adopting fertilization according to plant needs will reduce ammonia and nitrous oxide emissions through reducing ammonia and nitrate concentration in soil

⁹ The potential for spreading of pests should be considered before implementing this practice

¹⁰ SRC plantation had applied spacings of 3 x 6 meters between trees. This is considered wide enough for intercropping for at least the first 3 years of immature period

Additional steps can be adopted, these will directly affect the level of emission introduced into the atmosphere due to the rubber plantation mismanagement. Such steps are the following:

- Adopt reduced tillage options to increase the carbon storage capacity of soils; and
- Reduce ammonia and nitrous oxide emissions by enhancing soil aeration.

8.4.1.2 Mitigating Impacts on Water Resources

Once soil erosion is controlled, automatically the impacts of the rubber plantation on water resources, namely eutrophication, suspended solids and chemical loading, will be reduced; however, the problem of serum leaching persists. Dealing with the serum produced during coagulation is not as tricky as it seems. In fact, recent studies published in this field had suggested an alternative use for rubber serum mainly consisting of land application. In fact, using rubber serum as a soil fertilizer has been proven to be beneficial to crops like rubber, oil palm, grasses and leafy vegetables (Sonetra, 2001). It is then suggested to construct a simple drainage system just around the coagulation station, where serum will be transferred, underground, into a closed collection tank. This simple drainage system will allow collection of serum for future use as a nutrient rich fertilizer at the plantation. The collected serum can also be sold to other farmers for agricultural land application. The drainage system will be also considered as an efficient method to control the foul odors emission, through directing the serum into a closed system. Another option for serum disposal consist of transferring the collected serum into the rubber processing factory where a wastewater treatment plant can be constructed to treat both of the factory effluents and the collected serum before discharge into water resources. The treatment facility would have to adjust the BOD/COD levels of the wastewater to appropriate levels.

8.4.1.3 Mitigating Impacts of Air Emissions and Odors

Control of air pollutants and odors generated due to inappropriate management practices at the SRC plantation are directly linked to soil conservation and water protection measures recommended. To recapitulate the events, there are mainly three different air pollution impacts produced by the plantation; these include:

1. Reduced carbon fixation levels;
2. Nitrogen emission into the atmosphere; and
3. Foul putrid odors emission.

According to what was mentioned earlier in the report, carbon fixation can be improved through adopting reduced tillage options thus increasing the carbon storage capacity of soils. On the other hand, the nitrogen emission problem can be dealt with through enhancing soil aeration and through practicing Integrated Nutrient Management. Last but not least, malodors can be controlled through either serum treatment or underground collection.

8.4.1.3.1 Dust Emissions

8.4.1.4 Mitigating Impacts on Ecosystem and Biodiversity

Preservation of biodiversity at the plantation requires the adoption of healthier management practices, namely:

- Finding safer alternatives for the agrochemicals used (Refer to Table 8-3);
- Avoid overuse of biocides; and
- Rinsing solutions used to clean biocide containers should be recovered for reuse as diluting agents, or stored for adequate disposal.

Table 8-3: Suggested alternatives for some of the agrochemicals used at SRC's plantation.

Name of Chemical in Use	Safer Alternatives
Dursban	Permethrin, cypermethrin, imidacloprid, fipronil, bifenthrin, esfenvalerate, deltamethrin and cyfluthrin.
Mancozeb	Azoxystrobin (USEPA, 2005)

8.4.1.5 Mitigating Impacts on Human Health and Occupational Safety

Limiting the risk of injury at the plantation mainly lies in promoting awareness and good management practices among workers at the SRC plantation, especially when it comes to chemicals handling. These have serious adverse health impacts on those directly exposed to, especially during storage, application and disposal.

Facilities designated for storage of agrochemicals should respect a certain number of criteria in order to secure safer storage conditions. These include the following (ILO):

1. Location of the storage facility:
 - Should be located in accessible areas for delivery and transfer of the agrochemicals;
 - Should be located away from water bodies to reduce the risk of pollution subsequent to leaks and spillage;
 - Shouldn't be located in areas liable to flooding;
 - Shouldn't be located in upstream catchment areas for water supply;
 - Shouldn't be located in environmentally sensitive areas;

2. Construction conditions of the storage facility:
 - Should have adequate capacity for storing the maximum amount of agrochemicals;
 - Should provide secure stacking and easy access of agrochemicals;
 - Storage of agrochemicals should be separate from other stocks such as

flammable material;

- Should be resistant to fire, extremes of temperature;
- Floors should be so designed as to contain spillage or leakage and have a non-slip surface which can be easily cleaned;
- External walls should be impervious to water, their inside surfaces smooth, easily washable and free from dust traps;
- If a single-storey, the roof should be of non-combustible material which will fall in quickly and act as a vent in the case of fire;
- Should have suitable fire escapes (with fire resistant doors opening outwards);
- In areas with particularly sensitive environments, construct an internal drainage system connected to a containment tank with the capacity to hold all the agrochemicals in store;
- Should have adequate natural or artificial light;
- Windows should not allow direct sunlight to fall on to agrochemicals because ultra-violet light may cause deterioration of containers and contents (through shading windows or positioning windows);
- Electric lights and switches should be positioned so as to avoid mechanical damage;
- Adequate separation distance between lamps and stored agrochemicals to avoid the transmission of heat; and
- Should be properly ventilated to remove contaminated air.

3. Organization of the storage area:

- Should provide organized areas for storage (i.e.: shelves, secure stacking with clearly visible labels);
- Flammable products should be segregated by placing them in an isolated and particularly fire-resistant part of the store;
- Care should be taken to avoid overloading shelving or compressing

containers at the bottom of a stack.

