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REPORT

REVIEW OF INNOVATIVE AND APPROPRIATE TECHNOLOGIES FOR WASTE MANAGEMENT IN MOROCCO AND THE ARAB REGION

Acknowledgement

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Disclaimer

The report was prepared as a background document for the forthcoming "Regional workshop: Innovative technologies for waste management in the Arab Region – paving the way for the transition to a green economy". The opinions expressed are those of the authors and do not necessarily reflect the views of ESCWA. The document has been reproduced without formal editing.

Acronyms :

C&D :	Construction and demolition
C&I :	Commercial and industrial
CDM:	Cleaner development mechanism
Co-EAT:	Co-Digestion Economic Analysis Tool
CNEDS:	Centre national d'élimination des déchets spéciaux
EPR:	Extended Producer Responsibility
FEC:	Fond de développment communal
FODEP :	Fond de dépollution industrielle
GEPreC :	Outil de gestion efficace et profitable des ressources et de leurs coûts
GIZ :	Coopération Internationale allemande
HTO :	Hydothermal oxidation
IAA	Industrie agro-alimentaire
LAS:	League of Arab States
MBT :	Mechanical biological treatment
MDE :	Ministère Délégué chargé de l'Environnement
MRF :	Material recovery facility
MSW:	Municipal solid waste
NPO:	Non product output
PGPE :	Programme de Gestion et de Protection de l'Environnement
PROGRESS :	Programme allemand en faveur d'une utilisation efficace des ressources
RDF :	Refuse derived fuels
SCWO:	Supercritical waste oxidation
SIE	Société d'investissement énergétique
SNDD :	Stratégie Nationale de l'Environnement et du Développement Durable
WtE:	Waste to Energy
WWTP :	Wastewater treatment plant

EXECUTIVE SUMMARY (English):

This background study consists on a review of appropriate[1] and innovative technologies and practices as well as trends and opportunities for waste management in Morocco and the Arab region It seeks to contribute to a transition to more sustainable waste management at the national and regional level by highlighting appropriate waste technologies for the Arab region as well as best practice examples. Further, the study explores the potential for market penetration of technologies, taking into consideration the strength, weaknesses and costs for implementation as well as suggesting potential funding sources. This background study is intended to guide the work of the regional workshop organised conjointly by ESCWA, ECA-SRO/NA and CMPP on "Innovative technologies for the waste sector in the Arab Region – paving the way for the transition to a green economy".

Countries in the Arab region face increasing waste volumes influenced by trends of population growth and economic development. Producing over 250,000 tons of solid waste every day, with less than 20% properly treated or disposed of in landfills and only 5% recycled, the region requires planned and efficient waste management to protect the health of the population and the environment.[2] In many Arab countries, up to 50 per cent of the waste generated goes uncollected, and collected household waste is mixed with industrial and medical waste during handling and disposal. Even though many good practice examples exist, progress in waste management has in many countries been slow.

However, rather than seeing waste as a problem, it can be a potential resource for materials and energy. Waste management is likely to experience strong development in the Arab region in the next years and offers numerous business and job creation opportunities.
Arab countries are aware of the importance to adopt appropriate and innovative technologies to recycle, re-use and treat waste. The political, legal and institutional framework is crucial to enable and facilitate the adoption and operation of such technologies. Morocco for instance enacted a first law on waste management and disposal (law 28-00 December 2006) and the launch of the National Solid Waste Program (PNDM) 2008-2022, which laid the ground for the reform of waste management, now a national priority. The quantitative objectives of the PNDM[3] in providing services and environmental performance include that 90% of the urban population has access to modern services of collection of municipal waste by 2020, 100% of household and similar waste collected in urban areas will be disposed of in controlled landfills, and 20% of waste collected from households will be recycled. Other Arab countries finalized or are in the process of developing the political and institutional framework to promote sustainable waste management.

However, the authorities as well as the local private sector often lack the necessary practical experience required for the implementation and realisation of a sustainable waste management systems. The needs for treatment, recycling and landfills of solid waste are

[1] Technology that is suited to the needs, skills, knowledge and wealth of local people in the environment which they live
[2] AFED (2011) Annual Report Chapter 7: Waste management, http://afedonline.org/Report2011/PDF/En/chapter%207%20Waste.pdf
[3] Ministere de l'Energie, des Mines, de l'eau et de l'environnement du Maroc (2013), Recyclage des déchets ménagers et assimiliés au Maroc

very large and urgently require Appropriate, innovative and affordable technologies that are adapted to local conditions.

Examples of appropriate and innovative waste technologies in the Arab region:
A range of systems for processing mixed waste have been examined in this study. These vary from composting processes (which are net consumers of energy) to anaerobic digestion processes, which are net exporters of energy. Many of these are mature technologies with plants operating both in Morocco and abroad. The applicability of certain technologies depends very much on a range of issues such as waste stream characteristics, distance to markets, the financial situation and waste quantities.
Sharing case studies carried out in countries in the Arab region, including practical aspects and lessons learned provide a collection of inspirational examples that could be replicated in other countries. These case studies were mainly carried on the following thematic areas:

- Municipal solid waste (MSW)
- Industrial and hazardous waste
- Medical and pharamceutical waste
- Waste to energy
- Paper and cardboard
- E-waste
- Used cooking oil

The analysis of these technologies has been conducted reviewed the strengths and weaknesses as well as the costs for implementation. The compiled technologies are all valuable and should be considered in the light of specific criteria for each country in the region (Competitiveness, Financing, Environmental impact, Risks, Acceptability,…). They also help to minimize environmental impacts by reducing GHGs. They play an important role in the prevention, 3Rs and treatment of waste and consequently, pave the way for the transition to green economy.

The funding of technology and innovation needs to be examined based on the cost benefit of solutions implementation. The financing of waste management improvements should be discussed case-by-case, however a selection of opportunities for funding are highlighted, particularly those linking to domestic and international priorities such as climate change.
In Morocco, the main instruments include:

- "Imtiaz" and "Moussanada" set up via ANPME, targeting the support of high-growth potential companies such as Profitable Environmental Management (GEPreC), which supports resource efficiency.
- The industrial pollution Fund (FODEP) aimed primarily at encouraging the implementation of actions contributing to the protection of the environment and pollution mitigation.
- The voluntary mechanism, industrial pollution of water (MVDIH) that is reserved for industrial water pollution,
- Other economic / financial instruments, such as the Hassan II Fund for economic and social development, Energy investment company (SIE) and environmental ecotaxe on plastic products that will help the National Environment Fund (FNE) and help finance projects aimed at the development of the recycling industry.
- A program to support the transformation of MSW sector in Morocco was implemented according to thanks to the program financed by the World Bank (2009-2011). A new

loan of 130 million USD for the MSW management was recently approved. This loan comes under the financing relating to the fourth loan Household Waste Sector Development Policy.

- The PGPE-GIZ support programme the feasibility study and the implementation of several pilot projects for innovation in the waste sector and promoting biogas and resource efficiency
- In the context of Morocco and some other countries in the Arab region, there is large potential to mobilize finance for greenhouse gas emissions reduction. The distribution of climate finance in the Arab region amounts to USD 1020 million (out of approx 10 billion globally).[4] It is concentrated in Egypt and Morocco, with total amounts approved of USD 195 million and USD 640 million, respectively, mainly for mitigation projects. Over 96% of this finance has been for large-scale wind and CSP projects.

Much of the progress to date in waste innovation seems to have been in the area of development of new technologies to treat wastes. In the case of Arab region, there is evidence of many appropriate and innovative technologies, and efficient waste management approaches focusing on waste prevention, waste minimisation, source separated collection and specific technologies for treating particular waste streams. However, apart from assessing what would be an appropriate waste technology, comprehensive waste management requires a functioning, efficient and accountable institutional, regulatory and financial framework.

[4] Climate Funds (2015) Global climate finance architecture, http://www.climatefundsupdate.org/about-climate-fund/global-finance-architecture

EXECUTIVE SUMMARY (French):

Cette étude préliminaire consiste en un examen des technologies et des pratiques appropriées et innovantes ainsi que les tendances et les opportunités pour la gestion des déchets au Maroc et dans la région Arabe. Elle vise à contribuer à une transition vers une gestion plus durable des déchets au niveau national et régional, en mettant en évidence les technologies appropriées pour la gestion des déchets ainsi que des exemples des meilleures pratiques. En outre, l'étude explore le potentiel de percée sur le marché de ces technologies, en tenant compte de leurs forces, leurs faiblesses et les coûts de mise en œuvre, et en suggérant des sources potentielles de financement. Cette étude est destinée à guider les travaux de l'atelier régional organisé conjointement par l' ESCWA, ECA-SRO/NA et le CMPP sur "Les technologies innovantes pour le secteur des déchets dans la région arabe - Accompagner la transition vers une économie verte".

Le volume brut des déchets des pays Arabes est estimé à 250 000 tonnes par jour, sur la base d'un taux moyen d'environ 256 kg par habitant et par an. La fraction des déchets municipaux solides qui est traitée de manière adéquate est inférieure à 20%, alors que les déchets recyclés ne dépassent pas 5% du volume brut des résidus, bien qu'il ait été estimé que jusqu'à 80% de ces déchets pourraient être recyclés. Il est donc urgent de mettre en place une gestion planifiée et efficace pour protéger l'environnement et la santé de la population.5 De même, dans la plupart de ces pays, jusqu'à 50% de la quantité des déchets générés n'est pas collectée, et les déchets ménagers collectés sont mélangés avec les déchets industriels, médicaux et pharmaceutiques, pendant la manipulation et l'évacuation. Il est également important de noter que, malgré de nombreux exemples de bonnes pratiques, la plupart de ces pays progressent très lentement dans le domaine de gestion des déchets.

Toutefois, ces déchets ne constituent pas uniquement un problème environnemental, mais aussi une perte économique; il est donc possible de les considérer comme une ressource secondaire parfaitement exploitable et dont la gestion est susceptible de connaître un fort développement dans la région Arabe pour les prochaines années, avec la possibilité de création d'emploi. Les pays Arabes sont tous conscients de l'importance d'adopter des technologies appropriées et innovantes pour recycler, réutiliser et traiter les déchets. Le cadre politique, juridique et institutionnel est crucial pour faciliter l'adoption et l'exploitation de ces technologies.

