Promotion of BAT / BEP to reduce releases of uPOPs from open burning of waste in Madagascar

NATIONAL INVENTORIES OF WASTE OPEN BURNING PRACTICES SITES AND uPOPS RELEASE

December 2017

ABREVIATIONS

AFD	:	Agence Française de Développement
COI	:	Commission de l'Océan Indien
DASRI	:	Déchets d'Activités de Soins à Risques Infectieux
DGF/SRRLF	:	Direction Générale des Forêts/Service Reboisement Reforestation et Lutte contre les feux
FIVMPAMA	:	Fivondronan'ny Mpandraharaha Malagasy
GEM	:	Groupement des Entreprises à Madagascar
HDPE	:	High Density Polyethylen (Polyéthylène Haute Densité)
INSTAT	:	Institut National de la Statistique de Madagascar
LDPE	:	Low Density Polyethylen (Polyéthylène Basse Densité)
OMS	:	Organisation Mondiale de la Santé
PET	:	Polyéthylène Terephtalate
PNUD	:	Programme des Nations Unies pour le Développement
POP	:	Polluants Organiques Persistants
PP	:	Polypropylène
SIM	:	Syndicats des Industries de Madagascar
SMTP	:	Société Malgache de Transformation des Plastiques
SPAH	:	Société Malgaches de production d'Articles Hygiéniques

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 Context andjustification

As part of the Stockholm Convention on Persistent Organic Pollutants ratified by Madagascar in August 2005, Parties are required to take the necessary measures to reduce or eliminate releases of POPs covered by the Convention, namely, inter alia:

- measures to reduce or eliminate releases from intentional production and use;
- measures to reduce or eliminate releases from unintentional production;
- measures to reduce or eliminate releases from stockage and wastes.

In Madagascar, the implementation of integrated waste management practices including: reduction and separation (sorting) at source, reuse, treatments such as recycling, recovery, composting before landfilling of waste ultimate, is still only in its phase of experimentation at the country level. There are very few waste treatment facilities, such as incinerators that meet standards or sanitary landfills, and recycling activities are only at beginning stage.

As a result, municipal waste and other types of waste are typically dumped in open dumps and eliminate by open burning. In urban areas, waste is mainly composed of food waste, packaging (bottles, plastic bags, etc.) and hazardous waste (such as batteries and electronic devices), whereas in rural areas, agricultural waste predominates. In addition, hazardous waste is often diverted for purposes other than final disposal and discarded with other wastes

With regard to health care waste, their management from collection to disposal is generally correct in large hospitals with the necessary structures and infrastructure. On the other hand, in small health facilities (CSB, private clinics), especially in rural areas, waste is often not properly collected for disposal in appropriate infrastructure and is instead found in municipal waste

In addition, new types of waste appear like electrical and electronic waste. It is recognized that poorly managed mixed materials in the presence of chlorinated precursors and catalytic metals (copper, iron) are the main factors in the formation and release of uPOPs in open burning processes.

Therefore, as long as the open burning of mixed waste and agricultural residues is not properly addressed, the releases of unintentionally produced POPs would increase significantly in the future if adequate measures are not taken.

The regional project "Promoting BAT / BEP to reduce uPOPs releases from open burning of waste in participating SADC African countries" has its overall objective to significantly and sustainably reduce the releases of uPOPs in the combustion sector open waste by improving guidelines on Best Available Techniques and Best Environmental Practices (BAT / BEP) for open burning processes of waste and biomass.

The specific objective of the project is to achieve a continuous reduction of uPOP releases in the open burning waste sector in participating African countries in the SADC region by introducing best available techniques and best environmental practices (BAT / BEP) on certain priority demonstration sites.

In accordance with Article 5 of the Stockholm Convention on Persistent Organic Pollutants, the "Party" Countries must take measures to reduce the total volume of anthropogenic releases of unintentionally produced POPs, which is reflected in the implementation of a national or regional action plan to characterize and manage the uPOPs' releases.

The expected results of component 1 of the project are the updating of regional information on open burning practices and inventory of uPOPs in this sector.

For Madagascar to have this information, the identification of dumping sites and their management as well as the quantification of dioxin and furan releases must be made.

The objective of the inventory is to have all the information on municipal waste disposal sites, how they are managed, and the quantification of dioxin and furan emissions in this sector using the new UNEP Toolkit.

To do this, the consultant is asked to:

- Conduct national inventories of landfill sites and other relevant hot spots. : map, GPS coordinates;
- Provide information on the quantities of daily or monthly waste
- Identify the methods of waste management;
- Collect existing data on waste recycling into biomass and disposal and waste recycling companies;
- Update the results of dioxins and furans;
- Compile the information obtained in a report;
- Present the results of the study at the validation workshop;

2 Methodological approach

To carry out the various activities entrusted to the mandatary, the following procedure is adopted:

- Field visit to collect information relating to landfills: GPS coordinates of the landfill site, estimation of the area occupied, mode of waste management, particularly burning. In addition, those responsible for waste management at the local level (Urban District or Rural District) are contacted to have the quantity of waste produced and collected;
- Synthesis of the information collected in an excel file and processing in a cartographic database using a Geographical Information System taking into account the location, the surface of the landfill, the quantity of waste and the management mode in order to generate the maps landfills;
- Database consultation:

On the one hand, that of INSTAT, the official body responsible for registering companies at the time of their creation in order to identify companies whose activities are recycling and secondly, the other databases (Table Environmental Board, National Profile of Chemicals Management, National POPs Profile, ...) to provide information on waste management; other open burning activities (forest fires, ...)

- Contact and interview with the people in charge of the recycling process at the company level to determine the situation of the recycling industry and the related market. In the same way as for companies, people with information relating to other open burning activities are met: ministerial departments, municipalities, associations, etc.
- Compilation and synthesis of all information collected;
- Updating of the dioxins and furans inventory through the exploitation of collected data and using the latest version of the UNEP Toolkit to calculate the emissions of the different subcategories: biomass combustion and waste burning.

3 Inventory of landfills and other relevant hot spots

3.1 Situation of waste management in Madagascar

3.1.1 Texts regulating waste management

Apart from the various conventions that are ratified by Madagascar, such as the Basel Convention on the Transboundary Movement of Hazardous Wastes, the texts regulating waste management are presented in the table below:

Table 3-1 Summary of texts regulating waste management

Types	Contents
DECREE N ° 2012-753 of 07/08/12	Ban on waste under the Basel Convention in Madagascar until the installation of a suitable treatment center
DECREE N°2012-754 of 07/08/12	End-of-Life Products, Waste Sources and Hazardous Waste Management Procedures for the Implementation of the Basel Convention
DECREE N°2012-900 of 23 /01/13	Prohibiting the importation, distribution, sale, use and production of pesticides active ingredients of pesticides in agriculture and of chemicals for industries in the framework of the application of the Rotterdam Convention and the Convention of Stockholm in Madagascar
DECREE N°2014 – 1587 of 07/10/2014,	Prohibiting the production, importation, marketing and use of plastic bags on the Malagasy national territory
DECREE N° 2015- 930	Classification and environmentally sound management of waste electrical and electronic equipment in Madagascar

Types	Contents
DECREE N° 2017-010	Prohibiting the production, importation, marketing, stockpiling and use of plastic bags and bags made with plastics on the national territory

3.1.2 Management Infrastructures:

With the exception of a few sites (Taolagnaro, Fianarantsoa, Mahajanga, Nosy Be) with sanitary or controlled landfills, these waste management infrastructures are lacking in the other localities. The waste is deposited in wild dumps, which are for the most part "official dumps" for the districts.

However, some waste recovery and site development initiatives exist at the level of the projects of some NGOs and Associations (Fakofia, Madacompost ...) intervening in some cities (Mahajanga, Fianarantsoa, Toliara ...)