4. Other considerations:

- A water supply should be provided nearby but not in the store;
- Any water supply used to fill sprayer tanks or animal treatment baths should be so designed as to avoid back siphonage;
- A record should be made of agrochemicals in store but kept separately in a safe place where access in emergency cases is easy;
- Adequate first-aid facilities should be available to treat minor injuries and contamination of eyes and skin;
- Smoking and the use of a naked flame should be prohibited within the store;
- Fire extinguishers in good working order should be at hand, in case of emergencies;
- Washing facilities should be provided close to the store for anyone who handles agrochemicals. They should be equipped with a wash-basin and clean running water, soap and disposable towels;
- Separate ventilated accommodation must be provided for protective clothing and for personal clothing (i.e. a cupboard or locker outside agrochemical storage area);
- Protective clothing be washed at least three times and stored in a secure dry area with agrochemical waste;

Fertilizers may be supplied ready for use, while other agrochemicals might need special preparation, such as mixing with water. Dispensing agrochemicals usually should be carried out safely and efficiently, following measures like (ILO):

- Checking out the label for instruction of use (i.e., dose rate, dilution factors, etc.);
- The agrochemical preparation should be performed in a clean area away from

homes or livestock;

- Preparation area should be cleaned in case of any spillage;
- Wearing appropriate protective clothing, particularly gloves, as specified on the label or recommended in information sheets (Figure 8-1);

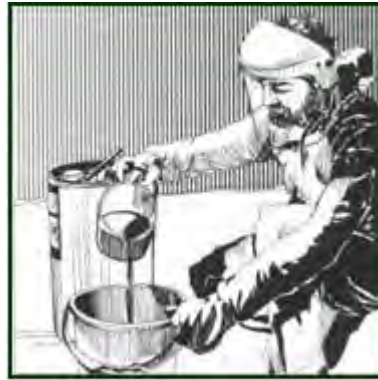


Figure 8-1: Appropriate Protective Clothing to Wear during Agrochemical Dispensing (ILO)

- Partial filling of applicator with diluting fluid to prevent any accidental splash-back of the concentrated substance;
- Careful emptying of agrochemical dusts and powders packs into applicators to avoid airborne particles production;
- Decontamination of used utensils by washing or cleaning and returning to safe storage; and
- Care should be taken to avoid inhalation, ingestion or skin absorption.

The peak of workers exposure to agrochemicals occurs during application. Precautionary measures are essential at this point to reduce the health risks. These include the following (ILO):

- All agrochemical users must be properly trained as sprayer operators. Training sessions should cover the choice of equipment, checking of equipment to ensure proper functioning, filling the applicator with the agrochemical, calibrating and operating;
- All agrochemical users should be well informed about safety precautions and emergency measures;

- All agrochemical users should be capable of attending to simple repairs;
- Users' instruction manual should always be available for reference;
- Pre-application of the agrochemical it's important to:
 - Review carefully the labeled instructions and any other information provided with the agrochemical, the application equipment or the protective clothing;
 - Assess the risks of application to people and the environment and decide what action is necessary to reduce or eliminate them;
 - Check application equipment to ensure satisfactory operation (i.e.: no leaking or spilling and calibration);
 - Check the condition of protective clothing and other safety equipment. It's important to replace any items that are worn or missing;
 - Set up an action plan to cover implementation;
 - Check weather conditions (i.e.: avoid excessive wind speeds and consequent spray drift);
 - Warn people nearby about the spraying if they might be affected;
 - Ensure the safe disposal of empty containers, tank washings and surplus pesticides.
- During application it's important to:
 - Wear appropriate protective clothing as prescribed on the label or information sheet for handling concentrated products;
 - Avoid blow-back from granule or powdered materials when transferring container contents into the application unit. A slow, steady release causes least disturbance of air and reduces the risk of particles becoming airborne and being inhaled.
 - Mix only the correct amount of agrochemical required for a particular task so as to avoid the need to dispose of any surplus.
 - Use an agrochemical only for the intended purpose and at the correct application/dilution rate;

- Do not eat, drink or smoke while applying agrochemicals;
- Ensure that dangerous practices are prohibited such as blowing in a blocked nozzle to clear it. Clean the nozzle with water or a soft probe, such as a grass stem;
- Do not allow other workers in the field when pesticides are being applied;
- Take notice of changing weather conditions, such as an increase in wind speed. This would cause drift and could blow the spray towards sensitive areas such as a drinking-water supply, resulting in health hazards. It may also blow the spray towards the operator, causing an inhalation hazard;
- Never leave containers or application equipment open or unattended;
- If spillage occurs, keep everyone away until it is cleaned up and disposed of safely. This may be done by washing or using absorbent material such as soil or sawdust to soak up the agrochemical;
- Post application it's necessary to:
 - Thoroughly wash hands, face and neck as well as other parts of the body which may have become contaminated. If gloves have been worn, wash them before removal;
 - Return unused agrochemicals to safe storage and safely dispose of empty containers and any surplus in the application equipment;
 - Decontaminate application equipment by washing it thoroughly. The washings should be drained into a soak-away or similar chamber to be safely confined and without risk to the environment;
 - Decontaminate protective clothing by thoroughly washing items. Launder the work clothing each day after spraying. Gloves should be washed inside and out and allowed to dry. Respiratory protection equipment should be wiped clean;
 - Bath or wash thoroughly again after completing the above four actions;

- Complete a record of use so as to provide information about the agrochemicals used, the date and place of use and the name of the user. This is both good management practice and also a source of reference in the event of agrochemical-related illness;

Besides biocides, formic acid is used during the coagulation process occurring at the plantation. Methods that are effective in controlling worker exposures to formic acid, depending on the feasibility of implementation, are as follows (OSHA):

- Process enclosure;
- Local exhaust ventilation;
- General dilution ventilation; and
- Personal protective equipment.

Last but not least, physical injuries occurring at the plantation can be eliminated through the use of personal protective equipments, such as gloves, masks, boots, etc.

8.4.2 Mitigation Measures for the Rubber Processing Facility / SRC's Rubber Factory

Prevention is the best strategy to combat environmental pollution. Efforts are being made worldwide to improve environmental quality and at the same time increase efficiency and profits through the implementation of pollution prevention techniques. These might include “reducing material inputs, reengineering processes to reuse by-products, improving management practices, and using substitutes for toxic chemicals” (USEPA, 2005). For this purpose, the following section will represent a detailed list of better management practices categorized according to the related environmental problem encountered that should be adopted by the WRC management.