Le Maroc, par exemple a déjà adopté une première loi sur la gestion et l'élimination des déchets (loi 28-00 Décembre 2006) et le lancement du Programme National des Déchets Ménagers (PNDM) 2008 - 2022, qui a jeté les bases de la réforme de la gestion des déchets. Le PNDM vise essentiellement à assurer la collecte des déchets ménagers pour atteindre un taux de collecte de 90% en 2020, réaliser des décharges contrôlées des déchets ménagers et assimilés au profit de tous les centres urbains et réhabiliter ou fermer toutes les décharges non-contrôlées existantes (100%) en 2020, et moderniser le secteur des déchets par la professionnalisation tout en développant la filière de « tri-recyclage-valorisation », avec des actions pilotes de tri, pour atteindre un taux de 20 % du recyclage en 2020.

[5] AFED, 2008

D'autres pays Arabes ont finalisés ou sont en cours d'élaboration du cadre politique et institutionnel pour promouvoir la gestion durable des déchets. Toutefois, les autorités ainsi que le secteur privé local manquent souvent d'expériences pratiques nécessaires pour la mise en œuvre et la réalisation de systèmes de gestion durable des déchets. Les besoins en matière de traitement, de recyclage et d'élimination des déchets solides sont énormes et exigent d'urgence des technologies appropriées, innovantes et adaptées à cette région.

Exemples de technologies appropriées et innovantes de valorisation des déchets dans la région Arabe:

Plusieurs systèmes de traitement de déchets mixtes ont été examinés dans cette étude. Ceux-ci varient du simple processus de compostage (consommateurs nets d'énergie) aux processus de digestion anaérobie, qui sont générateurs nets d'énergie. Beaucoup d'entre eux sont des technologies matures avec des installations fonctionnant à la fois au Maroc et à l'étranger. L'applicabilité de certaines technologies dépend de plusieurs facteurs comme les caractéristiques des déchets de flux, l'éloignement des marchés, la situation financière et les quantités de déchets.

Le partage des expériences menées dans les pays de la région arabe, y compris les aspects pratiques et les enseignements tirés permet sans aucun doute de fournir au différents pays de la région des exemples de "succes stories" qui pourraient être reproduites. Ces expériences rassemblées sous forme d'études de cas ont principalement concerné les thématiques suivantes:

- Déchets solides municipaux
- déchets industriels et dangereux
- Déchets médicaux et pharmaceutiques
- Valorisation énérgétqiue des déchets
- Papier et cartons
- Déchets éléctroniques
- Huiles alimentaires usagers

L'analyse de ces technologies a été menée selon leurs forces et faiblesses ainsi que les coûts de mise en œuvre. Les technologies compilées sont toutes utiles et devraient être considérées tout en respectant les critères spécifiques pour chaque pays de la région (compétitivité, financement, effets environnementaux, risques, acceptabilité, ...). Ces technologies contribuent également à minimiser les impacts environnementaux (réduction des GES), et jouent un rôle important dans la prévention, 3R, et le traitement des déchets et, par conséquent, ouvrent la voie à la transition vers l'économie verte.

Par ailleurs, le financement de la technologie et l'innovation doit être examiné sur la base des coûts-avantages de la mise en œuvre des solutions. Le financement des améliorations de la gestion des déchets doit être discuté au cas par cas.

Dans le cas du Maroc les principaux instruments mis en place sont les suivants:

- Les programmes « Imtiaz » et « Moussanada » mis en place via l'ANPME ciblant la promotion des entreprises.
- Le Fond de dépollution industrielle (FODEP) qui vise principalement à encourager la mise en œuvre d'actions concourant à la protection de l'environnement contre la pollution industrielle.

- Le Mécanisme volontaire de dépollution industrielle hydrique (MVDIH) qui est réservé à la dépollution industrielle hydrique.
- D'autres instruments économiques/financiers peuvent également être cités, comme le fond Hassan II de développement économique et social, la société d'investissement énergétique (SIE) et l'écotaxe sur les produits plastiques qui alimentera le Fonds national de l'environnement (FNE) et contribuera au financement des projets visant le développement de la filière de recyclage à partir de 2015.
- Un programme d'appui à la transformation du secteur des déchets solides municipaux au Maroc a été mis en œuvre grâce au programme financé par la Banque mondiale (2009-2011). Un nouveau prêt de 130 millions USD a été récemment approuvé.
- Le programme de soutien PGPE-GIZ pour l'étude de faisabilité et la mise en œuvre de plusieurs projets pilotes pour l'innovation dans le secteur des déchets et la promotion du biogaz et de l'efficacité des ressources.
- A l'échelle de la région Arabe, il existe un fort potentiel, dans le contexte actuel, pour mobiliser des financements liés à la réduction des émissions de gaz à effet de serre. L'Egypte et le Maroc peuvent être cités comme exemple, puisqu'ils ont bénéficié respectivement d'un financement de 195 millions USD et 640 millions USD, principalement pour des projets d'atténuation. Plus de 96% de ce financement a été dédié aux projets éoliens et solaires de grande envergure.

Les recommandations pour la gestion efficace des déchets dans la région arabe peuvent etre formulées comme suit:

- Mise en place de réformes et application des lois, organisation et responsabilité, Introduction de taxes sur les déchets et réglementation des finances,
- Flux orienté vers la valorisation et/le recyclage, et gestion économique des déchets,
- Encourager la participation de plusieurs parties prenantes à chaque étape de la gestion des déchets,
- Réalisation de projets pilotes pour acquérir une expérience pratique,
- Intégration de l'industrie privée sur les aspects financiers et organisationnels,
- Construction et modification de des installations de traitement des déchets,
- Construction de sites d'enfouissement réglementés,
- Construction de centre de traitement des déchets dangereux,
- Formation et perfectionnement, et développement d'une stratégie nationale de communication

1 INTRODUCTION

Many countries have recognized waste as a resource, rather than a liability and have developed technologies, mechanisms and policies that allow recycling and reusing a large part of the waste produced.

It is now widely recognized as an economically important resource because it is a secondary raw material and can be utilized as a substitute for primary resources. The use of this secondary resource contributes to the decoupling of economic growth from negative environmental impacts associated with the generation of waste. At the same time, better waste management has the additional benefit of reducing greenhouse gas emissions and other pressures on the environment. In the context of Morocco and the Arab region, there is large potential to mobilize climate finance for greenhouse gas emissions reduction related to market penetration of available waste management technologies.

To date, the Arab region lacks a regional approach to improving the sustainability of waste management practices. This has resulted in an inconsistent approach across the Arab region countries concerning the introduction of new and innovative waste technologies, difficulties of compliance with international standards and approaches, the absence of national and regional standards for landfill design and management of emissions, and lack of infrastructure in the recycling industry.

The study on innovative waste technology will serve as an important resource for the workshop by allowing participants to discuss key questions on waste management. The workshop will bring together representatives from Small and Medium Enterprises, academia and public institutions from the region to identify potential areas of cooperation for effective technology-based solutions and to seek for best available technologies (BAT) for waste management and other industrial activities.
The study:

- Identifies key emerging innovations, trends and opportunities in waste and resource-recovery technologies and practices relevant to Morocco and the Arab region;
- Reviews those technologies stating their strengths and weaknesses and costs for implementation; and
- Examines potential funding options for waste management solutions involving appropriate and innovative technologies needed in the Arab Region.

The potential for innovation for waste management at the level of enterprises in industries and other economic activities for the transition to sustainable production and consumption patterns will be explored.

2 BACKGROUD, OBJECTIVES AND METHODOLOGY

2.1 Background

The Food and Environmental Policies Section within the Sustainable Development Policies Division (SDPD) is leading the efforts to strengthen national capacities in the ESCWA member countries on developing green production sectors. In particular, it aims to build capacity of policymakers, civil society, business and industry associations in developing green technologies in the Arab region.

A major step in achieving this was the establishment of Green Help Desks in Lebanon, Jordan, Oman, Egypt, Tunisia and Morocco. ESCWA now continues its support to the Green Help Desks through cooperating for instance in the organisation of workshops. Morocco officially requested the establishment of a Green Help Desk to be hosted within the Moroccan Cleaner Production Center (CMPP), which was launched in January 2015.

CMPP and ESCWA will organize a two day regional workshop on "Innovative technologies for the waste sector in the Arab Region – paving the way for the transition to a green economy" by the end of September in Casablanca. This workshop aims to create a space where research, businesses, investors, bankers and policy-makers working on the issue of waste management exchange information and make the necessary connections for the adoption and adaptation of such innovative technologies.

2.2 Objectives and methodology

In the lead up to the 'Regional workshop on innovative technologies for waste management in the Arab Region – Paving the way for the transition to a green economy', ESCWA undertook to develop this background study to provide an overview of the situation in Morocco and the Arab region. The study is intended to assist the regional workshop in sharing knowledge on waste management options and facilitating exchange of experiences for the application and adaptation of innovative technologies.

2.2.1 Objectives

The objective of this consultancy is to prepare a concise, high-quality background paper on innovative technologies in the waste sector in Morocco and the Arab region. The document will identify enablers, barriers, gaps and questions on opportunities for technological innovation. The results of the Background Study will be presented and discussed during the workshop. The Background Study and workshop will paint a clearer picture of best available and appropriate technologies for waste management in the Arab region with a special focus on Morocco, drawing on best practice examples. The ambition is to develop opportunities for supporting the development and promotion of innovative waste technologies in the Arab region.

2.2.2 Scope

As a part of the preparation of the workshop, this study focuses on available and innovative technologies in the waste sector. This report contains a compilation of the most efficient technologies at the international and regional level. It mainly covers appropriate[6,] clean[7] and affordable technologies adapted for the recovery, treatment and disposal of waste. It assesses the cost effectives of best available technologies[8] that reduce, recycle and recover waste, and thus contribute to resource efficiency. Transferability of technologies regionally and globally is also taken into account.

[6] Technology that is suited to the needs, skills, knowledge and wealth of local people in the environment which they live.

[7] Economically competitive and productive technology that uses less material and/or energy, generates less waste, and causes less environmental damage than the alternatives.

[8] Techniques (technologies) which consists in finding the appropriate balance between environmental performance and technical and economical availability. BAT are published in the form of BAT reference documents (BREF) resulting from the exchange of information between the EU member states, industry, non-governmental environmental organizations

Particular attention is paid to innovations in the following thematic areas: Municipal solid waste (MSW) pharmaceutical and organic waste, Industrial and hazardous waste, Medical and pharmaceutical waste, Waste to energy (WtE), Paper and cardboard, E-waste, and used cooking oil.

In terms of geographical scope, the study covers the entire Arab region (the 22 countries of the League of Arab States), and focuses in particular on Morocco.

2.2.3 Methodology

The study is based on a desk review, supported by interviews, consultation both locally and overseas with industry, government and academic contacts on these technologies and their technology transfer within the countries of the Arab region.
The general approach is based on 3 main components shown below.