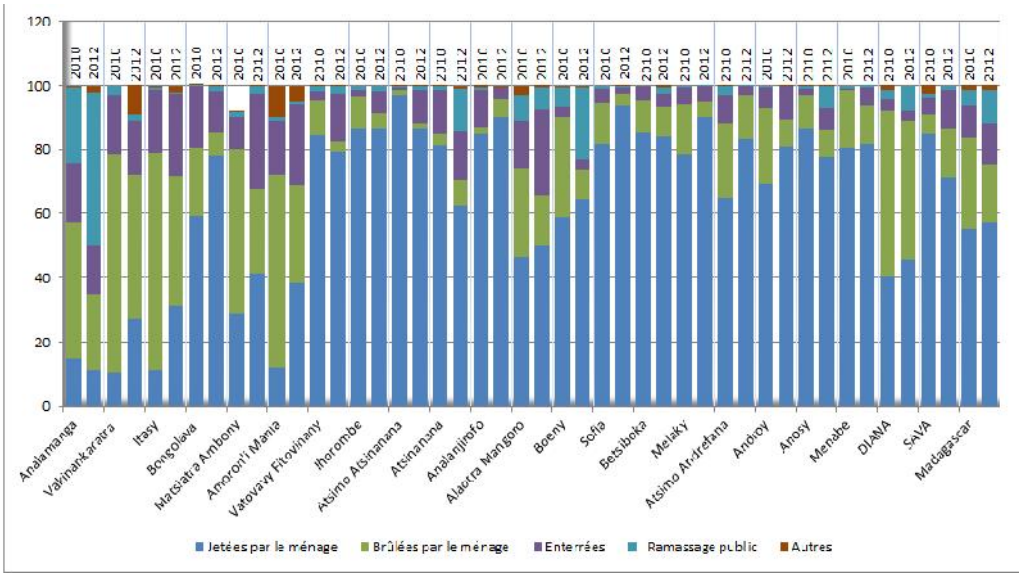
3.1.3 Waste production

As mentioned in the context, the integrated waste management system including: reduction and separation (sorting) at source, reuse, treatments such as recycling, recovery, composting before landfilling waste ultimate, is still only in its phase of experimentation at the country level. Only a few projects or associations working in waste management are developing this type of initiative. In addition, the structures and infrastructures necessary for the implementation of a selective sorting system, which is the basis of any recycling and recovery process, are poor.

A survey conducted by INSTAT on household behavior shows that sorting is not yet part of their habits because a large part is thrown away without any form of selection / separation (see figure 3.1).

In addition, Hery Rajaomanana's estimate of the amount of household waste produced by the main town in his thesis has shown that around 7840 tonnes of waste per day will be produced in the major cities of Madagascar in 2018 (see Table 3.2).

Figure 3-1Household Survey of 2010-2012



Source: INSTAT /DMS/EMP 2010 ET INSTAT /ENSOMD 2012-2013

Table3-1Estimation of the production of household waste by Chef lieu de Région

	Estimation of the production of household waste by Chef lieu de Région (Kg/city/day)						
	1993	**2000**	**2003**	**2008**	**2013**	**2018**	**2023**
Antananarivo-Renivohitra	426 142	526 601	575 357	661 851	756 562	860 713	973 192
ANTSIRABE I	75637	93468	102122	117474	134285	152771	172735
TSIROANOMANDIDY	102 186	126 276	137 967	158 708	181 419	206 394	233 365
MIARINARIVO	85 477	105 628	115 408	132 757	151 754	172 645	195 207
Fianarantsoa I	65 556	1 952 925	2 163 782	2 553 600	2 999 458	3 508 525	4 076 400
AMBOSITRA	104 146	132 924	147 276	173 808	204 155	238 804	277 456
TOAMASINA I	82 669	104 055	114 625	133 980	156 071	181 004	208 427

	Estimation of the production of household waste by Chef lieu de Région (Kg/city/day)						
	1993	**2000**	**2003**	**2008**	**2013**	**2018**	**2023**
FENOARIVO-ATSINANANA	111 088	139 826	154 029	180 038	209 724	243 227	280 078
AMBATONDRAZAKA	110 870	139 552	153 727	179 685	209 313	242 750	279 529
Mahajanga I	64 068	79 011	86 414	100 177	115 918	133 391	152 237
Maevatanana	50 355	62 100	67 918	78 735	91 107	104 840	119 653
Maintirano	24 889	30 694	33 569	38 916	45 031	51 819	59 140
TOLIARY I	48 496	59 276	64 620	74 442	85 498	97 657	110 746
MORONDAVA	38 442	46 988	51 224	59 009	67 773	77 412	87 788
TAOLANARO	101 737	124 353	135 563	156 168	179 361	204 869	232 330
ANTSIRANANA	572 839	693 880	753 772	864 000	986 727	1 119 585	1 260 600
ANTALAHA	89 810	108 787	118 177	135 459	154 700	175 530	197 638
ANTSIRANANA I	35 424	42 909	46 613	53 429	61 019	69 234	77 955
TOTAL	**2 189 831**	**4 569 253**	**5 022 163**	**5 852 236**	**6 789 875**	**7 841 170**	**8 994 476**

Source :INSTAT, RAJAOMANANA H – Gestion et traitement des déchets ménagers dans les pays en voie de développement. Thèse : Sciences et techniques (pollution)- Traitement : ONE

The IOC and AFD diagnostic study for optimized waste management in the Indian Ocean conducted in 2013 and 2014 presents in its session 1 the state of waste production and management in the member countries. (Comoros,Reunion, Madagascar, Mauritius and Seychelles).

For Madagascar, the production of hazardous waste and that of recoverable waste are presented in the tables below:

Table3-2Estimated annual production of recoverable waste in Madagascar

TYPES	QUANTITY (Tons)
Paper - Carton	89 681
Metals	13 797
Plastics	68 985
Tires	666

Source : Étude de diagnostic pour une gestion optimisée des déchets dans l'Océan Indien (COI/AFD-Décembre 2014)

The parts of recoverable waste are presented in the table below:

Table3-3Ratio of recoverable materials in household waste

Organic Matter	60%
Plastics	10%
Papers /Cartons	13%
Metals	2%
Glasses	4%
Others	11%

Source : Étude de diagnostic pour une gestion optimisée des déchets dans l'Océan Indien (COI/AFD-Décembre 2014

Table3-4Estimation of the main types of hazardous waste in Madagascar

TYPES	QUANTITY (Tonnes)
Batteries and accumulators	4 940
Lamp, neon	1 000
Used mineral oils	6 906
Car batteries	3 039
Refrigerants	524
DASRI	1 594

Source : Étude de diagnostic pour une gestion optimisée des déchets dans l'Océan Indien (COI/AFD-Décembre 2014)

Note that the capacity of collection and treatment of this waste is rather weak for the country. For example, for used oils, approximately 19% of the quantity produced is collected and processed, that is 1,322 T per year.

3.2 Landfills and mode of management

The field investigation provided information on the sites visited: location, GPS points, area, quantity of waste sent to landfill, the percentage of waste burned, the existence of development and the activities that are carried out (see Annex 2 - Summary of the results of the field trips).

The tables below summarize the different situations of landfills:

Table3-5Situation of dumpsites at ANTANANARIVO and its surroundings

ANTANANARIVO and ITS SURROUNDINGS					
Localisation	**Surface (estimation)**	**Quantity (estimation)**	**% burned**	**Laying out**	**Activities**
TONGARIVO	486	16 T/day	6%	None	Sorting by the scavengers
ALASORA	13 200	5 T/day	25%	None	Sorting by the scavengers
ANDRALANITRA	180 000	1500 - 2000 m3/day	10%	Fenced Leachate drainage	Sorting by the scavengers Composting
ANTEHIROKA : Andramiarana	2 400	23 m3/day	20%	None	Sorting by the scavengers
TALATAMATY : Andramiarana	2 400	18 T/day	20%	None	Sorting by the scavengers
IVATO	800 m2 (site 1) 2637 m2 (site 2)	10 T/day	15%	None	

TONGARIVO TANJOMBATO

ALASORA

ANDRALANITRA

IVATO

ANDRAMIARANA : TALATAMATY and AMBOHIBAO ANTEHIROKA

Table3-6Situation of dumpsite at ANTSIRANANA

ANTSIRANANA					
Localisation	**Surface (estimation)**	**Quantity (estimation)**	**% burned**	**Laying out**	**Activités**
Route d'Anamakia	8 370	70 T/day	100%	None	

DUMPSITE ALONG THE ANAMAKIA ROAD

Table3-7Landfill situation in the Vakinankaratra region

VAKINANKARATRA					
Localisation	**Surface (estimation)**	**Quantity (estimation)**	**% burned**	**Laying out**	**Activités**
AMBATOLAMPY : Marché	12	0,5 T/day	10%	None	
AMBATOLAMPY: Malamamaina	16			None	
Antsirabe : Ivohitra	1 377	60 T/day	80%	None	Sorting by the scavengers Composting

DUMPSITE OF THE CITY OF ANTSIRABE AT IVOHITRA

Table3-8Situation of dumpsites in Fianarantsoa and Ambositra

FIANARANTSOA					
Localisation	**Surface (estimation)**	**Quantity (estimation)**	**% burned**	**Laying out**	**Activities**
Maromby (Near Sœurs)	16 786	50 T/day	70%	None	
Maromby PK6	1 932	18,5 T/day	0,50%	Landfill cell Composting area	Sorting composting burying
AMBOSITRA					
Antsenan'omby - Ambohipierenana	652	18 m3/day	100%		