8.4.2.1 Water Pollution Control

Water pollution problems were divided in this report into water consumption patterns and wastewater disposal practices. Although these two issues seem different, adopting efficient practices in one will facilitate the control of the other.

When it comes to water preservation, a number of measures can be adopted by the WRC management. These measures if adopted will definitely inflict direct costs on the facility, however on the long term benefits will outweigh the costs. Water conservation measures include (Department of Industrial Works, 200; Wouapi et.al, 2006):

- Installing water meters for gauging water consumption in different areas;
- Ensure that workers turn off water taps after use (incentives could be used to achieve set targets);
- Ensure continuous maintenance of water pipe systems (i.e.: joints, valves and water pipes);
- Install pressurized water guns or nozzles to be used for cleaning machines, equipment and floors;
- Install automatic closing devices for taps and hoses;
- Monitor water level and flow rates of siphons to prevent excess use of water;
- Reuse of water during the production process (i.e.: used high quality water from the production process can be reused where high quality is not critical; and
- Effluent can be treated and reused for the production process.

Choosing the appropriate effluent disposal technique to be adopted at rubber primary processing facilities is still controversial. Some might advocate the end of pipe treatment method while others might support waste reduction at the source due to the lack of financial resources. Knowing the properties of the effluent

discharged from the WRC facility and the associated impacts on the public welfare and the sensitive ecosystems, the study team recommends the adoption both water conservation and end of pipe treatment. In fact, water conservation will play a major role in controlling the effluent's volume generated at the end of the production process, hence reducing operational costs of the wastewater treatment system to be established.

Considering the properties of the WRC effluent, minimum treatment processes should include (McGraw-Hill, 1991; World Bank, 2007; Wouapi et.al, 2006):

1. Primary treatment (to recover rubber particles and remove inert material that may hinder biochemical reactions later); and
2. Equalization tank (to stabilize the pH and BOD).

The recovered rubber during the treatment process can be either reused in the production process or sold to locals. In both ways efficiency in the use of natural resources will be applied.

If the option of using evaporation ponds for partial treatment of the effluent will still be adopted, proper lining of the pond bottom should be considered, in addition to elevating the edges of the pond to avoid river water contamination due to flooding. It's advised to discharge the effluent directly into the pond, in order to pump it later on to the treatment plant for further treatment prior to discharge into the river.

8.4.2.2 Air Pollution Control

Major emissions produced from rubber primary processing are associated with fuel combustion for energy production. Therefore, controlling emissions at WRC facility mainly involves adopting energy efficient practices throughout the rubber primary processing. Such practices might include (Department of Industrial Works, 2001):

- Synchronizing running of machines to avoid peak loads;
- Replacing motors with high efficiency types, consuming less electricity;
- Avoiding fuel ignition when there is no rubber in the drying tunnel;
- Accommodating the dryer's capacity to the cleaning processes to avoid excessive loads on the dryer or running it overtime;
- Increasing the retention time of rubber in the drying tunnel to reduce the need for continuous temperature adjustment; and
- Monitoring drying efficiency;

Additional control measures aimed at reducing NO_x emissions consist of controlling the combustion process through (Cooper et.al, 2001):

- Reducing the peak temperature of the flame zone through:
 - Using a fuel-rich primary flame zone;
 - Increasing the rate of flame cooling; and
 - Decreasing the adiabatic flame temperature by dilution.
- Or reducing gas residence time in the flame zone through:
 - Changing the shape of the flame zone; and
 - Reducing the peak temperature of the flame zone.
- Or reducing oxygen concentration in the flame zone through:
 - Decreasing the overall excess air rates;
 - Controlled mixing of fuel and air; and
 - Using a fuel-rich primary flame zone.

For the reduction of SO_x and odor emissions, it's recommended to apply flue gas treatment techniques namely wet scrubbing (Department of Industrial Works, 2001; Cooper et.al., 2001).

PM control can be achieved through rehabilitating the roads connecting the plantation to the production facility.

8.4.2.3 Preserving Biodiversity

Protecting the ecosystems surrounding the WRC facility is easily achieved by applying the water and air quality preservation measures discussed earlier in this section.

8.4.2.4 Occupational Safety

Recommended mitigation measures to be adopted by the WRC management include the following:

- Restrict unattended public access;
- Use adequate safety barrier and signs;
- Proper labeling storage of chemicals, oils and fuel;
- Promote safety education through training and provide appropriate personal protective equipment such as gloves, masks, ear plugs, etc...;
- Provide fire extinguishers at different locations of the operational site;
- Control leakages through continuous maintenance of equipment and storage containers;
- Frequent sweeping to control dust accumulation;
- Provision of electrical grounding, spark detection and prevention;
- Elimination of external ignition sources;
- Enhance ventilation in enclosed areas;
- Use ergonomic designs for working stations;
- Maintain working spaces and walking surfaces to prevent slips;

8.5 SOCIAL MANAGEMENT PLAN

Social Concern	Impact	Mitigation Measures
----------------	--------	---------------------

Environment, Health & Safety	Heal Health	No effect	
	Emergency Services	Positive effect	
	Noise	No effect	
	Crime and Delinquency	No effect	
	Environmental Impacts	No effect	
	Employment	No effect	
Community Services	Income Generation	No effect	
	Utilities	No effect	
	Road Infrastructure	No effect	
	Housing	No effect	
	Education & Training	No effect	
	Health Care Infrastructure	No effect	
Land Use & Archeological Resources	Land Use	No effect	
	Cultural Family Values	No effect	
	Religious or Cultural Sites	No effect	
	Archaeological Resources	No effect	

No Effect: does not mean a positive role.

8.5.1 Community Development Program

SRC should contribute to the sustainable development of the local communities in the plantation through community development programs. The main objective of such programs will be to improve the quality of life of the local communities at the plantation through social projects that deliver value-added benefits.