- **Component 1** aims to provide a description of the current situation and the status quo of waste management in Morocco and the Arab region.
- **Component 2** presents a selection of appropriate technologies in a table where each technology is analyzed with its strength and weaknesses (in a detailed annex). Subsequently, component 2 provides examples on the implementation of some available technologies within countries in the Arab region are provided.
- **Component 3** explores financing instruments for the implementation of technologies that can contribute to better waste management.

Each component corresponds to a chapter of the report.

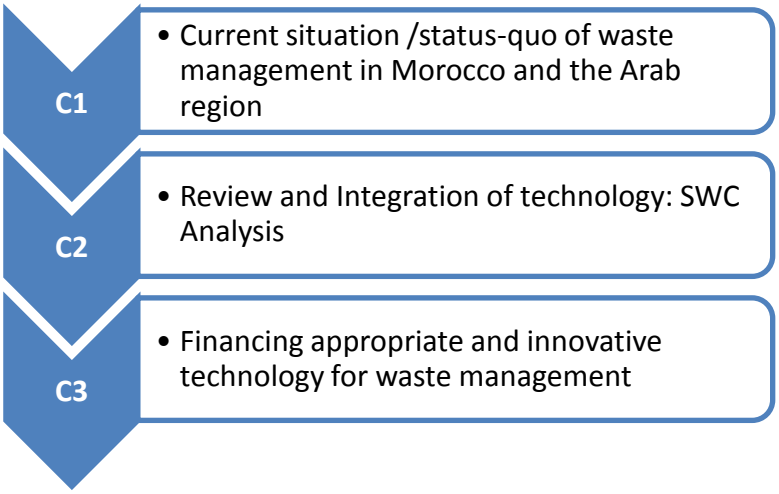


Figure 1: Representation of actions performed during the study

3 CURRENT SITUATION / STATUS QUO OF WASTE MANAGEMENT IN MOROCCO AND THE ARAB REGION

Economically, waste is a part of the “non-product output” (NPO), which represents a significant cost, and combines input, processing and disposal costs. The NPO cost lies between 10 and 30% of the desired product cost.[9] It poses a significant threat to the environment because it generates greenhouse gases and occupies large areas of land. As

[9] Carrapatoso, A., Kuerzinger, E. (2014) Climate resilient development, Routledge

an example, 1.4 billion hectares of land, which is equivalent to 28 per cent of the world's agricultural area is used to produce food that is then lost or wasted.
In the Arab region, the LAS countries generate over 75 million tonnes of waste (MSW only). Across most of the region no structured recycling industry exists. Approximately 1% - 3% of the total waste generated is recovered as recyclable materials and the rest is landfilled or dumped and "lost" for further re-use of the raw material. Based on an OECD analysis[10], the cost of Environmental Degradation in the MENA region, only generated by waste, lies between 0.1 and 0.5% of GDP.

3.1.1 Policy, legal and institutional framework for waste management

The Moroccan Government is leading the development of a national waste policy for the country. A recent study of waste and recycling trends in Morocco[11] showed that the municipal solid waste generation growth is about 1,36% with a low recycling ratio (8-10% of the total waste produced). This occurred in spite of the willingness to develop the recycling industry and waste recovery, through recycling programs and actions by the commercial and industrial sectors.

Morocco for instance enacted a first law on waste management and disposal (law 28-00 December 2006) and the launch of the National Solid Waste Program (PNDM) 2008-2022, which laid the ground for the reform of waste management, now a national priority. The quantitative objectives of the PNDM[12] in providing services and environmental performance include that 90% of the urban population has access to modern services of collection of municipal waste by 2020, 100% of household and similar waste collected in urban areas will be disposed of in controlled landfills, and 20% of waste collected from households will be recycled.

In addition to the above mentioned law, the management of the industrial and hazardous waste legal framework has been strengthened in recent years by laws on environmental impact assessments and on transport of dangerous goods.[13] The Department of Environment initiated in 2007, the National Hazardous Waste Management Master Plan. The legal and institutional framework for the management of medical and hospital waste is reinforced by the law 28-00 and the related decrees. The Moroccan Waste Catalogue also defines hazardous medical and pharmaceutical waste. To reform the medical waste management sector, Morocco committed to assessing the quality and quantity of medical waste produced in Morocco and its impact on the environment, and aims to improving the collection, sorting, and transport.

Law 28-00 on waste also covers green and agricultural waste stream, waste oils and lubricants, waste tires, construction and demolition waste and packaging waste. However, Waste Electrical and Electronic Equipment also known as e-waste, does not currently have any specific legislation in Morocco. Law 28-00 on waste management and disposal does not

[10] Sweep-net (2015) The cost of environmental degradation, http://www.sweep-net.org/cost-environmental-degradation
[11] Sweep-net (2013) Country report Morocco, http://www.sweep-net.org/document/country-report-morocco-2013
[12] Ministere de l'Energie, des Mines, de l'eau et de l'environnement du Maroc (2013), Recyclage des déchets ménagers et assimiliés au Maroc
[13] Ministere de l'Energie, des Mines, de l'eau et de l'environnement du Maroc, Recueil des lois, http://www.environnement.gov.ma/PDFs/Recueil_Des_Lois_fr.pdf

mention e-waste as a separate entity but includes it in the category of "hazardous waste". It should also be noted that both the Environmental Performance Review for Morocco[14], as well as the Country report by SweepNet[15] have looked into policies and actors of waste management in Morocco in detail; therefore we will in this study not focus on the policy, legal and institutional framework in more detail.

Regarding innovation and technology advances, a Task Force was formed an Deloitte supported in a study of the legal and regulatory framework governing the system of innovation in Morocco. This study provides an analysis of regulations and international standards in terms of innovation, and proposes new regulatory instruments adapted to the Moroccan context such as a special status for Young Innovative Companies and a management framework for the creation of spin-off companies.

Additionally, Morocco is convinced that innovation and technological development are key for the competitiveness of companies. Morocco is invested in building technological innovation hubs, which include innovative companies, project developers, universities, venture capital organizations and technology development centers.

Finally, the implementation of the Accelerated Industrial Plan [6] has strengthened the role of industry as a source of employment and growth. The plan aims to establish industry as a driver and introduces it to a new approach based on the setting up of ecosystems performers whose purpose is to ensure the integration of the local industrial fabric around leading companies that develop beneficial partnerships with SMEs. This will result in outsourcing contracts, upgrading of product quality, as well as accompaniment for ecosystem transformation, such as for instance the recovery of waste in the cement industry.

It is important to note that, although there is an evidence of existence of waste management legal frameworks, weak implementation is considered one of the main challenges facing waste management in the region. In recent years some Arab countries have introduced the integrated solid waste management concept. Collection and sorting, composting, incineration of medical wastes and sanitary landfills are starting to be implemented, while recycling, reuse and resource recovery are still at the initial stages.

3.1.2 Nationally

- **Municipal solid waste (MSW)**: Approximately 6.852 million tons of municipal solid waste is generated annually in Morocco, 85% of which is generated by the urban environment. This corresponds to, on average, slightly more than 0.76 kg per day per capita in urban areas. MSW has diverse components with a high proportion of organic matter. In 2013, the collection of solid urban waste covered about 74% of waste generated in urban areas. Yet only 37% of total waste generated is landfilled.
- **Industrial and hazardous waste**: Studies conducted to determine the quantities of hazardous waste generated in 2013 estimated the total amount at around 289,385 tons. These studies show that most hazardous waste is stored in situ, at the production sites. The risk of pollution is highest at the storage sites. Hazardous waste not stored in situ is

[14] UNECE, UNECA (2014) Environmental Performance Reviews, Morocco, http://www.unece.org/fileadmin/DAM/env/epr/epr_studies/ECE_CEP_170_En.pdf
[15] Sweep-Net (2014) Report on the Solid Waste Management in Morocco, http://www.sweep-net.org/sites/default/files/MAROC%20RA%20ANG%20WEB.pdf

disposed of with household and similar waste. Large international private chemical and pharmaceutical groups manage the problem of their hazardous waste internally. Companies such as ECOVAL and ECO-CIM have invested in waste treatment units for recycling and final treatment. Apart from these cases, however, there is no specific treatment for hazardous industrial waste at this time.

- **Medical and pharmaceutical waste**: Based on 2013 data contained within the National Hazardous Waste Management Plan, It is estimated that 142 public and 443 private hospitals generate 21,000 tons of medical waste per year, of which 6,000 tons are infectious waste. Several methods are currently being used to dispose of hazardous medical and pharmaceutical waste: shredding and disinfection, autoclave units and incineration. However, it should be noted that, even though many hospitals are equipped with an incinerator, most of these do not work or are obsolete.
- **Organic matter**: With regards to organic matter, Morocco, initially failed in the establishment of composting facilities. This can be partially explained by the inadequate quality of the compost (nature of substrate, carbon/nitrogen ratio, moisture, oxygen, temperature, pH and biotic factors). Green waste composting is, nevertheless, being encouraged in rural regions, and tests are being carried out on the Oum Azza landfill. Currently, several large cities of Morocco are in the process of establishing centers of modern treatment of household waste, like the city of Meknes that prioritizes resource efficiency, in a spirit of development of a circular economy aiming to recycle waste into raw material with biogas capture
- **Paper and cardboard**: Contrary to popular belief, recycling paper is not recent in Morocco. The Moroccan Company of cardboard and paper (CMCP), one of the largest Moroccan operators in the manufacture of paper and cardboard packaging today provides 90% of its production (120 000 tons per year) by recovering paper and cardboard waste. However, the recycling percentage is still very low (30%), even if Morocco consumes very small quantity of paper and cardboard (15kg / capita / year).[16]
- **Packaging waste**: 120 million tons of raw materials are used annually in the manufacture of plastic bags. Between January 2011 and October 2012, only a very small amount (1.485 million tons) were recovered as part of an agreement on waste-to-energy incineration between the cement manufacturers and the Ministry of the Environment. This is an insufficient amount to encourage investment in this sector. Moreover, as there is no formal recycling sector of glass, the informal sector and private sector collaborate for the recycling of glass. However, there is no precise data on the quantities collected and recycled.
- **E-waste**: At present, there is no centralized or even organized waste collection for e-waste. 3.083 tons are generated annually, which generally remains insufficient to ensure the economic performance of dismantling and recycling centres. With regards to the recycling infrastructure, the informal sector collects 90% of scrap metal. The majority of this collected metal is exported to foreign smelters. The remaining 10% of e-waste recycling and treatment is dedicated to various pilot projects, performed by the private and civil society sector. One such example is the electronic waste recycling project at the Guemassa, which involves separating and recovering the precious and non-ferrous metals in electronic boards in order to produce blister copper and gold and silver alloys.

