



Regional workshop:

Innovative technologies for waste management in the Arab Region –  
paving the way for the transition to a green economy

**REVIEW OF INNOVATIVE AND APPROPRIATE TECHNOLOGIES FOR  
WASTE MANAGEMENT IN MOROCCO AND THE ARAB REGION :  
Outcomes of the background paper, with best practice examples**

Casablanca, 29<sup>th</sup> -30<sup>th</sup> September 2015

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# Plan

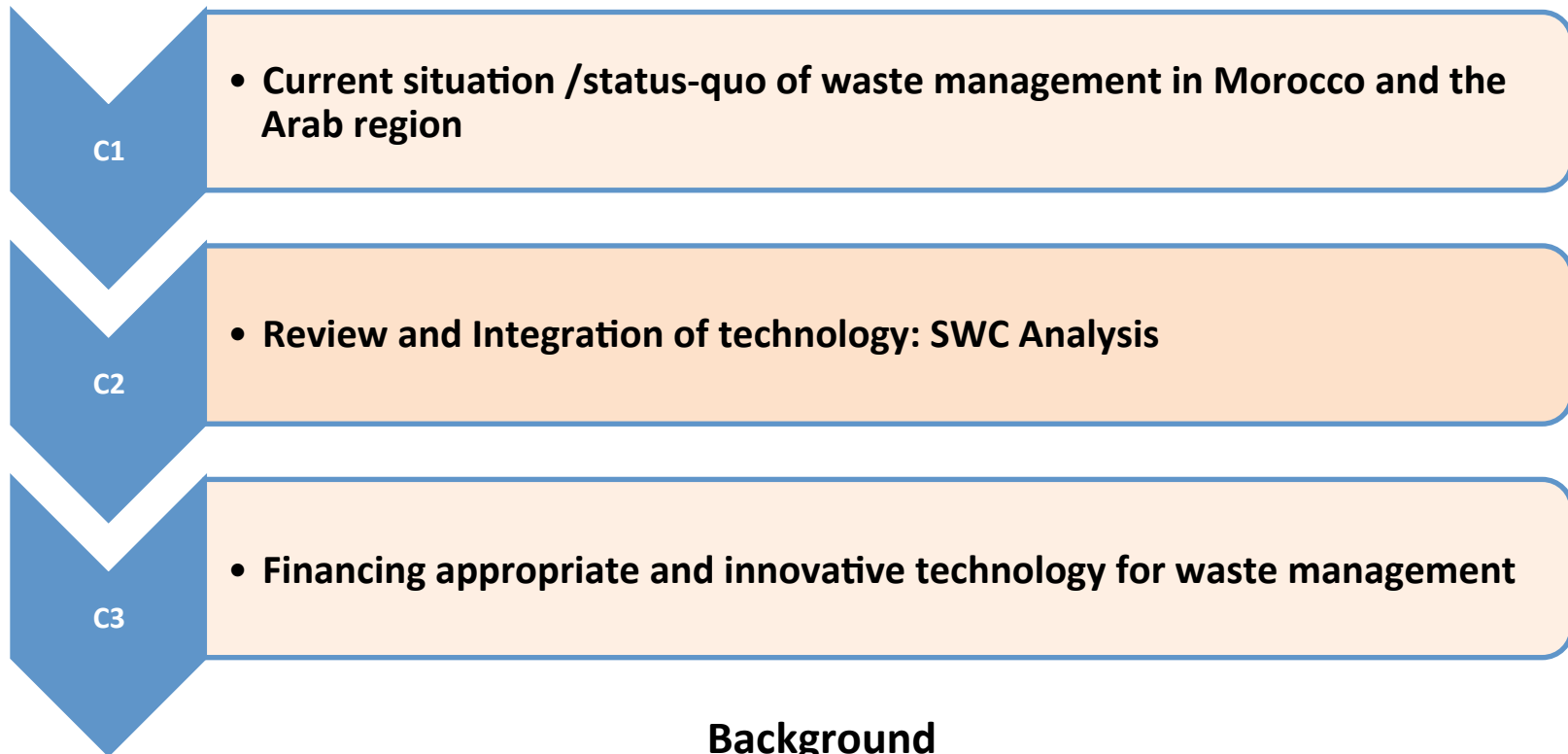
- ➔ **Objectives and methodology**
- ➔ **Current situation**
- ➔ **Innovative and appropriate waste technologies for the Arab region**
- ➔ **Financing appropriate and innovative technology for waste management in the Arab region**
- ➔ **Recommendations**

# Objectives

- **Mobilize all participants** about appropriate and innovative technologies in the waste sector and their role as a driving factors of competitiveness.
- **Generate, Foster exchanges, discussions and debate among the participants on the technological and institutional aspects** for more efficient waste management.