The socioeconomic (section 7) baseline established the prevailing conditions in each of the five camps in the plantation. Consultations with local residents and field surveys revealed that none of the villages had access to electricity, water, and other basic facilities, such as sanitation. The healthcare facilities at the plantation are minimal to nonexistent and schooling opportunities for children in most of the camps are limited to daycare levels except for the main school building within Camp 4 that provides up to high school level. The most dominant means of livelihood is working for SRC with scarce infrastructure and resources that result in low income

levels. Due to the remote location of the plantation itself and lack of transport services between the plantation and surrounding communities, residents of the camps have limited access to areas outside the project area.

8.5.1.1 Objectives

The objectives of the CDP are:

- Seek better opportunities to generate more benefit for the camps residents and SRC's workers;
- Manage expectations of key stakeholders;
- Maximize positive benefits of the project while minimizing negative impacts;
- Enhancing the livelihood conditions by meeting the necessary needs and requirements of the camps residents and the workers; and
- Contribute to the sustainable development of the area.

The overall goal is to improve the quality of basic services, including healthcare, education, and utilities, and create opportunities for enhancing economic activities in the area that would provide the locals with more sustainable means of livelihood.

8.5.1.2 Scope of the Program

The community development projects will focus on the following development areas:

- **Capacity Building:**
 - Provide training and educational opportunities to students to attain technical training providing them with better chances of winning gainful employment;
 - Provide technical training for SRC's workers to enhance their skills and productivity.

- **Skills Development:** Provide employment and business opportunities to local communities to develop the skill base and diversify economic activity in the area especially for women. This will help to meet the gaps and introduce new services, and utilities to the plantation's area; and
- **Enhancing Quality of Life:** Implement sustainable community development projects that will deliver long-term benefits to the local communities and will continuously improve their living standard, such as health awareness and infrastructure programs, hygiene and sanitation awareness, etc.

8.5.1.3 Potential Areas for Social Development

Subsequent to field surveys in the project area and consultations with residents of the camps, a preliminary list of potential social investment areas has been identified. SRC will support the social investment projects with special focus on areas related to infrastructure, education, health, and economic activities.

8.5.1.4 Construction/upgrade of Healthcare Facilities

The existing healthcare facilities within the plantation and the factory are limited to a primary healthcare and inadequate, resulting in difficult conditions for the residents of the camps as well as the workers to access good healthcare.

SRC intends to renovate and upgrade the existing clinic at the plantation (insert appendix showing proposed clinics). However, the upgrading of the factory's clinic will have to be considered as well due to separate distances between the factory and the plantation. SRC should coordinate with the Ministry of Health and Social Welfare to ensure that the healthcare facilities are operated in an efficient manner.

Healthcare infrastructure is environment a high prevalence of infectious-disease agents; patients, staff, and neighbor of the healthcare infrastructure face unacceptable risks of infection if water supply, sanitation, hygiene, and healthcare

waste management are inadequate. The healthcare infrastructure might even become the epicenter of outbreaks of certain diseases.

8.5.1.5 Construction and Upgrading of Existing Educational Infrastructure

The children of SRC's workers have access to primary and secondary education; however, some of the camps such as Camp 1, Camp 2, Camp 3 and Camp 5 do not have schools providing all major levels. Therefore, it is recommended to establish new schools taking into consideration location of camps, educational levels as well as other basic factors in school designs (Table 8-4). SRC should also provide and facilitate transportation of students to and from the schools. For example, secondary students will have to walk from Camp 1, 2, 3 and 5 a distance of at least 1.5 km to Camp 4 where the school is located. For this purpose, dedicated vehicles should pick the students from the camps and drop them off in their schools in the morning and bring them back in the afternoon. This service is likely to result in increasing school enrollment and attendance.

Table 8-4: Factors to be considered in school designs.

Socio-spatial Factors in School Design		
	Formal Learning Settings	Informal Learning Settings (inc. community use & public spaces)
Outdoor Spaces	<ul style="list-style-type: none"> • Outdoor classrooms • Learning through landscapes • Social interaction • Security gradients 	<ul style="list-style-type: none"> • Social interaction • Territoriality • Gathering • Surveillance • Out of bounds • Safety • Promenade • Green areas • Play areas • Quiet areas • Entrance area • Private spaces • Hard and soft landscaping
Indoor Spaces	<ul style="list-style-type: none"> • Crowding • Spaciousness • Social interaction • Personalization and 	<ul style="list-style-type: none"> • Community centre / use • Diversity and variety • Public areas • Technology for teachers

	<p>ownership</p> <ul style="list-style-type: none"> • Building functionality • Safety and security • Clusters / instructional neighborhoods • Compact • Flexible / adaptable • Diversity and variety of settings • Activity pockets and learning zones • Location of administration / teacher offices • Controlled climate / acoustics / lighting • Storage • Ceiling heights 	<p>and students</p>
--	--	---------------------

8.5.1.6 Provision of Electricity

Currently, the camps of SRC are not connected electricity; as a result there is no power supply in the camps. SRC intends to supply electrical power to the camps. The power supply requirements should be assessed and the methods of distribution and management should be planned accordingly.

8.5.1.7 Potable Water Supply

The presence of at least two wells in each camp does not meet the basic requirement of the local camp residents. Therefore, the number of wells should be increased according to the population of each camp. Moreover, a water quality testing and monitoring scheme as recommended in **(Insert section number)** should be implemented in order to keep track on the quality of water provided to the residents to minimize disease risk. Water storage tanks should be provided to each house within each camp to facilitate access to water.

SRC should continuously support water supply to the villages. It is recommended that a study should be carried out to determine the requirement of water distribution network to individual households.

8.5.1.8 Vocational training and local employment

The number of skilled labor in the plantation and the surrounding area is low. In order to build the local skill base in the area, SRC should sponsor vocational training programs for individuals in the surrounding communities. It is envisaged that many locals will get employment during the construction phase of the new facilities that has considerable requirement for unskilled and semi-skilled labor. SRC should identify individuals from the camps as well as surrounding communities and provide them with some form of training in areas that meet SRC's requirements.