[16] La vie Eco (2012) Seulement 30 des 500000 tonnes de papier consommés par an au maroc sont recycles, http://www.lavieeco.com/news/economie/seulement-30-des-500-000-tonnes-de-papier-consommees-par-an-au-maroc-sont-recyclees-15766.html

- **Used oils**: The estimated amount of waste oil produced is 100,000 tons, with an estimated quantity of this waste oil collected being 10,000 tons Some used oil is incinerated at cement plants, where contracts exist with large companies and authorized gas stations, but it is also incinerated in kilns and bathhouses. Unfortunately used oils are also often dumped unlawfully in the nature, which causes a great deal of pollution.
- **Other special waste stream sectors:** There is no data on the quantities of used tires that have been discarded in Morocco. Many of them are used in ceramic kilns or bathhouses as fuel, which causes a great deal of air pollution. Tires are also incinerated in cement plants, and a certain quantity is imported for this purpose (100,000 tons in 2009).[17] There is no official collection and recycling system for cells and batteries at this time.

3.1.3 In the Arab region

In this section, we chose to conduct a comparative study on the waste situation in the Arab countries. This comparison will allow us firstly to assess the degree of progress in the collection, treatment and disposal of waste. We gathered in a same table the countries of the Arab region for which sufficient recent statistics are available, thanks to data compiled by:

- Economic and Social Commission for Western Asia (ESCWA) by using national sources mainly data gathered from the National Statistical Offices and related ministries of each ESCWA member country, some international agencies, and the UNSD/UNEP Questionnaire 2013 on Environment Statistics for the Freshwater Resources and the Waste Management, and,
- The Regional Solid Waste Exchange of Information and Expertise Network (SWEEPNET) which works on reinforcing the institutional and personal capacities for integrated resource and solid waste management in Mashreq and Maghreb countries and in all the network's member countries.

Some Arab countries have published data on solid waste generation and collection (table1a,b); the management of municipal waste, including disposal method, recycling and composting, etc. (table 2). The table covers only the years where data is available.
Waste generation in the Arab region increased as the rate of population growth, urbanization, touristic and construction activities, fossil fuel and electricity production and consumption accelerated. The measures for resource efficiency and recycling proved insufficient. In terms of waste generation, some countries such as Morocco and Lebanon maintain a low level (1.36% and 1.65%), while other countries such as Mauritania and the Palestinian territories generate more than 4%.

In addition, the collection of statistical data on waste generation, composition and management does not rely on waste surveys or other data collection tools due to a lack of resources in statistical offices and ministries of the environment.
In many Arab countries, up to 50 per cent of the waste generated goes uncollected, and collected household waste is mixed with industrial and medical waste during handling and disposal.

On average, in most of the Arab region, the major part of collected MSW is either openly dumped or landfilled, and only a small percentage is recycled or composted. Compared with

[17] UNECE, UNECA (2014) Environmental Performance Reviews, Morocco, http://www.unece.org/fileadmin/DAM/env/epr/epr_studies/ECE_CEP_170_En.pdf

some EU member countries where almost half of the waste is recycled, the difference is very apparent. These facts indicate that MSW is poorly managed and lacks most of the basic engineering and sanitary measures for the collection and treatment of gas and leachate. This is also because of the lack of new technologies and/or their application to reduce, recycle and valorise this waste.

From the quantitative point of view, the analysis of these results clearly shows that the generation of waste in the Arab region is governed by MSW representing more than 50%, followed by agricultural and industrial waste. It is therefore important to focus on these three types of waste in our study. However, even if they are in small quantities, it is also vital to focus on other types of waste including special and hazardous waste. Their impact on the environment, humans and biodiversity in general, can be very harmful if they are not managed properly.

In addition, we can compare between the countries in the Arab region based on their GHG emissions generated by the waste sector. This information is included in the inventories on GHG emission under the different national communications of Arab countries to UNFCCC, and it is useful to explore the potential of GHG emission reduction within the waste sector.

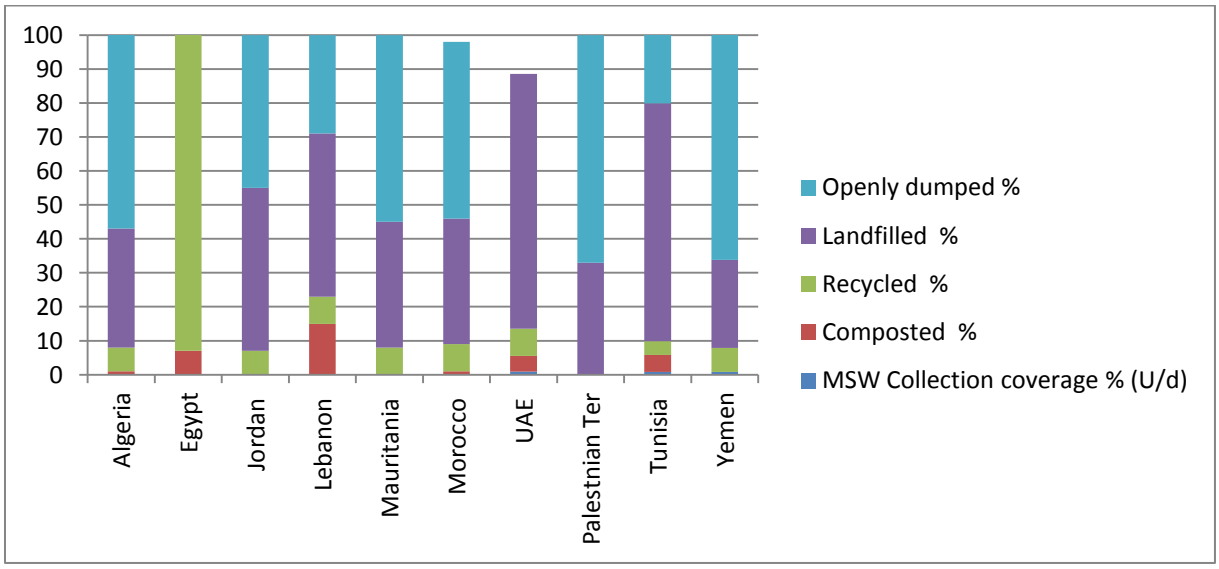


Figure 1: Waste technical performance in a selection of ten countries from the Arab region (http://www.afedonline.org/afedreport/english/book8.pdf)

	Algeria KT/year	Egypt KT/year	Jordan KT/year	Lebanon KT/year	Mauritania KT/year	Morocco KT/year	Oman KT/year	Palestnian Ter KT/year	Tunisia KT/year	Yemen KT/year
MS waste Growth	10,300 3 %	21,000 2 %	2,077 3 %	2,040 1.65 %	540 6%	6,852 1.36 %	1,600	1,387 4%	2,423 2.5%	3800 3%
Per capita U*/d **Per capita R*/d**	0.8 kg 0.6 kg	0.85 kg 0.45 kg	0.9kg 0.6 kg	1.075kg 0.8 kg	0.5kg 0.3 kg	0.76 kg 0.3 kg	1,5 kg *	1.5 kg 0.5kg	0.815 kg 0.15 kg	0.6 kg 0.5 kg
Medical waste	30	28.3	4	25.04	1.206	21	3.288	3.226	16	3.916
Industrial waste	2,550	6,000	45	188.85	n/a	1,600	1470	131.344	n/a	n/a
Hazardous waste	330	500	n/a	n/a	n/a	289.4	n/a	62.621	150	20.917
Agricultural waste	130	30,000	4,000	n/a	n/a	n/a	n/a	440 (Gaza strip)	4,033	n/a
C&D waste	11	4000	2,600	n/a	n/a	n/a	n/a	n/a		n/a
Tires waste	n/a	n/a	2500 No./year	n/a	n/a	n/a	50	5.55	15	n/a
E-waste	n/a	n/a	30	n/a	n/a	33,3	46.235	n/a	90	n/a
Packaging waste	n/a	n/a	700	n/a	n/a	55		n/a	99	n/a

Table 1a: Background information on generated waste in Arab region

	Bahrain KT/year	Comoros KT/year	Djibouti [1] KT/year	Iraq KT/year	Kuwait KT/year	Lybia KT/year	Qatar KT/year	Saudi Arabia KT/year	Somalia KT/year	Sudan KT/year	Syria KT/year	UAE KT/year
MS waste	1.500	57.8**	212.698	12.778	2.000		2.500	13.000	1916***	913.000		5.894
Growth	1.8%			_		0.010						
Per capita/d	1.8 kg	0.5 kg	0.68 kg	0.87kg	1.4 kg	_	1.5 kg	1.6 kg	0.5 kg***	0.6 kg	0.5 kg	1.4 kg
Medical waste		_	_	_		_			_	_	_	_
Indust. Waste	140*	_	_	_	7*	_	64*	95*	_	_	_	_
Hazardous W.		_	_	_		_			_	_	_	_
Agricultural waste	_	-	_	_	_	_	_	_	615*	615*	_	_
C&D waste	_	_	-	_	1,149*	_	782*	_	_	_	_	3,631*
Health-care	911*	_	_	_	33*	_	450*	_	_	_	_	_
E-waste	_	_	_	_	_	_	_	_	_	_	_	_
Packaging waste	_	_	_	_	_	_	_	_	_	_	_	_

Table 1b: Background information on generated waste in Arab region

4 INNOVATIVE WASTE TECHNOLOGIES FOR THE ARAB REGION

4.1 Survey of available and innovative waste technologies

Increases in the cost of landfilling and community pressure to avoid landfilling and increase recovery are the driving forces behind innovation in waste management. Technology in combination with sound policies and successful implementation are the means by which waste management can achieve a reduction in landfilling.

Previous emphasis has been on the source separation of materials and the necessary associated education campaigns, in order to keep materials pure for the most efficient processing. This reasonably passive approach could be tolerated when landfill disposal costs were low. Diversion is high for some easily separated materials of high value but the deficiencies of this approach became obvious when landfill costs increased and attention turned to lower value and logistically problematic materials such as food.

Now the clear trend in municipal and commercial waste collection is to collect materials mixed or with limited source separation. These limited mixed streams are processed at facilities that often use a combination of technologies such as initial mechanical separation followed by biological treatment of the organic fraction. This has long been the case overseas where landfill costs are high and there are additional regulatory drivers.

A survey of waste and resource recovery related technologies and innovations are conducted for this study. The survey has been conducted within the strategic framework established for the project. Information has been obtained from consulting locally and internationally with industry, government and academic contacts.