# 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.



**Background  
paper**

# Comparative study on the waste situation in the Arab region(LAS).



ESCWA



SWEEPNET  
ANGeD-GIZ

BACKGROUND RESEARCH

This comparison will allow us firstly to assess the **degree of progress** in the collection, treatment and disposal of waste

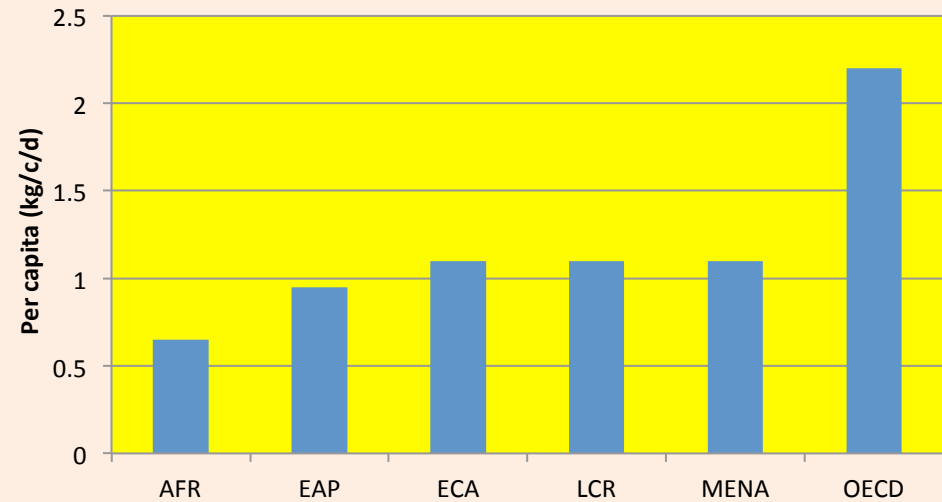
# Current Situation



Population	410 Millions (2014)
MSW generation	93.2 Millions Tons/year
Per capita MSW generation	0.89 kg/p/day
MSW growth	2.75 – 3 % per year

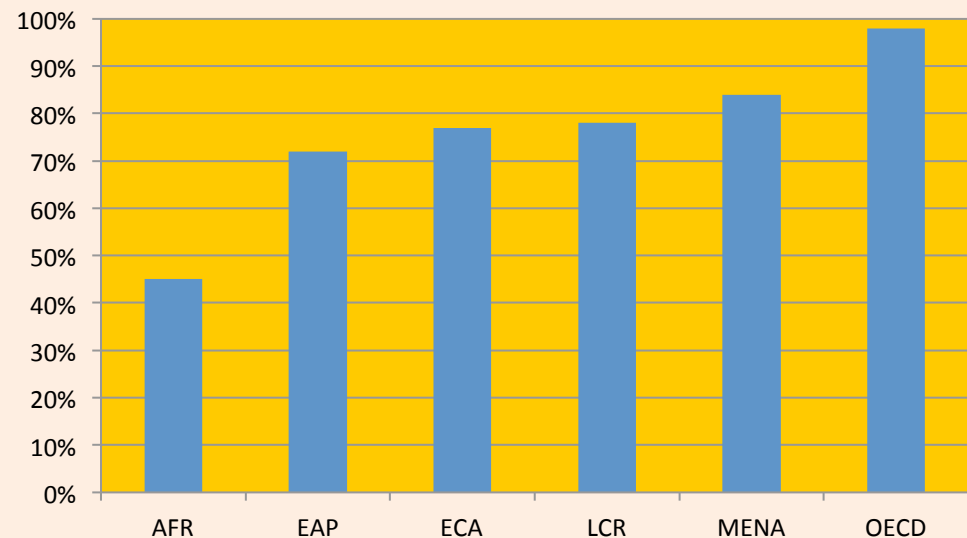
# Current Situation

## Waste Generation by region



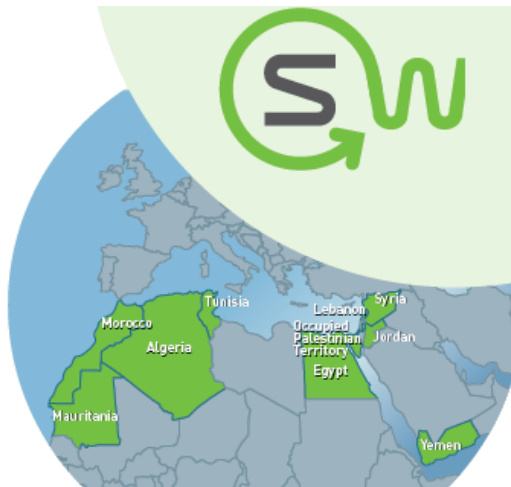
## MSW collection by region

In many Arab countries, up to 50 % waste generated goes **uncollected**, and collected household waste **is mixed** with industrial and medical waste during handling and disposal.