FIRST DUMPSITE AT MAROMBY (Near les Soeurs)



Sorting

Composting



Composting

Burying


SECOND LANDFILL AT MAROMBY MANAGED BY FAKOFIA

Tableau 3-9Status of dumpsite in TOLIARA

TOLIARA					
Localisation	**Surface (estimation)**	**Quantity (estimation)**	**% burned**	**Laying out**	**Activities**
Anjoriha	50 000 m2	37 T/j		Landfill cell Composting area Impoundment	Sorting Composting
RN 9	1000 m2		25%	Non	Sorting by the scavengers

FIRST DUMPSITE ABANDONED ALONG RN9

SECOND LANDFILL AT ANJORIHA MANAGED BY MADACOMPOST

Table3-10Location of the landfill at TAOLAGNARO

TAOLAGNARO					
Ankarefo	10 000 m2	ND	0%	Controlled discharge Recovery and leachate treatment	Sorting Composing

ANKAREFO: LANDFILL CELL

ANKAREFO: LEACHATE TREATMENT BASIN

ANKAREFO: COMPOSTING PLATFORM

The visits to the various landfill sites revealed the following main points:

- The vast majority of landfills have not been developed. The waste is deposited on the ground;
- Only a few sites (Fianarantsoa, Toliara, Taolagnaro) have been developed to meet the technical standards of sanitary landfills: geotextile / geo-membrane layer cell, leachate recovery system, leachate treatment, evacuation of gases, control the quality of groundwater...
- The mode of treatment including burning varies from one site to another. Burning decreases when the site has a sorting system for composting: the case of Fianarantsoa, Toliara, Taolagnaro. It is between 0 and 100% and the average of the different rates is about 32%;
- The BAT / BEP used at the site level is composting.

3.3 Landfill mapping

The information collected during field study is processed in a map database and is presented as a form of:

- Maps of landfill sites at the national level showing occupied areas and burn rate (see Figures 3.2 to 3.5);
- site maps at the regional level;

Figure 3-2Map at national-level sites representing areas occupied by landfills

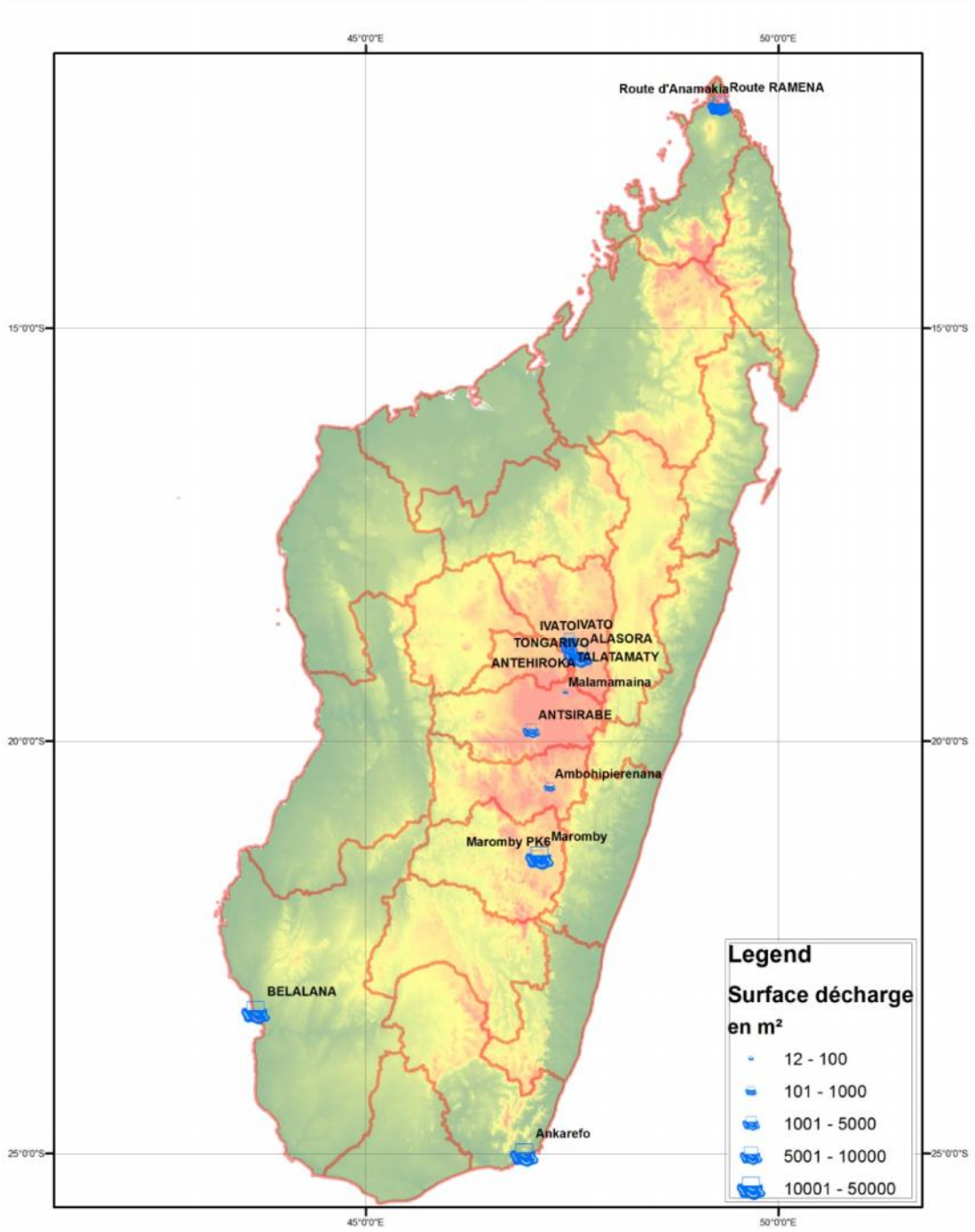


Figure 3-3Map of sites at the national level representing surface burn rates in landfills