8.5.1.9 Empowering Women and Supporting Auxiliary Business

In the majority of the camps, women do not contribute economically when it comes to earning a livelihood. Their role is mostly considered inside the boundaries of a house, which includes carrying out domestic chores. However, high percentage of the workers in Camp 5 is women. Yet, it is recommended that women in the camps receive support from SRC in the form of training (such as sewing) that could be used for vocational purposes amongst women, consequently resulting in addition income for the household.

SRC should facilitate the establishment of women's association in the camps and coordinate with them to identify areas and projects to support and implement

On the other hand, SRC should support the provision of small-scale businesses and enterprises in the camps to increase income of the residents. SRC can also participate in financing small businesses such as agricultural or commercial activities in the camps through micro credits.

8.5.1.10 Organization and Resources

The project will have an Environment and Social (E&S) Manager who will be assisted by at least one Community Relations Officer (CRO) and Community Relations Assistant (CRA). Partnerships will be developed with local administration and local community to implement the various community development programs.

8.5.1.11 Constructing & Rehabilitating new Household Units

As indicated in Section 7, the conditions of households in the camps are below standards and unfavorable for proper living. With the exception of Camp 4, all the houses in the rest of the camps need reconstruction. SRC is currently reviewing plans and designs for the construction of new houses in various camps (include appendix showing the proposed plans). The design of the new houses should:

1. Take into consideration the number of population as well as the number of families as identified in the conducted survey; accordingly, set the number of rooms within each house.
2. Introduce sanitary facilities into each housing unit such as:
 - a. Toilets.
 - b. Bathrooms.
 - c. Kitchens.
 - d. Septic Tanks.
3. Introduce utilities into each housing unit such as:
 - a. Potable water facilities.
 - b. Electricity.

8.5.1.12 Waste Management

There are no designated waste disposal sites in any of the villages. Domestic solid waste is usually disposed in an open area located within the plantation area. This

area is not fenced and the waste is usually left to decay without any kind of treatment. Moreover, there is no sewage network in the camps; the effluent is discharged into the environment without prior treatment; only camp 4 has open septic tanks usually inside the housing compound. The methods of emptying the pit are not known; however sanitation vacuum tankers are not available in the plantation area. During the site survey, it was observed that grey water is poured onto the ground where it is allowed to soak; there are no soak-aways or designated areas for grey water disposal. Practices pertaining to solid waste and sewage disposal potentially pose environmental and health issues in the plantation area. Therefore it is highly recommended to adopt a proper waste management plan that take into consideration the following:

- Designate suitable locations for storage of domestic solid waste and hazardous wastes generated during operation activities;
- Introduce an adequate waste management facility designed to prevent soil contamination of, storm water and groundwater;
- For non-hazardous wastes such as domestic waste, packaging material, empty containers, canteen/office wastes, etc., segregated storage to be sized based on generation rate and disposal to a suitable licensed landfill or recycling facility.
- Segregate different streams of hazardous wastes generated during operational activities at the plantation site such as lube oils, spent solvents, skimmed oil from wash areas, etc; and
- Medical waste generated from the clinic needs special treatment.

As for waste water, SRC should ensure adequately sized wastewater treatment plants at the plantation site with secondary and tertiary units capable of treating wastewater/effluent discharge from sanitary facilities and houses within the 5 camps.

8.5.1.13 Road Infrastructure

Roads and bridges within the plantation site need continuous and frequent maintenance especially during the winter season. Transportation facilities such as buses and cars that link between camps should be introduced into the plantation area.

8.5.1.14 Timeframe

It is highly recommended that SRC starts implementing the community development program in phases taking into consideration priority in needs. Majority of the community projects such as construction of new houses, empowering the clinic's capacity and enhancing the educational infrastructure should start as soon as possible. Other program areas, such as capacity building and skills development, will continue throughout the operation phase. The magnitude of the program will depend on other business aspects, e.g., resource requirements.

9 ENVIRONMENTAL & SOCIAL MONITORING PLAN

9.1 COMPLIANCE MONITORING

In this context, compliance with the regulations set by the EPA to limit air, water, and soil pollution shall be observed. Compliance monitoring requirements include *process control testing, process performance testing, and occupational health monitoring*. However, standards and regulations for such parameters have not yet been set. Therefore, reference will be made to international standards for guidance until the concerned authority in Liberia sets and publishes such standards and regulations. Meanwhile, Compliance monitoring shall be the responsibility of SRC's environmental officer(s), supervisors and administration.

For effective compliance monitoring, the following shall be assured:

- Trained staff (plantation and factory operators, laboratory staff, maintenance team, etc.) and defined responsibilities, and knowhow of the whole process.
- Adequate analytical facility, equipment and materials.
- Maintenance of all operational equipment and calibration of monitoring equipment.
- Provision of safety at all different locations of the working area and retention of records.

During the operation of both the factory and the plantation, qualified operators and laboratory staff should carry out process control and performance testing. If possible, the technical staff that would run the facility shall attend training programs (in their relative domains) to improve their qualifications and update their information. Both Contractors and Consultants would be involved in knowledge transfer to operators and management through regular assistance and specialized technical workshops.

9.2 IMPACT DETECTION MONITORING

Impact monitoring includes periodic sampling to assess the impact of both the factory's and the plantation's operation on the environment and human health and to ensure their progress towards minimizing its negative impact. As such, the major objective of the monitoring plan is to ensure mitigation measures are implemented and the potential negative impacts are minimized.

SRC's Environmental Team and the Environmental Officer should develop and implement a monitoring plan that would ensure environmental protection during operations and implementation of the mitigation measures. Table 9-1 presents a monitoring program for the different parameters relative to SRC and its activities.

Table 9-1: Summary of Proposed Environmental Monitoring Plan at SRC (both factory and plantation).