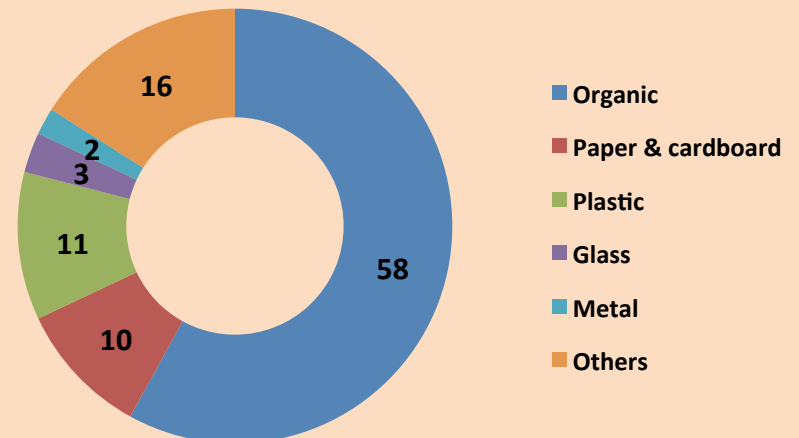
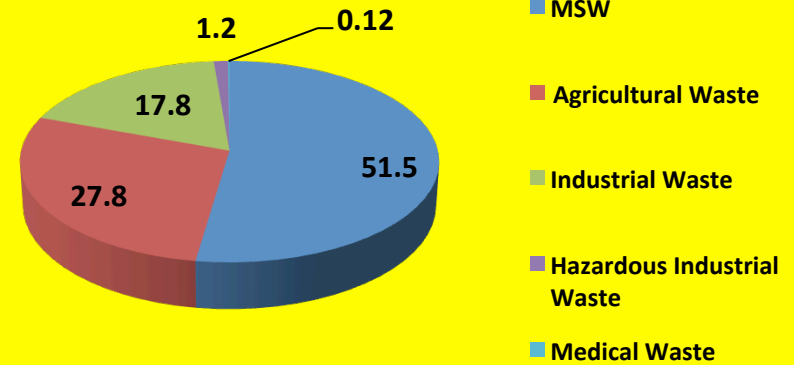