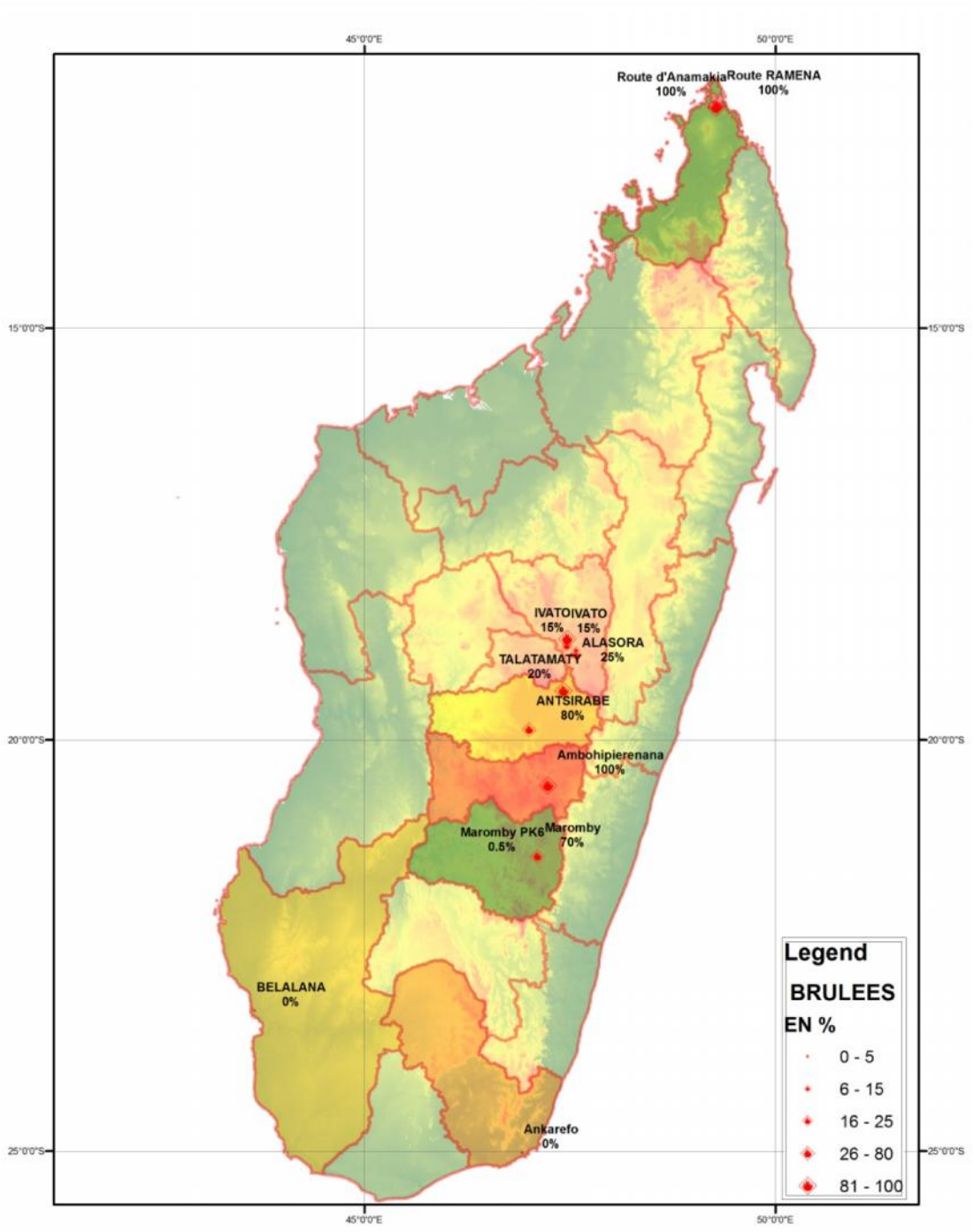


Figure 3-4Map showing landfills in Antananarivo and surroundings

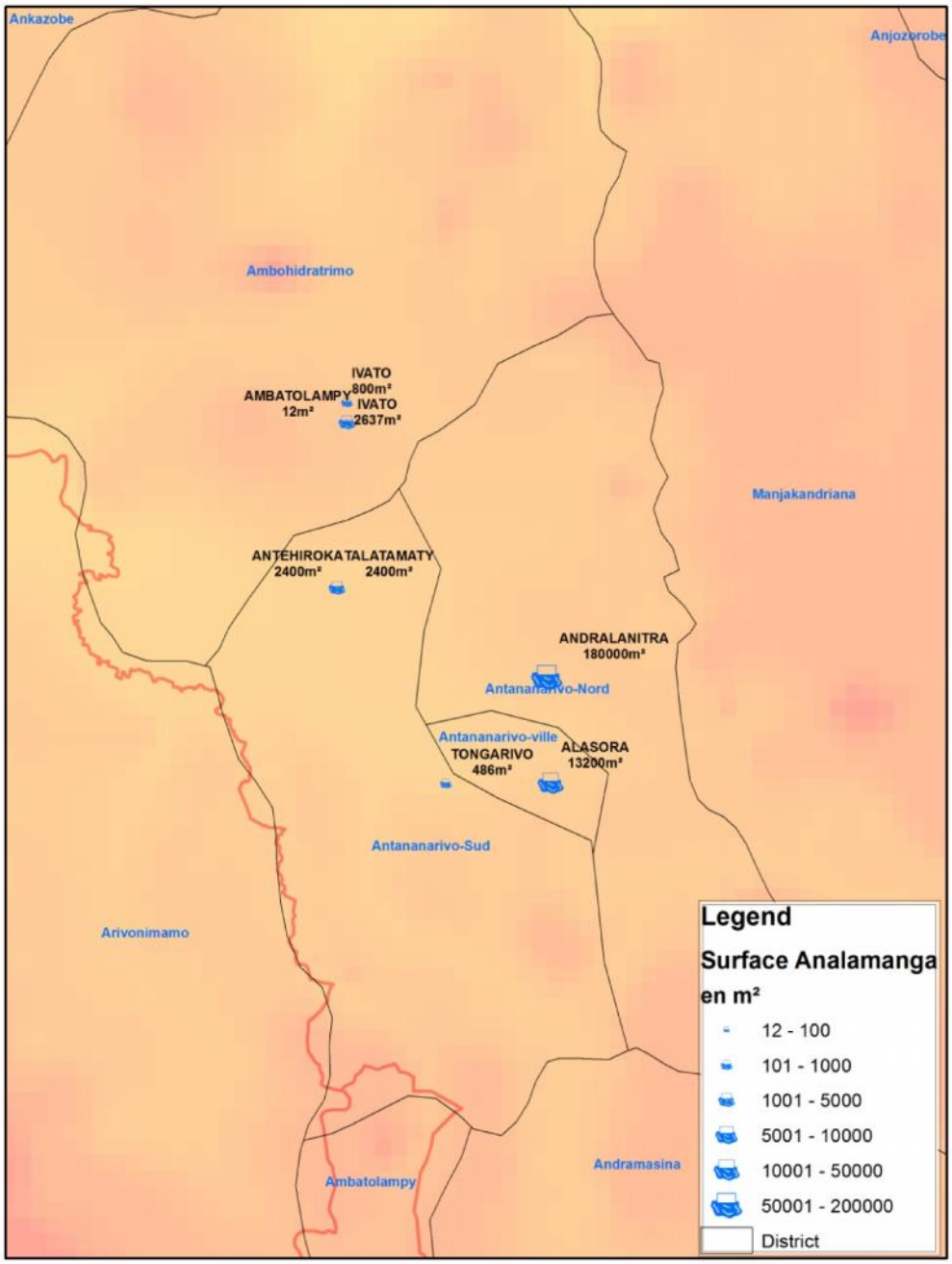
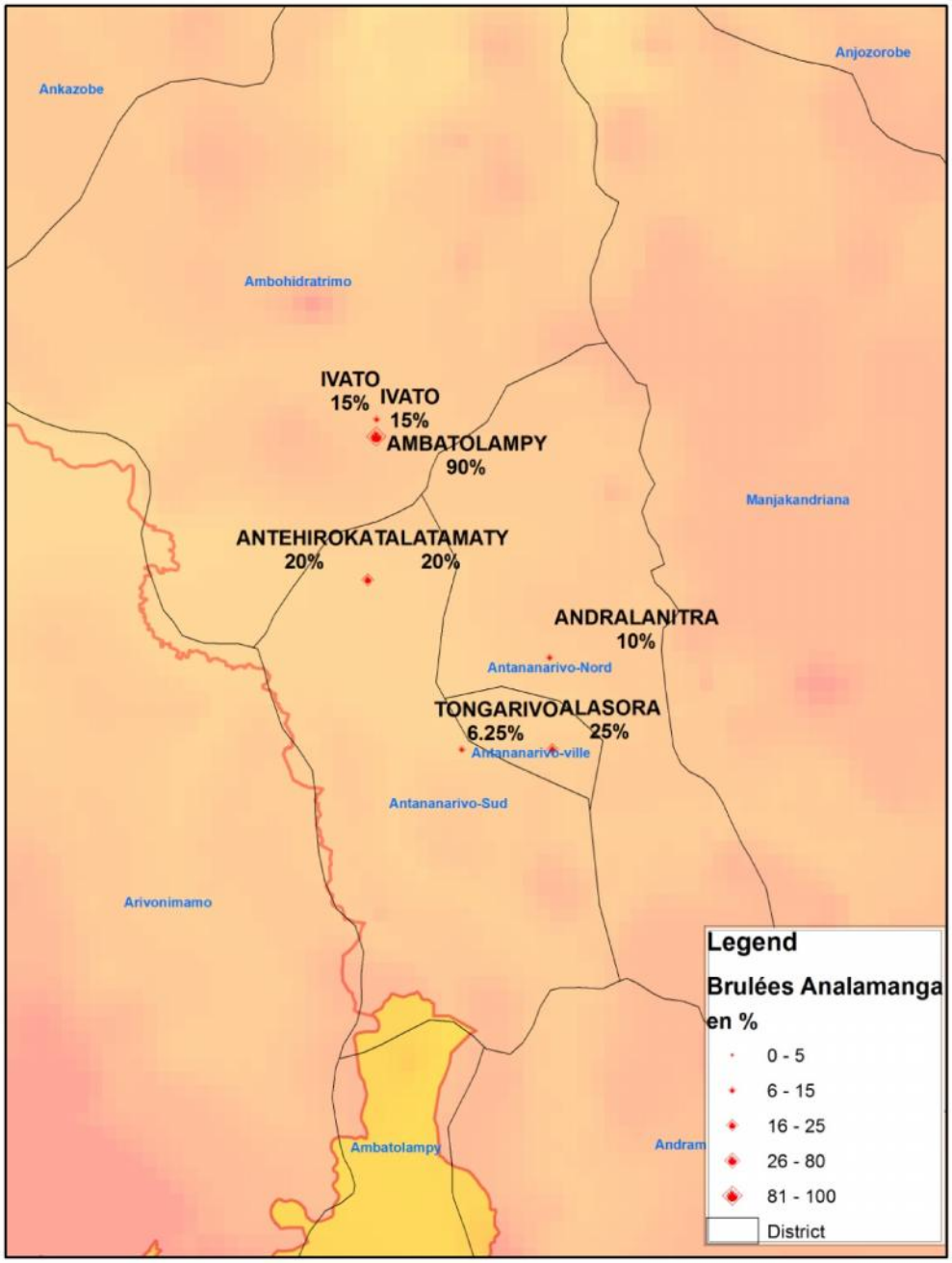


Figure 3-5Maps showing the burning of waste in landfills in and around Antananarivo



3.4 Inventory of other hot spots

Other hot spots that have been inventoried include bush fires that are divided into "Forest fires" and "non-forest", the burning of sugarcane during its production process including during the cutting.