The survey considered a range of possible technologies and innovations including:

- Reuse, recycling and resource recovery;
- Waste collection systems and sorting;
- Organic and food wastes;
- Alternative waste treatment; and
- Waste to energy;

The adoption and implementation of available and innovative technologies in the waste sector is conditioned by different factors such as:

- The competitiveness of this innovation
- Financing Technology
- The environmental impact.
- Identification of risks related to the implementation of this technology

Tables 3 and 4 summarize technology types used in the treatment of waste and special waste streams. A detailed description of each of these technologies is available in Annex 1.

4.1.1 Technologies for treatment of mixed waste

Technologies for processing mixed waste generally concentrate on separating and treating the organic fraction. If recyclables and green waste are removed from the domestic waste stream, the largest remaining proportion is food waste. These technologies are generally large scale and mostly designed to process municipal solid waste. They ultimately produce a

compost type material and some have the capacity to extract recyclable materials left in the residual waste stream. Food, and sometimes other organic waste, is processed either aerobically (with oxygen and therefore avoiding the generation of methane – a greenhouse gas) or anaerobically (without oxygen and with methane gas capture and electricity generation). Innovative technologies in this field include for instance digestion (two-stage digestion, co-digestion, and related analysis tools), hydrolysis (sonification of biomass), autoclaving and bioreactor landfills (see Annex for more details).

4.1.2 Technologies for waste to energy

Because of a relative scarcity of landfill airspace and a greater political emphasis on environmental sustainability, several countries in Europe have deployed thermal treatment of municipal and solid wastes as a means of volume reduction as well as for the generation of electrical power or combined heat and power. Policies need to be in place to encourage the recovery of energy from waste. In Denmark, approximately one fourth of the waste produced in 2005 is being incinerated for heat and power production, and approximately two thirds being recycled, and only 8 percent going to landfill. It is important to note that waste to energy projects should be implemented as a supplement to, not a replacement for, recycling efforts. Technologies for waste to energy include incineration, pyrolisis and gasification and plasma arc (see Annex for more details).

4.1.3 Technologies for green waste and other organic material

Composting reduces the waste mass, about 40% (by evaporation of moisture). Composting is a process for converting decomposable organic materials into useful stable products. Industrial scale composting in the form of in-vessel composting, aerated static pile composting, and anaerobic digestion takes place in most Western countries now, and in many areas is mandated by law.

4.1.4 Other innovative technologies

Other innovative technologies include:

- Sorting and organization of recycling waste, including routing machines, air classifiers, sorting drums, disc separators and optical sorting.
- E-waste recycling, which requires disassembling and processing, uses chemical and electrokinetic treatment as well as pyrolisis.
- Toxic industrial waste can be treated through hydrothermal oxidation, a high performance ecological waste treatment method for aqueous organic residues that breaks down synthetic oils.
- To treat hospital waste, microwave technology with a dual system of grinding and disinfection enables bacterial inactivation
- Waste tyres can be recycled and reused through mechanical processing, devulcanization as well as microwave technology, reductive distillation or pyrolysis, high pressure water, gas phase halogenations and steam gasification

Technology type	Waste Stream							
	MSW	Commercial & Industrial	Hazardous Waste	Pharmaceutical Waste	Food organics	Mixed plastic	Paper and cardboard	Glass
Mechanical Separation	Improved sorting techniques	Improved sorting techniques	Big Oversized Blender	-	Dry processes (drums) and wet processes	Optical sorting	Improved sorting techniques and reprocessing to same plastics	Optical sorting for improved recovery and re-use applications
Biological	Anaerobic and aerobic digestion, composting, biofuel production, bioreactor landfill	Anaerobic and aerobic digestion, composting, biofuel production, bioreactor landfill	Bioremediation, phytoremediation	-	Anaerobic digestion, composting		Anaerobic digestion, composting	-
Thermal	Pyrolysis, gasification, plasma arc, incineration, autoclaving, fuel production (RDF)	Pyrolysis, gasification, plasma arc, incineration, autoclaving, fuel production (RDF)	Molten metal catalytic extraction, plasma arc	Incineration Autoclaving	-	Fuel production (Refuse-derived fuels)	Fuel production (RDF)	-
Chemical	Hydrolysis	Hydrolysis	Molten metal catalytic extraction	Hydrothermal oxidation (OHT)	-	Pyrolysis and plasma arc	Pyrolysis	-

Table 3: Technology types (waste stream)

Technology type	Special waste Stream							
	Dry cell batteries	Wet cell betteries	Spent Solvents	Spent Acids	Sludge	Oils and lubricant	E-waste	Tyre waste
Mechanical Separation	Handling & disassembly systems, super cooling & shredding	Handling and disassembly systems, crushing and screening	Decantation	-	-	Decantation	Automated disassembly & handling, reprocessing	Crumbing, civil engineering uses
Biological	-		-	-	Auto-purification, aerobic-anaerobic			
Thermal	-	Refining and smelting	Incineration	-	Dehydration	Incineration	Pyrolysis	Fuel production (RDF), steam gasification, gas phase halogenation, pyrolysis
Chemical	Neutralised electrolytes, hydrometallurgy	Electrolytes filtering, paste desulphurisation, leaching	Distillation	Distillation	-	refining	Extract metals by supercritical water oxidation process	Devulcanisation, plasma, fuel production, continuous reductive distillation

Table 4: Technology types (special waste stream)

4.2 Analysis of the technologies

Morocco like other countries in the Arab region and in the world has been implementing sustainable development and embracing eco-friendly technologies. In order to enhance efficiency in the use of natural resources and energy, the industrial sector has started embracing cleaner production technologies. Clean technologies help to minimize environmental impacts by reducing GHGs and play an important role in the prevention of waste, reducing, recycling and reuse, as well as in the treatment of waste and consequently, pave the way for the transition to green economy.

The results of the analysis of different technologies mentioned in the waste sector are given in the tables 5, 6 and 7. Each of these technologies is described in detail in the Annex with a detailed description of the strengths, weaknesses and costs. Many of these technologies are applied in European countries, where waste collection, recycling and treatment are advanced, The below tables are thus meant as an overview of available innovative technologies. However, each technology should be considered in the light of specific criteria for each country in the region (Competitiveness, Financing, environmental impact, risks, acceptability). Section 4.3 presents numerous examples of already applied and tested technologies in Morocco and the Arab region. Following the workshop, where further examples of experience with applying technologies will be shared, this document will be updated and further complemented. Sound waste management practice should be flexible to local conditions, but also existing socioeconomic paradigms, regulatory frameworks and existing infrastructure.

Technology applicability is considered to not only include recycling infrastructure but also examination of the technology and management loops to recover materials, reagents and process residues as potentially valuable materials. The assessment recognizes that technology is just part of the solution to achieve a reduction in waste generation.

Technology transfer (TT) may cover various aspects: transfer of innovative technologies which have not yet been applied and are at a testing stage to mature technologies whose transfer is usually a winning transaction for both parties. This may also relate to services or methods: the organization and methods of waste collection, or urban planning. In all cases, it should properly prepare the conditions of the transfer, including in respect of industrial property, transfer or pledge as part of sustainable and stable partnerships. TT may take the form of both technical assistance contracts, contracts "BOT" (Build-Operate-Transfer), scientific and technical cooperation, creation of joint activities (joint venture), programs training / information, industrial franchise, patent license or know-how, networking, partnership contracts subcontracting or co-contracting.

	Technology	Origin	Description	Strengths	Weaknesses	Cost
Mixed waste	**Anaerobic co-digestion**		A process whereby energy-rich organic waste materials (e.g. Fats, Oils, and Grease (FOG) and/or food scraps) are added to dairy or wastewater digesters with excess capacity. In addition to diverting food waste and FOG from landfills and the public sewer lines, these high-energy materials have at least three times the methane production potential (e.g. biogas) of biosolids and manure	Improved nutrient balance and digestion. -Additional biogas collection. -Possible gate fees for waste treatment. -Additional fertilizer i.e. soil conditioner Renewable biomass disposable for digestion in agriculture.	-Increased digester effluent COD. -Additional pre-treatment and Increased mixing requirements. -Wastewater treatment and Hygienization requirements. -Restrictions of land use for digestate. -Economically critical, dependent on crop.	Economic advantages of co-digestion can result from shared equipment, easier handling of feedstock, and a more stable process in general
	Anaerobic digestion		Bacterial fermentation of organic material without oxygen produces a biogas (mainly methane) and a digestate, or residue, which can be composted and used as a soil conditioner of fertilizer.	Valuable products produced – biogas can be used to power the plant and provide a renewable energy source. Digestate can be further matured into a valuable compost product.	This technology is not suitable for the garden waste fraction of the waste stream	Can be financially viable at between 15,000-20,000 tpa – so a much smaller scale than incinerators. Cheaper than incinerators and other "energy from waste" plants.
	Autoclaving		Waste is sealed in an autoclave and treated with steam at 140-160°C. After the steam has been injected the pressure is maintained for 30-40 minutes. Autoclaving uses a combination of heat, steam and pressure, for general residual waste it is used along with the mechanical action of rotation	Modular - Less noxious emissions than incineration - Some materials are captured for recycling - If steam is also collected within the autoclaves the process is energy efficient	No front end recycling – everything put through the system including hazardous municipal waste - Quality of materials sent to recycling low - Likely to produce RDF	
	Bioreactor landfills		A conventional sanitary landfill that uses enhanced microbiological processes to transform and stabilise the readily and moderately decomposable organic waste constituents more quickly than a conventional landfill. The most significant element of a bioreactor landfill is the addition and recirculation of water (as leachate) through the accumulated waste	- Accelerated waste stabilization - Rapid landfills conversion - Environmental safety - Recovery of 15 to % of landfill space as waste decomposes and is converted to gas extends the useful life of landfills, reducing the need to site new facilities. - Expanded and concentrated - Production of methane gas	- Relatively new technology - The increased moisture content of bioreactor landfill reduces the structural stability of the landfill. - Rapid accumulation of landfill gases, primarily methane may cause explosion of pipes. - Excessive production of H2S	Built bioreactor landfills have lower costs than traditional and retrofit bioreactor landfills, mainly because of air space recovery and leachate treatment Cost of aerobic landfills is greater than anaerobic when gas recovery and use is possible