# Current Situation

## Waste category



## Waste composition

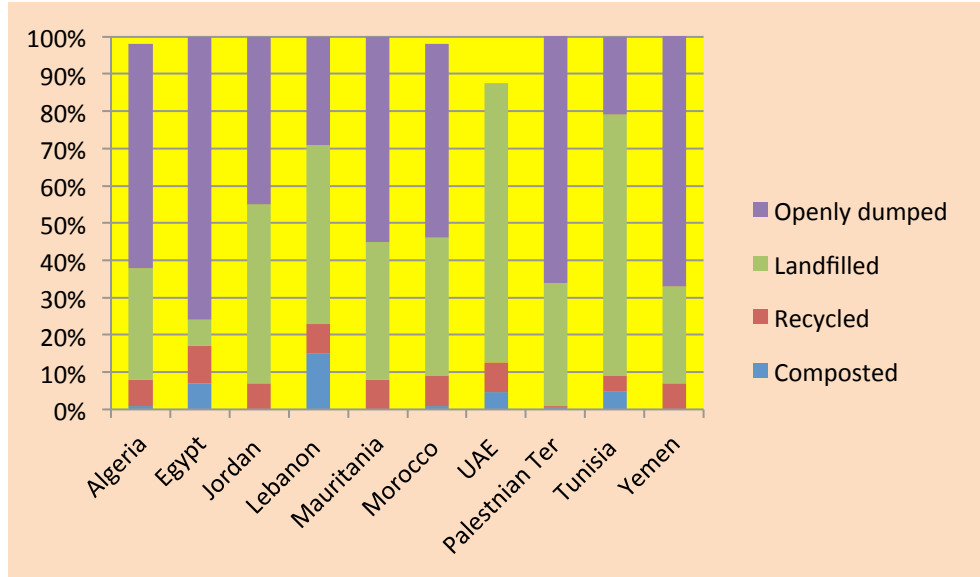




# Current Situation

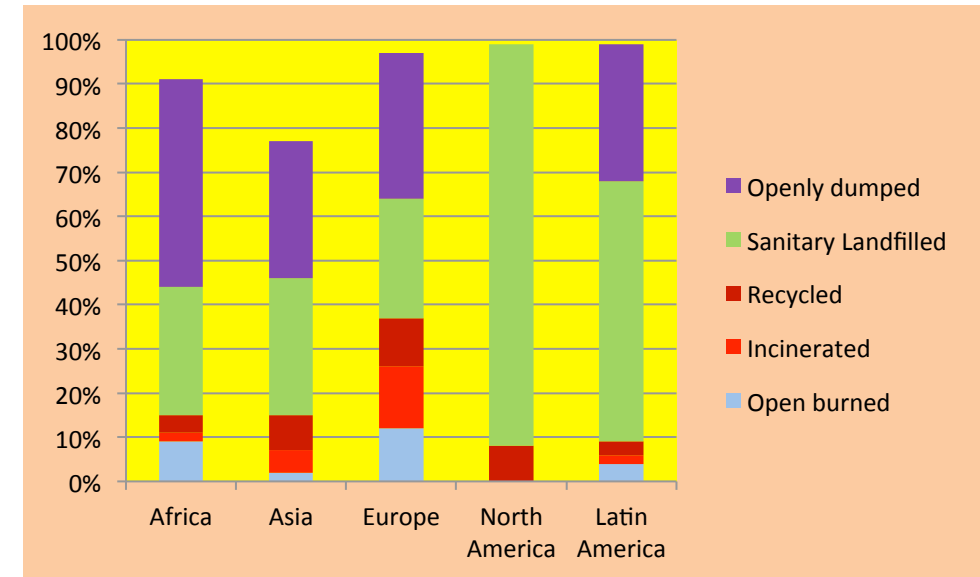
## MSW disposal by country\*\*

Composting, Landfill, Recycling



\*\*<http://www.afedonline.org/afedreport/english/book8.pdf>

## MSW disposal by region\*



\*World Bank, 2012

## Summary:

- In many Arab countries, up to 50 % waste generated goes **uncollected**, and collected household waste **is mixed** with industrial and medical waste during handling and disposal. (need of efficient Mgt: Resources, Tech.)
- In addition, the **collection of statistical data** on waste generation, composition and management does not rely on waste surveys or other data collection tools. (need of IS, TIC and Resources)
- 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 (poorly managed). (need of efficient Mgt: Resources, Tech.)
- Generation of waste in the Arab region is governed by **MSW representing more than 50%**, followed by agricultural and industrial waste ( focus on these three types of waste in our study)