3.4.1 Forest fires

Table 3.12 shows the situations of fire points and areas burned while Figure 3.5 shows the evolution of fire points from 2006 to 2016.

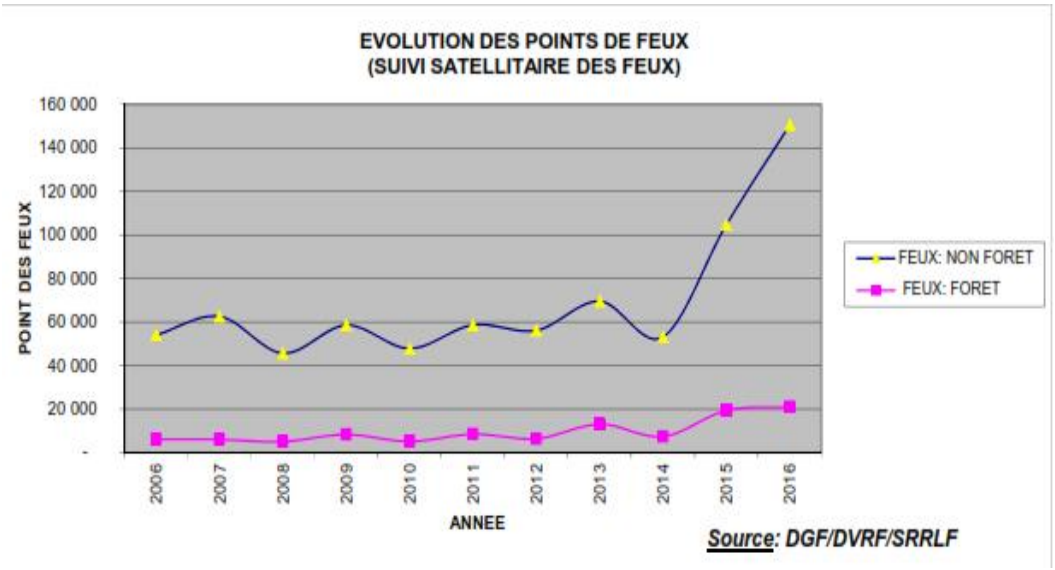
Table3-11Situations of fire points and area burned from 2006 to 2016

SITUATION DES POINTS DE FEUX ET SUPERFICIE INCENDIEE : ANNEE 2006 à 2016

	SUIVI SATELLITAIRE DES FEUX				
ANNEE	FEUX: FORET	FEUX: NON FORET	POINT DE FEUX	OBJECTIFS (< ha)	SUPERFICIE (Ha) BRULEE
2006	6 102	47 922	54 024	450 000	455 815
2007	5 970	56 597	62 567	400 000	318 091
2008	5 050	40 575	45 625	350 000	168 963
2009	8 274	50 275	58 549	300 000	322 791
2010	5 092	42 730	47 822	250 000	496 258
2011	8 472	50 189	58 661	200 000	188 500
2012	6 366	49 767	56 133	200 000	124 057
2013	12 998	56 560	69 558	200 000	126 021
2014	7 365	45 799	53 164	200 000	161 438
2015	19 331	85 468	104 799	200 000	189 327
2016	20 955	129 719	150 674	200 000	200 986

Source : DGF/DVRF/SRRLF

Figure 3-6 Evolution of fire points



ONE's National Environmental Scorecard states that areas burned at the national level include tanety, natural forests, reforestation forests and unauthorized clearings.

FAO in its Report "Global Forest Resources Assessment 2015" mentions the following points regarding forest fires:

- For the year 2012, the area burned is 124 000 ha and the forest area is 8 600 ha (see Table 3.12)

Tableau 3-12 Total area of land and forest burned from 2003 – 2012 in Madagascar

Années	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Terrains brûlés (x 1000 ha)	546	42	356	456	320	169	424	496	188	124
Forêts brûlées (x1000 ha)	24.0	7.0	38.7	9.8	10.0	4.0	52.8	10.5	0.8	8.6

(Source: Global Forest Resources Assessment 2015 – FAO)

For bushfires, note the following:

- Significant increase in fire points during the years 2015 and 2016. It could be related to several factors: climate (drought in some regions), political (manifestation of dissatisfaction), security (increased theft of cattle and creation of fire to eliminate traces);
- the fire points located in the forests tripled in 2015 compared to 2012;
- Tendency to increase the area burned since 2013;
- In 2015, the Global Forest Resources Asssessment mentions that the forest occupied 21.4% of the land

3.4.2 The treatment of sugar cane

In the process of treating sugar cane, two methods are used for cutting: a mechanized cut and a manual cut that requires burning of the cane stems. In Madagascar, only two sites (Ambilobe and Namakia) still apply this method. In order to be able to estimate the quantities burned, the tables below give the areas planted as well as cane production in tones at these two sites. Note that the burned parts represent about 10% of the cane.

Table3-13Surface planted with sugar cane at Ambilobe and Namakia

SURFACE PLANTEE DE CANNE A SUCRE EN HECTARE

ANNEE		2012/13	2013/14	2014/15
Ambilobe	Usine	5 576	5 677	4 495
	Planteurs	2 930	4 656	675
Namakia	Usine	2 697	2 575	2 584
	Planteurs	-	-	49
TOTAL		**11 203**	**12 908**	**7 802**

Source : Centre Malgache de la Canne et du Sucre

Table3-14Cane production in Ambilobe and Namakia

PRODUCTION DE CANNES EN TONNES

RUBRIQUES	2012/13	2013/14	2014/2015	2015/2016
Ambilobe usine	452 169,00	509 197,00	468 126,94	359 946,04
Ambilobe Planteurs	-	-	-	178 716,00
Namakia usine	168 854,93	182 971,00	189 692,00	195 528,00
Namakia Planteurs	-	-	-	6 526,00
Nosy be	-	-	-	-
Brickaville	-	-	-	-
Morondava	163 606,00	150 235,00	160 000,00	-
TOTAL			**817 818,94**	**740 716,04**