Table 5: Analysis of technologies-mixed waste

	Technology	Origin	Description	Strengths	Weaknesses	Cost
Waste to Energy (WtE)	**RDF Incineration**	Germany	RDF or a substitute fuel or alternative fuel is a fuel that is produced from waste. This can be either low-refined, separated high calorific fractions or from waste produced fuels with a high treatment intensity. RDF/ alternative fuel can be produced out of waste from domestic, industrial or commercial product	Substitutes primary energy sources (in connection with financial savings or even proceeds from using RDF), Reduces the amount of waste for which other treatment and/or disposal options would otherwise have to be found, saves landfill space, Harmful content and reactivity of the waste is drastically lowered	Causes higher thermal stress and wear to the industrial combustion facility, faster deterioration of the installations in the result of rather aggressive corrosion, quality of flue gas is partially worse than that from the dedicated incineration of waste, may possibly alter products (cement, bricks, steel), produces reactive bottom ashes and slags, requires additional investment + more complex management and control	Costs less than the operation of a standard waste incinerator. The cost required for the option (MBT + RDF) is highly dependent on market, but it can cost the same and even more than the incineration option.
	Pyrolysis		Pyrolysis refers to the thermal degradation of waste in the absence of air, that is, waste is cooked to about 800C without O2. The waste falls apart, separating into a compact residue (char), pyrolysis oil and syngas		No universally accepted specification or standards for bio oil	
	gasification		Gasification is similar to pyrolysis but uses a small amount of air in the heating process. Hydrocarbons are broken down into a syngas by carefully controlling the amount of oxygen present			A base case scenario with a 680 ton/day would cost an estimated $150 million. A ton of waste may produce 0.8 MW of electricity, worth around $70 per MW. Payback about 8 years.
	Plasma arc	Canada, Japan, UK	This technology works by passing relatively high voltage, high current electricity between two electrodes, spaced apart, creating an electrical arc. Inert gas or air under pressure is passed through the arc into a sealed container of waste material. Temperatures more than 13,800°C are reached in the arc column. At these temperatures most types of waste are broken into basic elemental gases and solid waste	Cleaner and greener than incineration. Plasma recycling can cope with any kind of waste, including the most hazardous, high-grade, and hard-to-treat forms. Individual sub-systems are all very mature and established.	Improved version of incineration. The solid aggregate waste is considered a useful construction material, but to date its safety cannot be guaranteed.	

Table 6: Analysis of technologies-Waste to Energy

	Technology	Origin	Description	Strengths	Weaknesses	Cost
COMPOSTING	**Turned windrow**		The waste is accumulated into long stacks called "windrow" which are regularly mixed and manipulated.	Flexibility to vary the treated waste and the capacity	Requires a large area Can cause odour problems if the system is poorly managed The choice of a location for any outdoor installation may be difficult politically	Relatively low investment costs Relatively low operating costs
	Aerated static pile		Similar to turned windrow composting except windrows or piles remain almost stationary for the duration of the composting process.	Forced ventilation reduces the required area and helps to avoid odour problems It is not necessary to turn piles (reduced maintenance requirements) The necessary spaces are less than for the windrows, Good odour control, lower operating costs	- Higher investment costs in the case of windrows - Bad adaptation with fluctuations in the composition of waste - The dispersion of the forced air into the pile may not be uniform	Higher investment cost (forced aeration infrastructure)
	Covered channels		The waste is usually confined between parallel walls of any type, and regularly moved and returned with a suspended machinery.	Usually fitted in buildings, so normally no odour problems. Required space less than in the case of windrows.	As a closed chamber system, this system is not flexible to adapt to changes in the treated waste. The odour control system requires a large volume of air. Odours may occur off site if the facility is poorly managed	Moderate investment and operating costs
	Closed container		The composting process is carried out inside a container or a sealed enclosure, the environment is subject to tight control and limited access.	These systems are designed to create ideal composting conditions and produce compost as soon as possible. Uses the smallest area compared to all the composting techniques.	Requires a good level of technical and operational knowledge	Costly solution compared to other composting methods.
	Vermi-composting		Composting or natural conversion of biodegradable garbage into high quality manure with the help of earthworms. Earthworms play a key role in soil biology; they serve as versatile natural bioreactors to harness energy and destroy soil pathogens. One of the best options available for the treatment of organics-rich solid wastes.	- Effective of treating pathogen-rich waste materials and domestic solid and liquid - wastes - requires little space in which to operate - enriches soil	Takes Time Noticeable Odor	Relatively inexpensive technology, particularly when compared with in-vessel composting technologies

Table 7: Analysis of technologies-Composting

4.3 Examples of waste technologies from Morocco and the Arab region

The main objective of this section is to stress effective technologies that can be adapted to the region, and may be of interest to contribute to more effective management of waste as a secondary resource.

4.3.1 Attawafouk waste collector cooperative (Morocco)

A significant portion of the waste sector in Morocco operates in an informal manner, particularly with regards to waste sorting, recycling, and disposal in uncontrolled facilities. The World Bank loan agreement to support the National Solid Waste program (PNDM) carries provisions that encourage waste collectors inclusion initiatives to ensure that waste collectors from the informal sector are systematically integrated into the sector restructuring and upgrading.

A successful example of this initiative is the Attawafouk waste collector cooperative that was developed with the assistance of an international NGO, Care, and the private landfill operator, Pizzorno. Implemented in June 2011 after the initial phases began in 2007, waste collectors from the informal sector working in the closed landfill in Akreuch were organized into a cooperative and now work at the new sorting facility at Oum Azza near Rabat, Morocco (figure below).
This facility is the most important industrial landfill for waste treatment of Rabat, Salé and Temara: 700 000T / year. It is characterized by:

- Sealing containers
- Reverse osmosis treatment of leachate (480 m3 / J)
- Sorting center (1st in Morocco)
    - Entry Point in the valorization: separation of organics, recyclables and residual waste
    - Consolidation of "old informal sorters" in a cooperative for sorting material
- Daily anti-odor treatment
- Environmental monitoring - analysis of surface water and groundwater
- Biogas treatment: CDM pilot project with the FEC and the World Bank

Sorting center and platform movement and storage

Organic matter separation

Sorting table

The lessons learned from the Attawafouk Cooperative project are:

- To include a provision requiring a social plan for the inclusion of waste collectors in Public-Private waste service provider contracts for controlled landfills;
- Transitions from the informal to formal sector must be systematically integrated into national or local government policy.

The World Bank has slated a third municipal solid waste sector Development Policy Loan (DPL) to continue providing support to Morocco in developing its solid waste management sector. The focus will remain on reforming the institutional and financial framework; providing financial and capacity building assistance to local authorities; advocacy and program communication. A larger focus will be given to social aspects through the development of recycling and sector strengthening that is aligned with Morocco's initiatives for regionalization.

4.3.2 Industrial and hazardous waste treatment center (Tunisia)

The implementation of a treatment center for industrial waste in Jradou (Tunisia) could be seen as a model for others Arab countries. According to a case study by Sweep-Net, the cost of restructuring and redefining the center of Jradou cost approximately 32 million Dinars ($20 Mio). It contained physical-chemical treatment, stabilization and solidification, buildings for short-time storage of valuable or untreatable waste, a landfill for pre-treated solid waste and a laboratory. Over a period of 16 months the center has processed 12 000 tons of industrial and special waste.

Landfill for pre-treated solid waste

Short-time storage of valuable or untreatable waste

Waste Analysis Laboratory

The operation of the center as well as the maintenance of equipment was suspended since February the 28th, 2011. Earlier in the same year, representatives of citizens complained about Jradou and filed a law suit. The Court of the first instance at Zaghouan stated that ANGed has to change the treatment process in order to achieve an activity that does not generate leachate.

Despite the cessation of the Jradou installation, the implementation of national program for the management of the hazardous industrial waste with all its components (transport organization, process tracking and tracing, waste treatment by type of waste) is a technological example that can serve as an example for other countries because it had come to treat 12.000 tons of hazardous industrial waste according to the contractual technical standards within 15 months prior to its closure. This experience could be replicated in other countries in the region, but with some recommendations to avoid past pitfalls:

- Ensure that the very dangerous pollutants are not mixed or concealed in other waste. This would cause more environmental degradation.
- Adapt technologies to types of waste: radioactive, explosive or waste from health-care activities
- Raise the awareness of residents and ensure more and full transparency in the management, the origin and outcome of hazardous waste

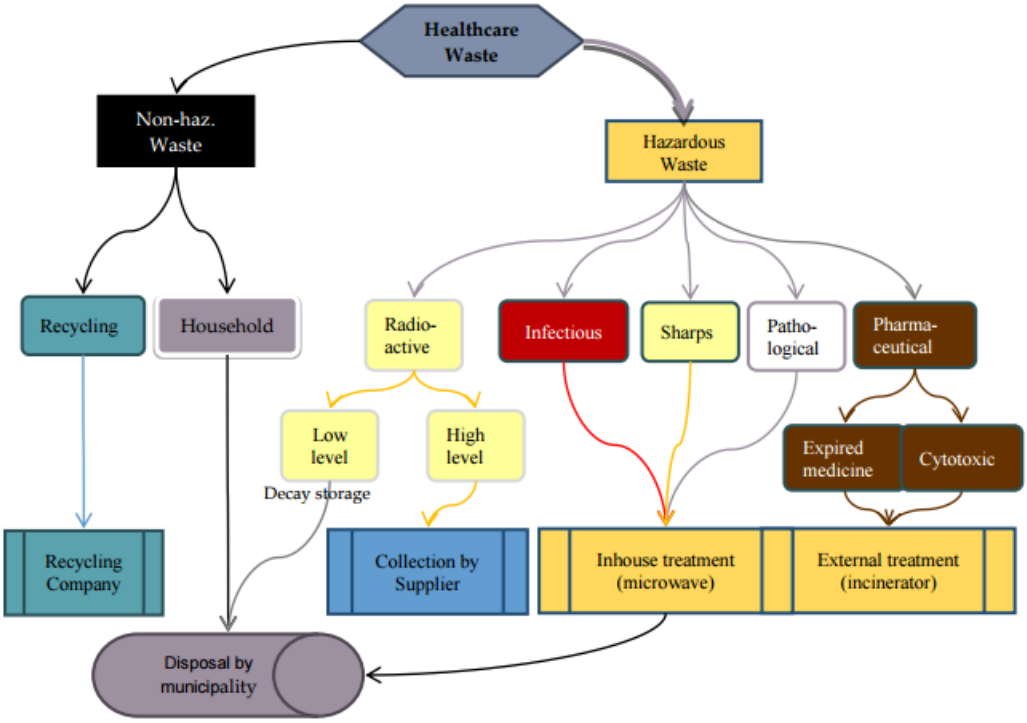
These recommendations could be very useful, especially for the future National Center for Special Waste Treatment (CNEDS) in Morocco.