Element	Monitoring Frequency	Type of Analysis	Cost (\$USD)	Location	Responsible Personnel
Dust	Monthly	PM ₁₀ (µg/m ³) at outlet of cyclone		▪	
				▪	
VOC	Monthly			▪	
				▪	
Noise	Weekly	(dBA)		▪	
Health and Safety	Daily			▪	
Water for process use	Weekly	• pH			
		• Conductivity			
		• TDS			
		• Turbidity			

Water for process use	Monthly	<ul style="list-style-type: none"> • Feceel • Coliform/100ml • E. Coli 100 ml • Iron • Manganese • Sulphate • Nitrate • Lead • Mercury • Zinc 					
Effluent Discharge	Weekly	<ul style="list-style-type: none"> • pH • BOD₅ • COD • Total Nitrogen • Total • Phosphorus • Oil and grease • Total • Suspended Solids (TSS) • Temperature Increase • Total Coliform Bacteria 					

9.2.1 Water Monitoring

Table 9-2 indicates the parameters and the frequency of monitoring them along with the guidelines to be followed. There are no local guidelines, and the mostly used guidelines in Liberia are those of WHO.

The factory's management uses water collected from the nearby Yia Creek for the processing of rubber and water from wells for domestic use and drinking purposes for the workers. Similarly, camps residents within the plantation rely on groundwater wells for drinking water as well as domestic purposes. Therefore, it is highly recommended to monitor the quality of the water collected from both the factory's and plantations' wells on a frequent basis as indicated in Table 9-1, and based on the parameters and guidelines indicated in Table 9-2. It is also necessary to monitor off-site water sources since the factory might have negative impact on them if effluent discharge or waste water is not treated.

Table 9-2: Water parameters to be tested on a frequently along with WHO guideines for drinking water.

Type of Analysis	Monitoring Frequency	Guideline Value
pH	Weekly	6.5 – 8.5
TDS	Weekly	1000.00
Trubidity (NTU)	Weekly	5.00
Colour	Weekly	15.00
Fecal Coliform/ 100ml	Weekly	0.000
E. Coli /100ml	Weekly	0.000
Iron	Monthly	0.30
Manganese	Monthly	0.30
Sulphate	Monthly	400.00
Nitrate	Monthly	10.0
Lead	Monthly	0.050
Mercury	Monthly	0.001
Zinc	Monthly	5.000

9.2.2 Effluent Monitoring

Samples for effluent discharge should be collected from outlet of effluent pond as well as the effluent pond itself (**Figure 6-13**). The sampling frequency as indicated in Table 9-3 should be on a weekly basis; however, this frequency can be on a monthly basis if a water treatment plant is installed to treat the effluent discharge. Process discharge should not be diluted prior to treatment with the objective of meeting the discharge or water quality standards. Moreover, the sampling method should be conducted by entities permitted or certified for this purpose. Sampling and analysis Quality Assurance/Quality Control (QA/QC) plans should be prepared and implemented. QA/QC documentation should be included in monitoring plan.

Table 9-3: Parameters to be monitored in effluent pond and effluent discharge.

Parameter	Maximum value milligrams per liter (mg/L)	Frequency
pH	6-9	Weekly
BOD ₅	50	Weekly
Chemical Oxidation Demand (COD)	250	Weekly
Total Suspended Solids (TSS)	50	Weekly
Oil and Grease	10	Weekly
Ammonia nitrogen (NH ₄ -N)	10	Weekly
Phosphorous (P)	5	Weekly
Temperature increase	Less than or equal to 3°C ¹¹	Weekly

9.2.3 Air Quality Monitoring

During operation, air quality should be monitored in terms of PM-10, VOCs, CO, SO₂ and NO₂. Air quality standards set by WHO and USEPA can be adopted since local standards are not available. Table 9-4 can be adopted for atmospheric pollutants. The 1-hr and 24-hr Total Suspended Particles (TSP) / PM-10 levels should be measured to delineate the temporary impact of construction dust. Both

¹¹ The effluent should result in a temperature increase of no more than 3 degrees Celsius at the edge of the zone where initial mixing and dilution takes place. Where the zone is not defined, use 100 meters from point of discharge.

measurements should be conducted by drawing air through a high volume sampler fitted with a conditioned pre-weighed filtered paper, at a controlled rate. After sampling for 1 hour (or 24 hours), the filter paper with retained particles is collected and returned to a laboratory for drying in an oven at 110 °C followed by accurate weighing. The average TSP/Pm-10 level is calculated from the ratio of mass of the particulates retained on the filter paper to the total volume of the air sampled. When positioning the sampler, the following points should be noted:

- A horizontal platform with appropriate support should be provided to secure the samples against gusty winds; airflow around the sampler should be unrestricted (a portable high-volume sampler can also be used).
- Any wire fence or gate to protect the sampler should not obstruct airflow.
- The distance between the sampler and an obstacle (i.e. building) should be at least twice the height that of the obstacle protrudes above the sampler.
- No furnace or generator should be nearby.
- A secured supply of electricity is needed to operate the sampler.

An alternative means of measuring 1-hr averaged TSP/PM-10 concentrations is through a hand-held particle counter (capable of sampling in the range of 0.1-100 mg/m³). This method does not require laboratory analysis and gives instant TSP/PM-10 readings. Air samplers are drawn for a period of one hour and the device provides the time-averaged TSP/PM-10 level. Calibration of the monitoring equipment should be conducted prior to implementation of the monitoring program and as specified by manufacturer.

Table 9-4: Standards for atmospheric pollutants and monitoring frequency.

Pollutant	USEPA (µg/m ³)	Averaging Time	Frequency	Location
Total Suspended Solids (TSS)	120	24 hours	Monthly	• Grain storage warehouse

Suspended Particulates PM < 10 microns (PM₁₀)	150 50	24 hrs 1 year	Monthly	• mill
--	-----------	------------------	---------	--------

In addition, monitoring of emissions generated from on-site machinery and generators should be conducted in terms of VOC, CO, SO₂, and NO₂ (Table 9-5). This monitoring can also be done by using portable gas analyzers. Most analyzers give instantaneous readings which are stored and averaged over the sampling period. When positioning the sampler, the following points should be noted:

- Any wire fence or gate to protect the sampler should not obstruct airflow.
- No combustion source should be present in the vicinity of the sampling equipment.