Source : Centre Malgache de la Canne et du Sucre

Photos showing the burnt parts of the cane before cutting

Photo showing the cane after burning

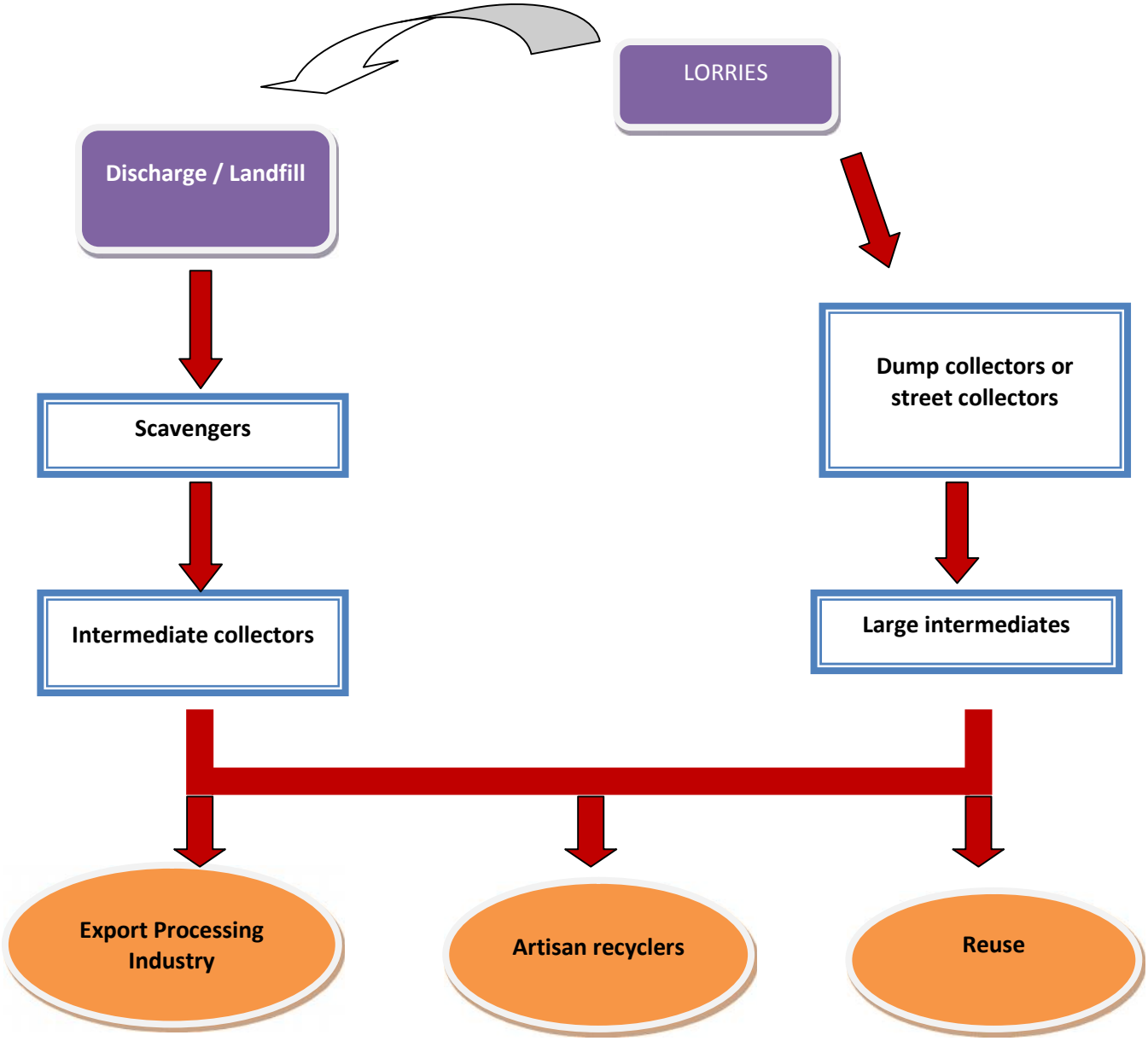
4 Situationof the recycling industry and market at national level

In Madagascar, the recycling industry is in its beginning. Very little formal value chain exists in Madagascar. In fact, apart from a few large industrial units located in the Analamanga region, small businesses or associations carry out recycling activities, which, for the most part, are not yet registered in the formal system.

4.1 Valorization of sector in Madagascar

As previously mentioned, there are few formal channels for upgrading and processing capacity. Much of the valuable waste is recovered by the informal sector. Informal workers are one of the main actors in the waste cycle in Madagascar. Figure 3.2 shows their place in the sorting recovery circuit and valorization.

Figure 4-1Informal workers in the recuperation of recoverable waste



To illustrate this description of the informal sector, two cases are presented below:

- Waste recovery case at the Andralanitra landfill

A survey carried out by Gevalor in 2012 at the Andralanitra landfill site, the main landfill site of the Urban Community of Antananarivo, the capital of Madagascar, gave the results presented in Table 4-1 for recycling and valorisation of waste:

Table4-1- Valorisation of waste at Andralanitra

Produits	Nb. de personnes adultes (*)	Quantité récupérée/j	Prix de vente	Devenir
Ferrailles	20 à 30	1,6 - 3 tonnes/j	350 - 400 MGA/kg	- Récupérées par la fonderie 3DMP à Ambohimanambola - Repris par des récupérateurs de la ville
Plastiques	16 à 20	200 - 400 kg/j	80 MGA/jour pour les bouteilles et 400 MGA/kg pour les autres plastiques	- Bouteilles et assiettes récupérées par des Chinois - Bouchons des bouteilles, cuvettes, seaux sont pris par les deux sociétés : SFOI ou Société de Fabrication de l'Océan Indien et la VITAPLAST
Os	6	150 kg/j	200 MGA/kg	Envoyés à Ambatolampy pour la fabrication de ranomena
Terreau	32	12t/j	20 MGA/kg	Utilisation pour le jardinage, le maraîchage et les pépinières
Bois	10	15 sacs de Charbons produits/semaine	430 MGA/kg	Transformés sur place en charbon
Charbon	15-20	8 sachets /j (environ 15 - 20 kg/j)	400 MGA/kg	Vendus localement aux Hôteliers à Ambohimangakely et Ikianja
Carton	15-20	125 kg/j	120 MGA/kg	Envoyés à une entreprise chinoise à Ivato pour transformation. Récupération uniquement en saison sèche

Source : *Gevalor, 2012*

Source : Tableau de Bord Environnemental – Enquête Gevalor 2012

Note that this recycled / valuable waste represents only a small part of the approximately 800 tons of waste collected per day in the city of Antananarivo, which themselves constitute for only about 37% of the waste generated by the population.

- *Case of recycling circuit of aluminum cans*

The cans are recovered either at the level of the Lorries or at the level of the dumpsites by the scavengers and the ambulant pickers. They are then brought back

to the intermediaries who deliver them to the recyclers' artisans for the manufacture of kitchenware (cooking pots ...) or works of art.

Kitchen articles and works of art made from aluminum

In addition to this informal sector of valorization of waste, one of the alternatives of some companies is the search for units outside the country to treat their waste, ie the export of recovered materials.

Regarding hazardous waste, apart from ADONIS Environnement, which recovers waste such as used oil, batteries, hospital waste, very few companies are involved in collecting this type of waste.

4.1.1 Recycling activities by industrial units

There are some industrial units whose main activity or part of their activities is recycling recyclable materials. Among those located in Antananarivo and its surroundings are:

- **The SMTP***(SociétéMalgache de Transformation des Plastiques)*

A forerunner in sustainable development, it has started recycling used plastics, especially low-density polyethylene (LDPE) purchased directly from local customers. This in a constant effort to fight against global warming. It produces, among other things, pits, tanks, food trays and pipes (HDPE, PPR).

- **TheSPAH** *(Société malgache de Production d'Articles Hygiéniques)*

SPAH collects and recycles paper waste into "toilet paper". It works with the Ministry of the Environment, Ecology and Forests for the collection and recycling of office waste. SPAH has been producing ecological products for five years.

Recyclage des déchets de papiers en tissus de papiers

- **ADONIS ENVIRONNEMENT**

ADONIS ENVIRONNEMENT deals with the treatment and recovery of hazardous waste such as hydrocarbons, filters, batteries and valuable materials such as plastics.

- **SACOPLAST**

Industrial unit whose main activity is the production and sale of plastic packaging can recycle LDPE, HDPE and PP.

- **VITAPLAST**

Company that manufactures plastic household items (buckets, cuvettes ...) has devoted part of its production process to the recycling of LDPE, HDPE, and PP.

In addition, some large companies have in their waste management system a recycling process of those they generate. Let us mention the case of NEWPACK, a company that manufactures cardboard packaging that recovers the drops of cardboard from their production and those of its customers to export them for recycling. The STAR, manufacturer of drinks, for its part, subcontracts with a cement plant for the recycling of glasses.

4.1.2 Some initiatives by some associations / projects:

- **FAKOFIA**

Company with Socioeconomic Goal (EBS) acting at the level of the city of Fianarantsoa, FAKOFIA takes care of the collection, sorting of organic waste, recoverable and ultimate. Organic waste will be composted while reusable waste (channels) made of plastics, metals, glass, rubber,.... are stored at the Sorting and Valorization Center in anticipation of a valuation process depending on the case (resale for the needs of local crafts: pots, watering cans, shoes or treatment at the national level). The ultimate waste will be landfilled on site.

FAKOFIA : Production de compost

FAKOFIA : Filière PET

FAKOFIA : Site d'enfouissement

- **MADACOMPOST**

In the city of Mahajanga, Madacompost, a local Malagasy company that has entered into a partnership with Gevalor, a French association specializing in the recovery of urban waste in the South, is composting the organic part of household waste that constitutes more than 70% of the total. Farmers use this compost as a natural fertilizer. In addition to compost production, other types of waste are also valued :

- Manufacture of interlocking tiles and bricks from plastic bags. As an indication, in 2014, 11 million of plastics bags were recycled (Source Madacompost),
- Use as a biological fertilizer the crushed zebus horns,
- Conversion of green and woody waste into fuel briquettes,

o **M'IHARISOA**

The M'Ihari-Soa association in Ambohidratrimo transforms PET bottles into interlocking tiles by mixing them with sand after melting them in an oven.