4.3.3 Medical and pharmaceutical waste treatment at the Mohammed VI University Hospital Center in Marrakech (Morocco)

In Morocco, the Mohammed VI CHU (the University Hospital Center) in Marrakech is committed to improving its waste management system both internally as well as regionally. The Marrakech CHU eliminates its hospital waste and began a selective sorting system that has considerably improved the quantity of medical and pharmaceutical waste going to the municipal landfills (99781 kg before sorting and 5757 kg respectively after sorting).[18]

The hospital segregated waste as follows[19]:

[18] Sweep-net (2013) Country report Morocco, http://www.sweep-net.org/document/country-report-morocco-2013
[19] Pieper, U., Bisbjerg, Pd. (2012) Sustainable Capacity Development of Authorities responsible for waste management and relevant private companies in Morocco



It was reported that the hospital is generating about 800 kg of hazardous healthcare waste per day. This is approximately 0,58 kg per occupied bed per day[20]. The household waste is transported by the hospital cleaning staff, stored at an interim storage place and collected by the municipality. Parts of the hospital have a source separation system for plastic and cardboard.

Cytotoxic waste is collected in brown bags and collected by an external company. Low level radioactive waste is stored for decay, documented and then collected by an external company. The decay room is coated with lead, but not labeled and insufficiently equipped (waste is stored on the floor). Toilet waste from the cancer wards is stored in two underground tanks and left so that all radioactive materials can decay. Radioactive source Cobalt 60 which is categorized as high level waste (half-life time of 5,23 years), is stored separately and collected by a specified company (supplier). The whole process is overseen by a physicist. The healthcare waste is collected from the hospital's internal storage areas by an external contractor, transported by trolley to the central storage area. Here the waste is weighed and labeled with bar-code labels. From the storage, the healthcare waste is transported for final treatment in Casablanca and Tetouan.

[20] Pieper, U., Bisbjerg, Pd. (2012) Sustainable Capacity Development of Authorities responsible for waste management and relevant private companies in Morocco

New microwaving system at the hospital

Test treatment (microwaved and shredded)

The hospital center has purchased two Sterilwave 440 microwave treatment units from Bertin in France. These can treat 30 kg per cycle and altogether about 1,2 tons per day.

- Necessary next steps include: develop a standardized Standard Operating Procedure for the handling of healthcare waste
- Set up of a certification system for the responsible persons on healthcare waste management, which includes regular updates of the certificates. Only certified persons should be allowed to be appointed as responsible person
- Update and revise the existing hygiene education materials in universities, institutes and medical schools in regard of safe and environmental friendly healthcare waste management.

4.3.4 Waste to energy from paper and cardboard manufacturing rejects (Lebanon)

The paper & cardboard manufacturing sector generates at the end process non-hazardous waste called rejects, mainly non-recyclable plastics. These rejects (waste) are converted to energy using the combined heat and power gasification process. 6,000 tons of waste per year create 80,000 MW of energy used in the industrial facility as electricity and in boilers.

Realized gains are as follows:

- 1 ton of waste creates 3.5 MW of energy – equivalent to 300kg of fuel oil
- Waste Reduction: 88% in weight and 95% in volume
- Gradual Phasing out of fossil fuels and creation of 25 new green jobs

The investment is about 5,000000 USD and the payback is around 4 years.

4.3.5 Paper and cardboard recycling (Morocco)

GPC company has set up a collection, sorting and recycling of waste paper to reduce and recycle waste packaging manufactured and marketed the company. The recycling process is as shown in the figure below.

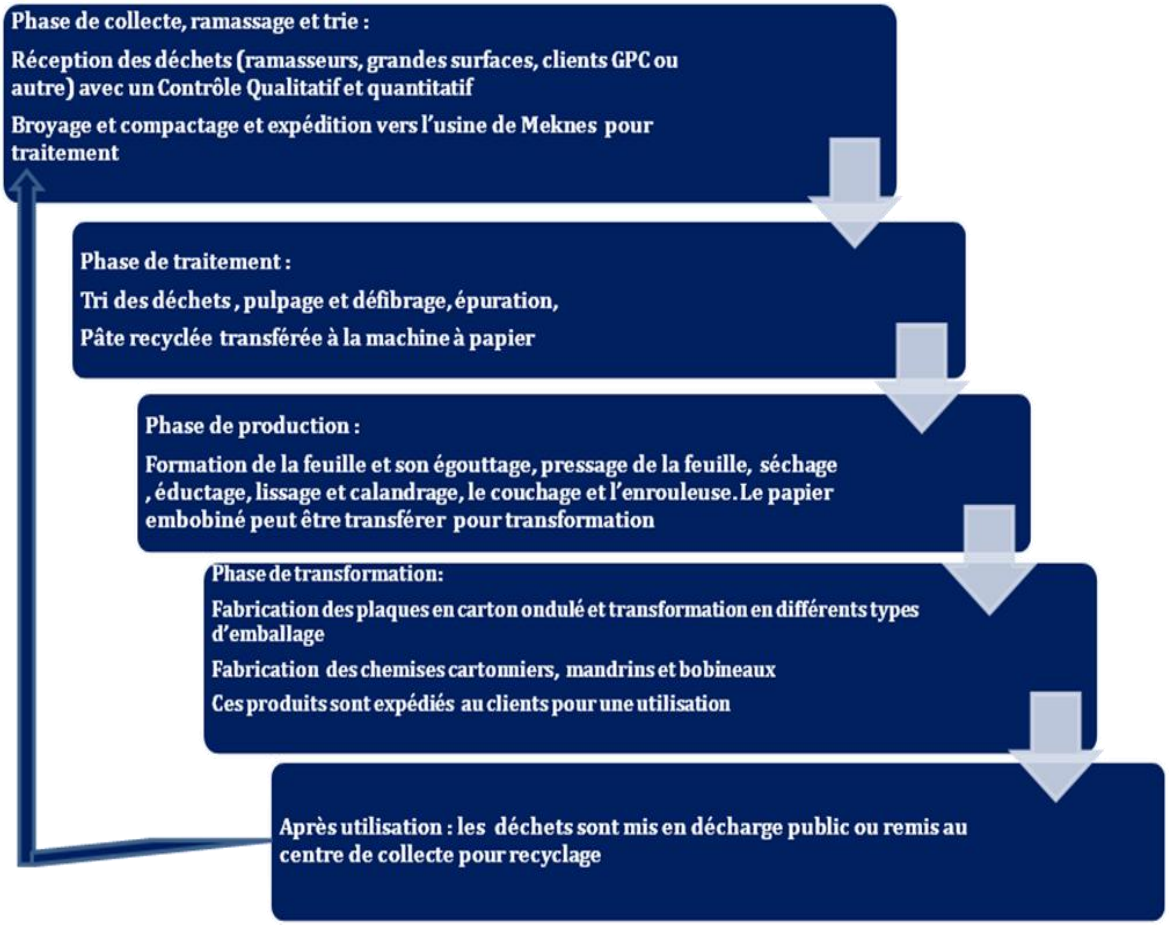
The economic impacts of the paper and cardboard recycling include:

- Reduced purchasing costs of raw materials, wood, water and energy
- Opportunities for direct and indirect employment for low-skilled staff through the creation of cooperatives and collection of paper and cardboard waste.
- Cost reduction at the Waste Management (Economics consumption linked to incineration, composting or landfill)
- Economics of extraction, collection and transport of the raw material.

- Economy of the high costs of importation of virgin paper

Environmental benefits include:
- Each tone of recycled paper saves: 1.41T of wood, 48.2 m3 of water, 0.04 TeqCO_2

Weaknesses in the paper and cardboard recycling experience include an unstructured collection system and the fact that the collection rate in Morocco is among the lowest in the world (less than 30%).



4.3.6 E-waste recycling (Egypt and Morocco)

Egypt: Recyclobekia company for e-waste recycling:[21]
Recyclobekia is an electronic waste recycling company based in Egypt that serves the Middle East and North Africa (MENA) region. It is the first company in the Arab world offering green recycling of electronic waste and safe data destruction services, creating revenue from the precious recyclable materials inside e-waste. Currently, RecycloBekia conducts e-waste collection, transportation, dismantling / refurbishing, and sorting. The refining process is conducted outside Egypt with a partner company in Europe. Since the establishment of RecycloBekia, the company has recycled about 60 tons of electronic waste (Sweepnet 2014).

The company receives e-waste from dealers and SMEs and is cooperating with a refining plant in Europe and cartridge recycling companies in Egypt and Singapore.
RecycloBekia targets to reach all segments from private and public sectors to each individual in the society, however the company now works with the private and public sector where there are large quantities and requires less marketing cost.

The management of RecycloBekia is willing to expand the business in the MENA region by 2020 and aims to build a refinery which will revive Egypt's economy and create more jobs. Particularly, they are looking to expand the business to the K.S.A & U.A.E through local partnerships and financing mechanisms from impact investment ventures or interested holding companies. [22]

According to the CEO of RecycloBekia, “This business is complex and you have to know where you would put your money or you are going to lose it all”
- You have to know the nature of region you are working on;
- The business should start small with minimum resources and then grow as you gain experience.

Morocco: Managem urban mining project:

[21] Changemakers (2015), Unilever sustainable living young entrepreneurs awards, http://www.recyclobekia.com/
[22] https://www.changemakers.com/discussions/entries/new-entry-156

The Moroccan mining company Managem Group is a key player in the mining and hydrometallurgy sectors.[23] For over 85 years, the group has been operating in the extraction, development and marketing of base metals, precious metals, cobalt and other minerals, in Morocco and Africa. As part of the sustainability strategy of the company, Menagem has implemented a "zerowaste" program that aims to put the tailings through a recycling process. Waste generated by mining operations is thus transformed to create new business opportunities by making resources available for the development of new products. Electronic items contain precious metals, a resource which has not yet been exploited. In 2010, Managem has decided to set up an “urban mining” project which includes the environmental, industrial and social dimension.