Table 9-5: VOC, CO, SO₂, and NO_x monitoring scheme for SRC.

VOC	-	-	Monthly	• Rubber processing factory
CO	870	ppm	Monthly	• Rubber processing factory
SO ₂	500	ppm	Monthly	• Power Plants (both factory & plantation)
NO ₂	250	ppm	Monthly	• Power Plant (factory & Plantation)

9.2.4 Noise Level Monitoring

Noise monitoring should follow the monitoring process presented in Section 6.2.6, mainly during production, and at least once a month without production for comparison purposes. Four locations are recommended for this monitoring. These locations are indicated in Table 9-6 and are mainly focused in the factory, since the plantation is not expected to be a source of noise pollution.

Local guideline values for ambient noise are not set yet. Therefore, the values obtained during the monitoring process (Section 6.2.6) can be used as guideline values, because the analysis and interpretation of the obtained noise level at the various locations of SRC indicated acceptable levels except for the rubber processing plant and the power plant. Proper periodic maintenance and repair in these plants are strongly recommended in association with compulsory use of protective ear plugs by workers. The maintenance measures should be applied to maintain the obtained values and prevent the increase of noise levels in the future.

The guideline values indicated in Table 9-6 was based on the Leq values obtained during the monitoring process (Section 6.2.6).

Table 9-6: Noise Monitoring Scheme recommended for SRC.

<i>SAMPLING REFERENCE</i>	<i>SAMPLING LOCATION</i>	<i>BRIEF DESCRIPTION</i>	<i>GUIDELINE VALUES</i>	<i>FREQUENCY DURING PRODUCTION</i>
L1	MAIN ENTRANCE GATE (FACTORY)	DURING OPERATION; LOCATED FEW METRS FROM PROCESSING PLANT, AND ABOUT 50m FROM POWER PLANT.	<75.3	WEEKLY
L2	PROCESSING PLANT (FACTORY)	LOCATED BEHIND POWER PLANT. SEPARATED BY A CONCRETE WALL.	<84.7	WEEKLY
L3	POWER PLANT	MAJOR SOURCE OF HIGH NOISE LEVEL	<102.6	WEEKLY
L5	NEAREST RESIDENTIAL UNIT (OUTDOOR)	LOCATED 300M FROM FACTORY PLANT & 400M FROM POWER PLANT	<62.7	WEEKLY

9.2.5 Safety

The safety measures indicated in this section are to be applied both in the factory and the plantation. Operators and supervisors on-site have to provide and maintain safe systems of work to ensure the safety of their workers who could be affected by

the operational activities. The following monitoring scheme should be implemented by the environmental officer and Human Resource Department on a daily basis:

- Safety signs including signs of helmets, goggles, gloves, boots, masks, earphones, wet floor, etc. should be available at the different operating buildings.
- Signs prohibiting unauthorized entrances without the management's permission, and signs prohibiting gunning of engines and horn blowing should also be installed.
- Emergency exits should be available in each building.
- The workers should be aware of the use of fire extinguishers and should know all emergency exits.
- The workers should be aware of the location of emergency phone numbers and their use in case of accident.
- All vehicles must be provided with fire extinguishers and drivers should know how to use them.
- Vehicles maintenance should be regularly done to prevent risks of accidents. Lights, reflectors, brakes, horns should be revised.
- Provide workers with personal gas detectors.

In case of accident occurrence, a mechanism for proper reporting should be maintained. The description of the accident occurrence, duration for clearing the risk, and final conclusions should be written down. Proper corrective actions should be studied and implemented to reduce the probability of the accident re-occurrence.

Continuous awareness lectures are important to be given to all workers. This would help them know why safety measures should be taken and inform them on all safety

measures and their locations. Workers would know how to act faster in case of any accident occurrence.

9.3 RECORD KEEPING

Monitoring efforts would be in vain in the absence of an organized record keeping practice. It is the responsibility of the environmental officer and the SRC administration to ensure the development of a database that includes a systematic tabulation of process indicators, performed computations, maintenance schedules and logbook, and process control and performance monitoring outcomes. Such a historical database benefits both the plant operator and design engineers.

Such database can also be used to assess the effectiveness of the mitigation measures and to correct or to update these whenever necessary to maintain lowest negative impacts of the SRC.

9.4 CAPACITY BUILDING

Considered as corner stone of the EMP, the capacity-building program consists of Specialized Training Workshops (STW). SRC's management has already funded two of its environmental officers to attend a workshop organized by the EPA. These individuals have been certified by the EPA as Counter Part Evaluators.

9.4.1 Specialized Training Workshops

STWs consist of a combination of theoretical lectures, focused training sessions, and field demonstrations that are believed to maximize workshop impacts. A highly technical training manual could be distributed to the participants to serve as a basis for future reference and application of proper environmental guidelines. In addition to safety and health issues, the manual should provide the trained staff with remedies for potential problems that could be encountered during operation.