Transformation of PET bottles into interlocking tiles

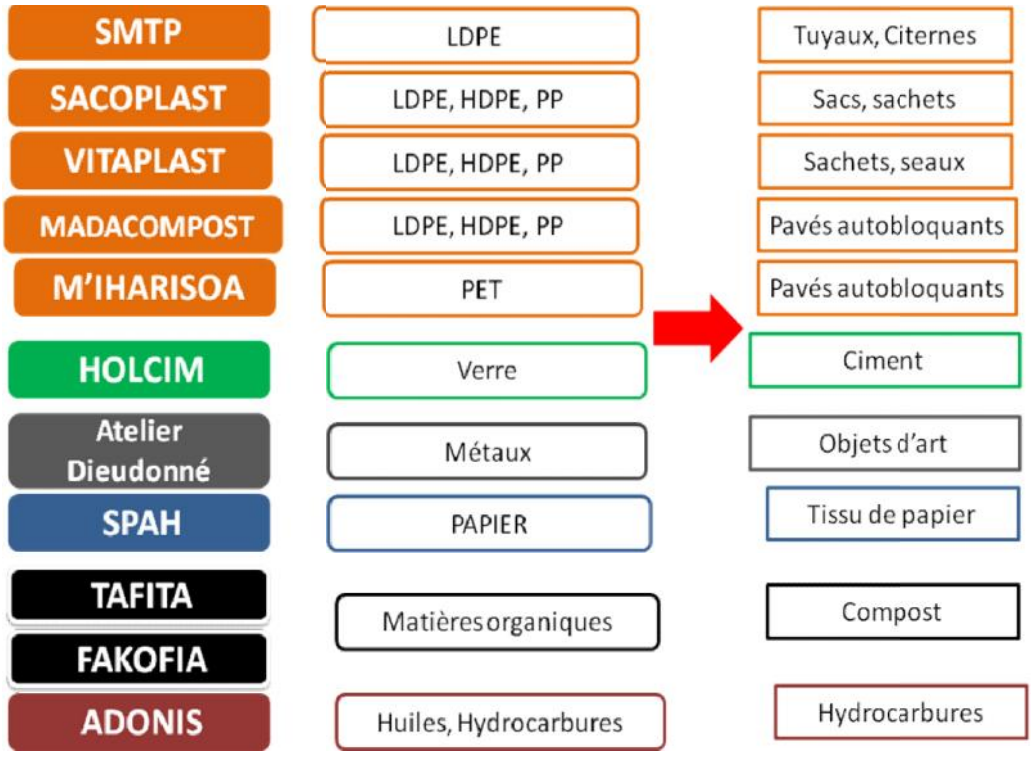
- **Association TAFITA**

As an association working in the collection and processing of organic waste in the community of Ambohimanambola, TAFITA deals with the sorting of waste and the composting of organic waste. Street pickers take up other types of waste such as plastics, cans, cartons.

Note also the existence of some initiatives that are still at the research or project stage. Among these, let us mention the transformation of this plastic waste in bricks as well as building tiles that do not deteriorate, carried out by two (2) researchers at the University of Diego.

The plastic waste collected is initially melted without emanating toxic smoke and mixed with sand, earth, rice bran and wooden sawdust among others to obtain a kind of tar that will be poured into specific molds, then cooled.
Figure 4.2 summarizes the existing recovery routes for waste in Madagascar

Figure 4-2Summary of value chains



4.2 Current market estimation for some sectors

An estimation of the current market for some sectors is made taking into account the data mentioned above. Table 3.4 summarizes this information and the evolution of this market:

Table4-2- Current market estimation for some sectors

SECTORS	TYPES	ESTIMATION	QUANTITY ESTIMATED (T/Yr)	
			2014 (a)	2018 (b)
PLASTICS	LDPE, HDPE	29%	20 000	82 940
	PP	18%	12 417	51 480
	PVC	12%	8 278	34 320
	PS	8%	5 518	22 880
	PET	7%	4 828	20 020
PAPER- CARTON	-	100%	89 000	371 800
METALS	Ferrous and non-ferrous	2% household waste	13 797	57 200
GLASS		ND	ND	ND
MINERAL OILS	-	20% collected	1 400	ND
ORGANIC MATERIALS	COMPOSTING	60% household waste	413 910	1 716 000

(a) Production de déchets estimée à 689 850 T

(b) Production de déchets estimée à 2 860 000 T

5 Update of the inventory of Dioxins and Furans

Recall that for emission sources in category 6 (Open Burning), the latest emissions estimate (2010) calculated with the new version of the Toolkit is shown in the table below:

Table5-1Estimated emissions of dioxins and furans in 2010

Emission Factor	Calculated by New version of Toolkit (g TEQ/ year)
	2010
Air	16.437
Water	ND
Land	2,868
Product	NA
Residue	NA
Total	**19.305**

(Source : Rapport d'inventaire des dix nouveaux POPs- Rapport de mise à jour des inventaires –MINENVF)

5.1 Estimation des émissions de dioxines et furannes par le brûlage de biomasse (6.a) pour l'année 2015

5.1.1 Forest fires

5.1.1.1 Activity rates

The data used to estimate activity rates are those presented in section 3.4.1. Given that until now the satellite monitoring system of fires does not allow to have directly burned surfaces but points of fire, an estimation of these surfaces is necessary by using the available data.

Remind the following points:

- The available data for forest fire in the FAO's Global Forest Resources Assessment 2015 concern 2012 : 124,000 ha burned and 8,600 ha burned forest;

- localized fire points in forest tripled in 2015 (19331) compared to 2012 (6366) (DGF / SRRLR)
- In 2015, the total area burned is 189,327 ha (DGF/SRRLR)
- In 2015, the forest occupied 21.4% of the land (Global Forest Resources Assessment)

In order to estimate the area of forest burned in 2015, the 2012 data could be taken as a reference.

The following hypotheses could be advanced in estimating the area burned in 2015:

- The 8600 ha of forest burned in 2012 are maintained in 2015,
- Considering that the fire points tripled in 2015, there is 65,327 ha increase between 2012 and 2015 (189,327 ha Vs 124,000 ha)
- Of these 65,327 ha, 21.4% could be occupied by forest which corresponds to 13,900 ha;
- The total area of burned forest could be estimated at around **22,500 ha**

In order to calculate the tdm / ha, these 22,500 ha of forests are mostly classified in "tertiary tropical forests" as mentioned in the last inventory. If we refer to the latest version of the Toolkit, the value is 32 tdm / ha. The 22 500 ha correspond to **720 000 T** of dry matter.

5.1.1.2 Estimation of emissions

If these values are reported in the Toolkit, forest fire emissions are presented in the table below:

Table 5-2- Estimation of emissions for forest fires

	Biomass burning	**Emission Factors (gTEQ/an)**				
		Air	**Water**	**Land**	**Product**	**Résidue**
	Forest fires	0.72	ND	0.108	NA	ND

5.1.2 Grassland and savannah fires

5.1.2.1 Activity rates

To determine the activity rate for savannah fires, the following points should be taken into account:

- In 2015, 180,327 ha of surface burned (DGF/SRRLF);
- If the area of forest burned is estimated at 22,500 ha, the remaining 157,827 ha is the out-of-forest fire, most of which is savannah fires, especially grassland.

If we refer to the Toolkit, the equivalent in tdm / ha for grassland is 3.5 tdm / ha. The 157 827 ha correspond to **552 394 T** of dry matter**.**

5.1.2.2 Estimation of emissions

The estimated emissions for savannah fires are given in the table below:

Table 5-3 Estimation of emissions for grassland and savannah fires

	Biomass burning	**Emission factors (gTEQ/an)**				
		Air	**Water**	**Land**	**Product**	**Residue**
	Grassland and savannah fires	0.276	ND	0.083	NA	ND

5.1.3 Sugarcane burning

5.1.3.1 Activity rates

If we refer to the data mentioned in paragraph 3.4.2, the production of sugarcane in the two sites (Namakia and Ambilobe) is 740,716.04 tons in 2015/2016. The leaves that will be burned before the manual cutting of the cane represent 15% of the total mass of the plant. This corresponds to **111 107.4 tons** of dry matter.