In order to organise the collection, regrouping and treatment of e-waste, the group first entered in a partnership with Al-Jisr, an NGO aiming at improving the performance of the Moroccan education system. In this context, a partnership agreement between Managem, Al-Jisr, the foundation Drosos, the Ministry of National Education and the Ministry of Employment and Professional Education made it possible to set up a “Green Chip” workshop for the training of out-of-school young people in e-waste dismantling. Electronic chips are directly valorized in the Managem unity of Guemassa, while other compounds, such as plastics, steel, etc. are being sent to the corresponding recycling branches.
Some of the expert key recommendations for the Strategic Steering Committee provided in the Technical report on the assessment of e-waste management in Morocco are:

- Perform an international benchmarking to develop a system appropriate for Morocco;
- Formulate a specific application decree for e-waste management;
- Help to establish a sustainable e-waste system (policy, regulations, collection, transport, storage,
- dismantling, crushing/ mechanical sorting, management of hazardous e-waste disposal, recovery and export) and structure the sector.
- Develop an information gathering and surveillance system
- Establish an extended producer responsibility (EPR) system for entities that import, produce anmarket electronic or electric products;
- Develop outreach, awareness and education programs and campaigns on the issues surrounding e-waste;
- Study and establish the required infrastructure for each stage of the e-waste value and disposal chain

An economic feasibility of e-waste recycling in Morocco stated that, although currently, e-waste recycling businesses in Morocco can be run by relying on the intrinsic value of the treated material only, changing conditions can pose relevant risks to the business. (EMPA, 2011) Sustainable recycling businesses can therefore only grow in Morocco in combination with a comprehensive institutional, economic and financial framework, which ensures:

1. that business sustainability is guaranteed under unfavorable economic conditions, i.e. an additional flexible income stream enabled through a financing scheme needs to be established for situations where the intrinsic value of the treated material is not sufficient for a break-even;
2. that recycling businesses can grow in a level playing field; i.e. that legislation, as well as monitoring and control mechanisms favor high standard operations;

[23] Menagem (2011) Corporate Presentation, www.managemgroup.com/content/download/861/5719/file/pr

3. that market incentives are put in place to achieved high collection and recycling rates

The study concluded, that in the absence of a financing scheme, a level playing field and the right market incentive it is likely that recyclers will not be interested in investing into sound operations and that cherry-picking activities with low environmental and social performance as well as low collection and material recovery rates will prevail the situation in Morocco.

4.3.7 Used cooking oil (Morocco)

The production of biodiesel from waste vegetable and/or fish oil offers a triple-facet solution: economic, environmental and waste management. The main technology in biodiesel production is transesterification which requires heating a mixture of 80–90% oil, 10–20% methanol, and a catalyst. The catalyst is usually an acid or a base, but bases such as NaOH and KOH are more common, in part because transesterification can happen at a lower temperature. Methanol is more commonly used in the production of biodiesel than ethanol.

"Kilimanjaro Environnement" is a company specializing in the collection and recycling of used cooking oil, from which it produces biodiesel. The company made a choice to invest in this niche with positive environmental, social and economic impacts. Being the leader in the national market for the collection and recycling of used cooking oils and fats, Kilimanjaro Environment focused on waste, called "liquid biomass" that are dumped every year by individuals, industries, restaurants and hotels directly into sewers. Kilimanjaro Envionnement, launched a tasting phase in early January 2015 for the collection from individuals in some neighborhoods, in order to initiate the Moroccan household to source separation and recycling of waste. This home collection project will eventually create 2,000 jobs, reducing CO2 emissions by nearly 230,000 tons of waste a year and contributes to the emergence of a sector estimated at 1 billion DH.

The pilot plant has a production capacity of 100 tons per month and could evolve up to 300 tons per month thanks to its scalable unit. The production is destined exclusively to the export.
Collection is done in three steps:

- The customer receives returnable barrels, that are clean and comply with food standards; and a collection frequency is defined according to the availability of oil in each location.
- Upon collection the receipt of oils and traceability of transactions is recorded an attested to the customer
- Each end of the month, the customer receives a detailed reporting of the amounts collected. The oil is then stored in tanks of a ton before being processed and exported

The cooking used oil transformation process could be refined to achieve a better yield in biodiesel with less energy and better quality of the final product.
This experience should be supported at the regional scale for better optimization of the biodiesel production process. Then it could be transferred to other countries in the region.
It could also be generalized to the case of fish waste which is very rich in oil, which would however require previous separation of the oil from the food waste. There is large potential for other food waste oils that can be separated from water and used as raw material for biodiesel production.

5 FINANCING APPROPRIATE AND INNOVATIVE TECHNOLOGY FOR WASTE MANAGEMENT IN THE ARAB REGION

5.1 Current and future profile of key innovations, trends and opportunities

Emerging opportunities in the waste and resource recovery sectors are outlined in this study. The viability of different resource recovery and management options and technology and innovation options are influenced by knowledge and public information on trends in international commodity prices as well as trends in environmental asset pricing, including carbon and water pricing and finally, landfill pricing.
Waste trends are complicated and resource recovery rates are dependent on factors such as the effectiveness of recycling systems,material processing and marketing systems as well as international commodity markets. These trend lines should be examined and discussed for waste streams based on current and past practices and data. Data should be collected to enable opportunities for appropriate and innovative technologies to be quantified and substantiated.

Funding options for waste management In Morocco, the following programs could be important financial and economic instruments to accelerate technological innovation especially in industries:

- Programs "Imtiaz" and "Moussanada" set up via ANPME; one targeting the support of high-growth potential companies for the granting of a premium to the material or non-material investment; and the other accompanying companies in their efforts to modernize and improve their productivity and performance. This includes the promotion Profitable Environmental Management (GEPreC), which supports resource efficiency.
- The industrial pollution Fund (FODEP) aimed primarily at encouraging the implementation of actions contributing to the protection of the environment and pollution mitigation. This is a tool to help finance installation projects to reduce or eliminate the pollution caused by industrial enterprises, and other projects of collection and waste recycling units.
- The voluntary mechanism, industrial pollution of water (MVDIH) that is reserved for industrial water pollution, as a continuity of the environmental upgrading of Moroccan enterprises.

Other economic / financial instruments can also be cited, such as the Hassan II Fund for economic and social development, Energy investment company (SIE) and environmental ecotaxe on plastic products that will help the National Environment Fund (FNE) and help finance projects aimed at the development of the recycling industry.The Moroccan National Cleaner Production Centre, even though not a funding source, has a role to play in identifying potential funding opportunities for clean technology and facilitating the network between the relevant stakeholders. The CMPP aims to further the application of appropriate technologies through its support to small and medium enterprises in adopting more resource and cleaner production techniques. The Centre has built capacity of industries in improving efficiency in the status of production systems / equipments in order to reduce wastage of raw materials and energy aimed at minimizing waste generation at source.

<u>Internationally,</u>

- A program to support the transformation of MSW sector in Morocco was implemented thanks to a program financed by the World Bank (2009-2011) that helped support waste

policy. The program provided the necessary regulatory framework to create the conditions for implementation of integrated systems for municipal solid waste management. A new loan of 130 million USD for the MSW management was recently approved. This loan comes under the financing relating to the fourth loan Household Waste Sector Development Policy.[24]

- The PGPE-GIZ support program, supports the feasibility study and the implementation of several pilot projects for innovation in the waste sector and promoting biogas and resource efficiency.

MENA region level:

The distribution of climate finance is concentrated in Egypt and Morocco, with total amounts approved of USD 195 million and USD 640 million, respectively. 88% and 96% of Egypt and Morocco's respective approved finance has been for mitigation projects. Over 96% of this finance has been for large-scale wind and CSP projects, primarily through the CTF, but USD 61.6 million has also been approved for eleven projects focused on energy efficiency, sustainable transport and small-scale solar technology. CFU data shows that of the 21 MENA countries, only 11 countries are recipients of climate finance. The granting of these funds has been conditioned by criteria such as level of vulnerability, lessons learned in project and program design and implementation, and adaptive capacity to the adverse effects of climate change.

It is important to emphasize that the funding of technology and innovation needs to be examined based on the cost benefit of solutions implementation. The financing of waste management improvements should be discussed case-by-case. In the absence of a Life Cycle Approach, landfilling is the most cost effective approach to meeting sanitary objectives associated with waste disposal. Therefore there is an urgent need to provide additional means of funding for the implementation of new and innovative technologies to overcome these commercial and financial barriers. This could possibly come through infrastructure grants linked to environmental performance outcomes.

6 CONCLUSION

In conclusion, this study was conducted with the aim of drawing up an inventory of relevant and innovative technologies as well as examples of appropriate technologies tested in Morocco and the Arab region.

Much of the progress to date in waste innovation seems to have been in the area of development of new technologies to treat wastes. In the case of Arab region, there is evidence of many appropriate and innovative technologies, and efficient waste management approaches focusing on waste prevention, waste minimisation, source separated collection and specific technologies for treating particular waste streams. However, apart from assessing what would be an appropriate waste technology, comprehensive waste management requires a functioning, efficient and accountable institutional, regulatory and financial framework.

[24] World Bank (2015), US$ 130 Million to support recycling and improved solid waste management in Morocco, http://www.worldbank.org/en/news/press-release/2015/02/12/130-million-support-recycling-improved-solid-waste-management-morocco

As a solution for better improvement of waste management in the Arabic region, the following recommendations would facilitate the process:

- A regulatory, institutional and accountability framework that considers waste management and related green technology application a priority
- Introduction of waste fees and regulation of the finances,
- Encouraging multi-stakeholder involvement in every stage of waste management,
- A statistical monitoring system and data recording to address the lack of data on waste
- Training and further education, and development of a national communication strategy to advocate for the reduce, recycle and reuse waste
- Enhancing the recovery and recycling of waste streams can improve the efficient use of materials, save waste and reduce GHG emission
- Better management of organic waste that would offer opportunity to deliver sustainability and innovation benefits through for instance anaerobic digestion (biogas) waste for energy production
- The policy should focus on 'fit-for-purpose" technology, facilities and business models that enable business development and growth and business certainty for investment.
- The policy may set a national/regional target and treat waste as a resource that will provide opportunities for the development of new processes, technologies, industries and jobs
- Capacity building at regional level
- Waste management policy should have a clear focus on prevention and resource efficiency: countries in the Arab region should establish national plans and/or programmes, dedicated to efficient waste management and more generally to resource efficiency, promoting concepts such as circular economy, industrial ecology, cleaner production, etc.Construction and modification of waste treatment plants, well-regulated landfill sites, hazardous waste treatment plants,

- Creating business opportunities: matching research and business to create solutions and accelerate innovation:
  - Research into improving recovery and reprocessing technologies
  - Develop research and adapt technologies to small scale waste processing (organics)
  - Develop research and technology in thermal/biological conservation field, plasma arc technology for hazardous waste,
  - Creation of research centres on technological innovations in the waste sector
  - Creating technology transfer centres in the waste sector (regional and national)
  - Developing waste exchanges (the waste of one could be the input of the other)
  - Providing incentives to efficiently collect and transport materials to strategic locations for reprocessing
  - Providing incentives to develop local and export markets for recovered materials and value added products, and encourage the community and businesses to actively participate in these schemes
  - Realisation of pilot projects to gain practical experience, monitoring and reporting

- Creating and enabling environment for innovation and green growth:

- increasing funding for science and technology research and innovation in the waste sector; and fostering collaboration among Arab countries on science and technology for development
- encouraging relevant professional management expertise

Having assessed strength, weaknesses and cost of various technologies for waste management, as well as presented examples of technologies applied in the region, the study aims to provide a basis for stakeholders in the waste management sector to build on. The workshop, which will be held in Casablanca on 29-30 September 2015 will provide further insights into opportunities for waste management and provide an opportunity for knowledge exchange and networking.

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