10 CONCLUSIONS AND RECOMMENDATIONS

REFERENCES

References

- ATSDR. (2002). *Sodium Hydroxide*. Available from:
www.atsdr.cdc.gov/substances/sodium_hydroxide/ [September 12, 2008]
- Cox, C. (2000). *Herbicide Factsheet: Triclopyr*. Journal of Pesticide Reform 20. (4): pp 12-19.
Available from: <http://www.pesticide.org/triclopyr.pdf> [September 12, 2008]
- FAO. (2007). *FAO Specifications and evaluations for Agricultural Pesticides*. Available from:
www.fao.org/ag/AGP/AGPP/Pesticid/Specs/docs/Pdf/new/metazach.pdf [September 12, 2008]
- Department of Industrial Works. (2001). *Industrial Sector Code of Practice for Pollution Prevention (Cleaner Technology)*. Available from:
php.diw.go.th/ctu/pdf/codeofpractice_rubber_en.pdf [September 12, 2008]
- Department of Primary Industry. (2008). *Soil Acidification*. Available from:
<http://www.dpi.vic.gov.au/DPI/nrenfa.nsf/childdocs/-80E62E2EAB672EE24A256B520005A0AF-7C866D87F6E182014A256B52000B09C0?open> [September 12, 2008]
- Gouyon, A. (2003). *Eco-certification as an Incentive to Conserve Biodiversity in Rubber Smallholder Agroforestry System: A Preliminary Study*. World Agroforestry Center.
Available from:
www.worldagroforestry.org/Sea/Networks/RUPES/download/paper/AGouyon_Eco-certification.pdf [September 12, 2008]
- International Rubber Research and Development Board. *Rubber based farming systems development for increasing smallholders' income in Indonesia*. Available from:
<http://www.irrdb.com/default.asp> [September 12, 2008]
- ILO. *International Program on Chemical safety*. Available from:
www.itcilo.it/english/actrav/telearn/osh/kemi/pest/pesti2.htm [September 12, 2008]
- OSHA. *Occupational Safety and Health Guideline for Formic Acid*. Available from:
<http://www.osha.gov/index.html> [September 12, 2008]
- PAN Pesticide Database. (2008). *Mancozeb*. Available from:
http://www.pesticideinfo.org/Detail_Chemical.jsp?Rec_Id=PC35080 [September 12, 2008]
- Pesticides News. (1996). *Glyphosate Fact Sheet*. Pesticides News (33): pp28-29. Available from:
www.pan-uk.org/pestnews/Actives/glyphosa.htm [September 12, 2008]
- Pesticides News. (2002). *Carbendazim Fact Sheet*. Pesticides (57): pp 20-21. Available from:
www.pan-uk.org/pestnews/Actives/Carbenda.htm [September 12, 2008]

Pidwirny, M. (2006). *Fundamentals of Physical Geography, 2nd Edition*. Available from: <http://www.physicalgeography.net/fundamentals/9s.html> [September 12, 2008]

Sonetra, S. (2002). *Masters Thesis: Rubber factory waste water as fertilizer for forage cassava and water spinach*. University of Tropical Agriculture Foundation, Cambodia. Available from: <http://www.utafoundation.org/utacambod/msc99thes/sonecont.htm> [September 12, 2008]

UNCTAD/IRSG. (1997). *Opportunities and Constraints for the Internalization of Environmental Costs and Benefits into the Price of Rubber*. Available from: www.unctad.org/trade_env/docs/manch-ws.pdf [September 12, 2008]

US EPA, 1997. *Technical Guidance Manual for Performing Wasteload Allocations, Book II: Streams and Rivers – Part 1: Biochemical Oxygen Demand/Dissolved Oxygen and Nutrients/Eutrophication*. Available from: www.epa.gov/waterscience/models/library/npdeslowflow.pdf [September 12, 2008]

USEPA. (2005). *2,4-D RED Facts*. Available from: www.epa.gov/oppsrrd1/REDS/factsheets/24d_fs.htm [September 12, 2008]

USEPA. (2006). *Wetlands Definition*. Available from: <http://www.epa.gov/owow/wetlands/what/definitions.html> [September 12, 2008]

USEPA. (2008). *External Combustion Sources: Natural Gas Combustion*. Available from: www.epa.gov/ttn/chief/ap42/ch01/final/c01s04.pdf [September 12, 2008]

Washington State Department of Ecology. (2005). *Draft Human and Environmental Risk Assessment of Calcium Hydroxide*. Available from: http://www.ecy.wa.gov/programs/wq/pesticides/final_pesticide_permits/lakes/RISK%20ASSESSMENT%20OF%20CALCIUM%20HYDROXIDE.pdf [September 12, 2008]

WIPO. (2004). *The Use of Liquid Smoke for Natural Rubber Processing*. Available from: <http://www.wipo.int/pctdb/en/wo.jsp?IA=ID2002000004&DISPLAY=STATUS> [September 12, 2008]

World Bank. (2007). *Environmental, Health, and Safety Guidelines for Plantation Crop Production*. Available from: [http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_PlantationCropProd/\\$FILE/Final+-+Plantation+Crop+Production.pdf](http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_PlantationCropProd/$FILE/Final+-+Plantation+Crop+Production.pdf) [September 12, 2008]

World Bank. (2007). *Environmental, Health, and Safety Guidelines for Metal, Plastic, and Rubber Products Manufacturing*. Available from: [www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui.../\\$FILE/Final+-+Metal,+Plastic,+and+Rubber+Products+Mnfg.pdf](http://www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/gui.../$FILE/Final+-+Metal,+Plastic,+and+Rubber+Products+Mnfg.pdf) [September 12, 2008]

Wouapi, N., Maimo, T. V. (2007). *A Master Thesis Project: Towards a Comprehensive Analysis of Cleaner Technology Potentials to Address Industrial Pollution Arising from Natural Rubber Processing Industry: A Case Study of Cameroon Development Corporation - Rubber Factories*. Roskilde University, Denmark. [Online]. Available from: <http://diggy.ruc.dk/handle/1800/2775> [September 12, 2008]

Zhang, H., Zhang, G. L. (2005). *Landscape-scale soil quality change under different farming systems of a tropical farm in Hainan, China*. *Soil Use and Management* 21. pp 58–64. Available from: cat.inist.fr/?aModele=afficheN&cpsidt=16800024 [September 12, 2008]

Zhang, H., Zhang, G. L., Zhao, Y. G, Zhao, W. J., Qi, Z. P. (2006). *Chemical degradation of a Ferralsol (Oxisol) under intensive rubber (Hevea brasiliensis) farming in tropical China*. *Soil and Tillage Research* 93 (1): pp 109-116. Available from: cat.inist.fr/?aModele=afficheN&cpsidt=18464598 [September 12, 2008]