5.1.3.2 Estimation of emissions

Using the latest version of the Toolkit, the emissions related to the burning of sugar cane are presented in the table below:

Table 5-4 – Summary of emission for Sugarcan burning

	Biomass burning	Emission Factors (gTEQ/an)				
		Air	Water	Land	Product	Residue
	Sugarcane burning	0,444	ND	0,006	NA	ND

5.2 Estimation of PCDD/PCDF emissions by open burning of waste (6.b) for 2015

5.2.1 Open burning of domestic waste

5.2.1.1 Activity rates

In order to determine activity rates, the information / data presented in paragraphs 3.1 and 3.2 are reminded as follows:

- The production of waste in big cities for the year 2015 is around 7 000 T / day, which corresponds to an annual production of 2 555 000 T and of which about 511 000 T are burnt at the household level (about 20% of households burn their waste);
- The municipal waste collection rate would be an average of 40%, which would correspond to 1 022 000 tons of waste collected and landfilled;
- The data collected at the level of the municipalities visited concerning the burning of waste in the landfill sites show that on average 32% of the waste sent to landfill is burned. The amount of waste being burned at landfills is estimated at about 327 000 T

It could therefore be said that about **838 000 tons** of waste were burned in the open in 2015.

5.2.1.2 Estimation of emissions

By reporting the amount of waste burned in the latest version Toolkit, the emissions for domestic waste burning are summarized in the table below:

Table 5-5 Emissions for open burning of domestic waste

	Open burning of waste and accidental fires	Emission Factors (gTEQ/an)				
		Air	Water	Land	Product	Residue
	Open burning of domestic waste	33.52	ND	0.838	NA	NA

5.3 Summary of emissions for Open burning

The estimates of dioxin and furan emissions for 2015 concerning different subcategories are summarized in Table 5.5:

Table 5-6 Summary of emissions of Dioxin and Furan for 2015

	Open burning	Emission Factors (gTEQ/an)				
		Air	Water	Land	Product	Residue
6.1	**Biomass burning**					
1	Forest fires	0.72	ND	0.108	NA	NA
2	Grassland and savannah fires	0.276	ND	0.083	NA	NA
5	Sugarcane burning	0.444	ND	0.006	NA	NA
6.2	**Open burning of waste and accidental fires**					
3	Open burning of domestic waste	33.52	ND	0.838	NA	NA
	TOTAL	**34.961**		**1.034**		

TOTAL OF EMISSIONS IN 2015 : 35,995 gTEQ/an

Notons que les estimations dépendent des informations disponibles.

Note that a survey conducted with the Ministry in charge of Agriculture and Agricultural Statistics found that, apart from the rice bran used as fuel in bricks production in the highlands, agricultural residues from major crops (Maize , Rice, Cassava) are for the most part used by farmers as fodder.

From 2010 to 2015, an increase in emissions of 16.69 gTEQ / year is observed. This increase mainly concerns the burning of waste. In fact, the estimated amount of waste burned has increased significantly. 174 000 T of waste were estimated in 2010 while they are estimated at 838 000 T for 2015. The following explanations could be put forward:

- Increase in waste production linked of the population growth,
- Availability of data relating to waste management: inventory made in the different sites to know the practices, study carried out and projection compared to the production

The estimates depend on the availability of information.

6 Conclusion

The inventory of landfill sites and other fire points at the national level has made it possible to:

- identify the various practices including open burning in these different sites and to estimate their magnitude;
- know the situation of landfills (location, surface, quantity of stored waste, etc.) and the existing treatment methods;

The updating of the emissions inventory has, on the one hand, made it possible to see the important place of open burning of domestic waste and, on the other hand, to have a reflect on the choice of Best Available Technologies (BAT) and Best Environmental Practices (BEP) to be implemented at these sites as well as actions that should be taken to reduce dioxin and furan emissions.

BIBLIOGRAPHY

- COI/AFD (2014) – Etude de diagnostic pour une gestion optimisée des déchets dans l'Océan Indien
- Christian A. Kull (2002) – Madagascar aflame : landscape burning as peasant protest, resistance, or a resource management tool ?
- FAO (2015) – Global Forest Resources Assessment
- Kellie Koenig/NASA/CI (2017) – Firecast : a fire prevention and forest monitoring system
- MEEF (2015), Rapport d'inventaire des dix nouveaux POPs- Rapport de mise à jour des inventaires des Dioxines, Furannes et Polycholorobiphényles
- PNUE, STOCKHOLM CONVENTION (2013) – Toolkit for identification and quantification of releases of Dioxins, Furans and other unintentional POPs
- RAJAOMANANA Hery/ONE – Gestion et traitement des déchets ménagers dans les pays en voie de développement
- RALAIMIHOATRA Solofoniaina Nandrianina- CI – Le système de suivi satellitaire des feux, un outil de gestion des ressources naturelles à Madagascar
- http:/www. Etcterra.org/fr/energie-déchets/africompost
- http:/mg.one.un.org/content/unct/madagascar
- https:/www.pnae.mg/tbe/national
- https:/logiprod.conservation.org/FirecastWebAnalytics

APPENDICES

Appendix 1: List of people contacted

REGION	Nom et prénoms	Entité	Titre/Responsabilité	Coordonnées
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	Michel	MinENV-DREFFT		032 50 592 88
	Sana MAROSON	Min ENV-DREFFT	Chef de Service Régional des Forêts	032 04 250 06 034 05 250 06
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	RAKOTOSON Sitraka	DREFF Haute Matsiatra	Directeur Régional	

REGION	Nom et prénoms	Entité	Titre/Responsabilité	Coordonnées
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	RAKOTOSOLO Albert Clément	CR IVATO	2ème Adjoint au Maire	033 04 129 97
	Mr NICO	CR Talatamaty	Voirie	034 69 365 19
	RATOVONDRAINY Sitraka	CR Sabotsy Namehana	Voirie	034 48 633 63
	Bodoarilala RASOLOMANANA	MINENV	Chef de service Reboisement, reforestation et lutte contre les feux	034 18 649 51

REGION	Nom et prénoms	Entité	Titre/Responsabilité	Coordonnées
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	RANDRIANARIVELO Lucien	Ministère Chargé de l'Agriculture	Directeur Général de l'Agriculture	

Appendix 2: Summary table of the results of the on-site visit

CATEGORY 6 : OPEN BURNING								
Sub-category	**Location**	**GPS**	**Estimated surface**	**Unit**	**Estimated quantity**	**Unit**	**Année**	**Comments**
-								
3- Open burning of domestic waste								
ANTANANARIVO	TONGARIVO	S 18° 57' 58.0" E 047° 31' 21.8"	486	m2	16	To/day	2017	Burned : 1 To/day (ririnina) 0,1 To/day (Fahavaratra)
	ALASORA	S 18° 57' 59.7" E 047° 34' 42.3"	13 200	m2	5	To/day	2017	Burned : 1,25 To/day
	ANDRALANITRA	S 18° 54' 36.9" E 047° 34' 35.1"	180 000	m2	1500 - 2000	m3/day	2017	Pas de brûlage
	AMBOHITRIMANJAKA							Pas de décharge communautaire Décharge par ménage / Population : 40 000 80% Brûlés
	ANTEHIROKA : Andramiarana	S 18° 51' 45.2" E 047° 27' 53.6"	2 400	m2	23	m3/day	2017	20% burned - Projet de site à Antsilolika
	TALATAMATY : Andramiarana	S 18° 51' 45.2" E 047° 27' 53.6"	2 400	m2	18	To/day	2017	20%
	IVATO	S 18° 45' 50.9" E 045° 28' 12.8"	800	m2	10	To/day		15% burned

CATEGORY 6 : OPEN BURNING

Sub-category	Location	GPS	Estimated surface	Unit	Estimated quantity	Unit	Année	Comments
		S 18° 46' 28.9" E 047° 28' 12.2 "	2 637	m2				
	SABOTSY NAMEHANA		500	m2				
ANTSIRANANA	Route d'Anamakia	S 12°19'00.7" E 049°16'51.1"	8 370	m2	26 000 Tonnes	Totally burned		
	Route RAMENA	S 12°17'58.7" E 049°17'55.3"						
VAKINANKARATRA	AMBATOLAMPY : Marché	S 18° 46' 28.9 " E 047° 28' 12.3"	12	m2	0,5	To/Day	2017	90% récupérés par les paysans 10% brûlés
	AMBATOLAMPY: Malamamaina	S 19° 24' 20.6" E 047° 25' 26.0"	16	m2				
	ANTSIRABE : Ivohitra	S 19° 52' 29.8" E 047° 00' 22.2"	1 377	m2	60	To/Day	2017	80% burned
HAUTE MATSIATRA	Maromby (Près Sœurs)	S 21° 24' 59.5" E 047° 06' 30.8"	16 786	m2	50	To/day	2016 - 2017	70% Burned
	Maromby PK6	S 21° 24' 34.9" E 047° 05' 05.5"	1 932	m2	550	To/month		0,5% burned
AMORON'I MANIA	Antsenan'omby - Ambohipierenana	S 20° 33' 23.1" E 047° 13' 57.3"	652	m2	18	m3/day	2017	100% burned