# Innovative and appropriate waste technologies for the Arab region

## Survey of available and innovative waste technologies

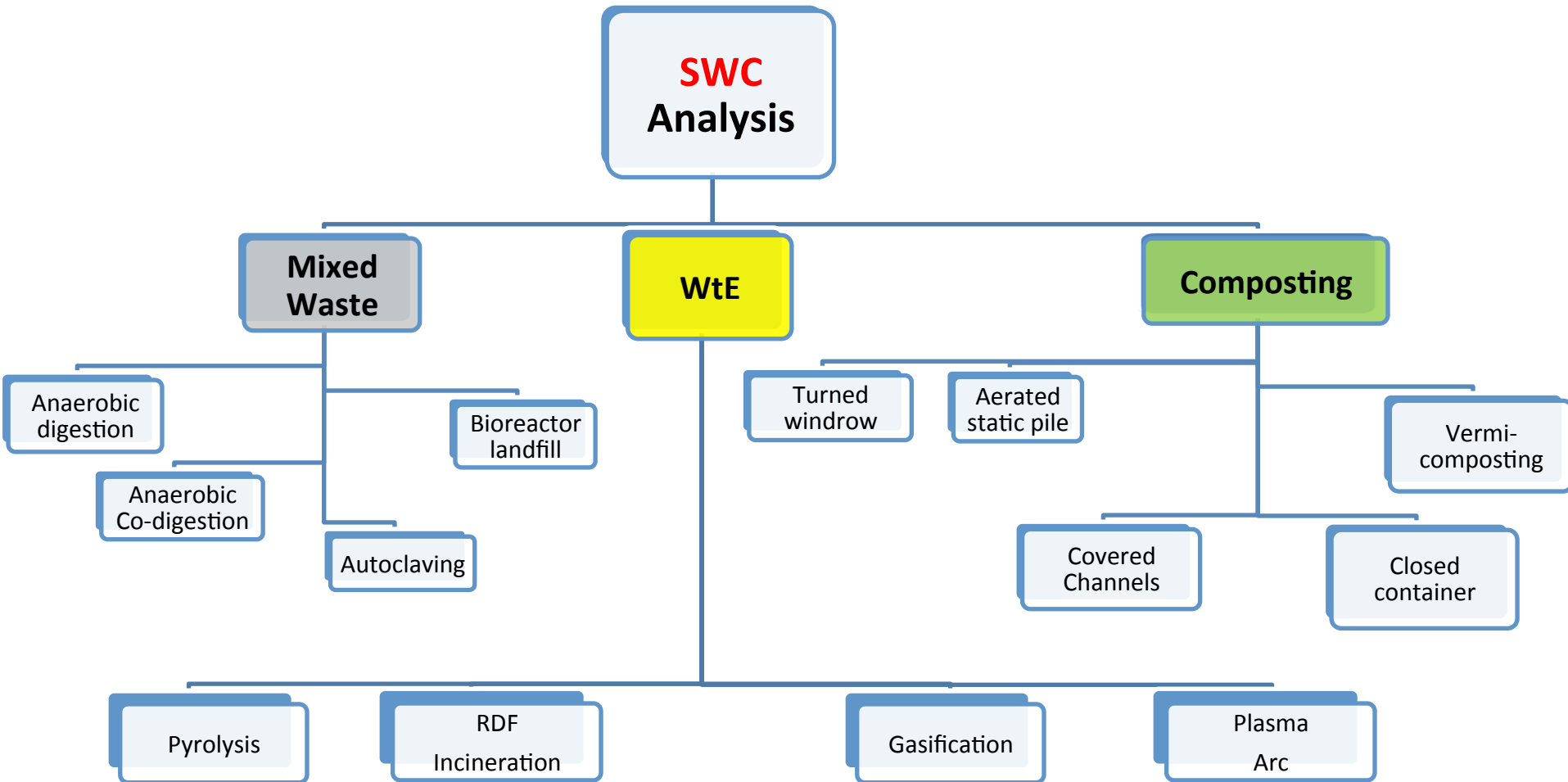
Technology type	Waste Stream							
	MSW	C&I	Hazardous W	M&PhW	Food organics	Mixed plastic	Paper and cardboard	Glass
<b>Mechanical Separation</b>	Improved sorting techniques	Improved sorting techniques	Big Oversized Blender	-	Dry processes (Trommels) and wet processes	Optical sorting	Improved sorting techniques and reprocessing to same plastics	Optical sorting for improved recovery and re-use applications
<b>Biological</b>	Anaerobic and aerobic digestion, composting, biofuel production, bioreactor landfill	Anaerobic and aerobic digestion, composting, biofuel production, bioreactor landfill	Bio-remediation, phyto-remediation	-	Anaerobic digestion, composting		Anaerobic digestion, composting	-
<b>Thermal</b>	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 (RDF)	Fuel production (RDF)	-
<b>Chemical</b>	Hydrolysis	Hydrolysis	Molten metal catalytic extraction	Hydrothermal oxidation OHT	-	Pyrolysis and plasma arc	Pyrolysis	-

# Innovative and appropriate waste technologies for the Arab region

Technology type	Special waste Stream							
	Dry cell batteries	Wet cell batteries	Spent Solvents	Spent Acids	Sludge	Oils and lubricants waste	E-waste	Tyres waste
<b>Mechanical Separation</b>	Handling and disassembly systems, super cooling and shredding	Handling and disassembly systems, crushing and screening	Decantation	-	-	Decantation	Automated disassembly and handling, reprocessing of components	Crumbing, civil engineering uses
<b>Biological</b>	-		-	-	Auto-purification, aerobic-anaerobic			
<b>Thermal</b>	-	Refining and smelting	Incineration	-	Des-hydratation	Incineration	Pyrolysis	Fuel production (RDF), steam gasification, gas phase halogenation, pyrolysis
<b>Chemical</b>	Neutralised electrolytes, hydro-metallurgy	Electrolytes filtering, paste de-sulphurisation, leaching	Distillation	Distillation	-	refining	Extract metals by supercritical water oxidation process	Devulcanisation, plasma, fuel production, continuous reductive distillation

# Innovative and appropriate waste technologies for the Arab region

## Analysis of the technologies: SWC







# Innovative and appropriate waste technologies for the Arab region

Area	Technology	Strengths	Weaknesses	Cost
Mixed waste	Anaerobic co-digestion	<ul style="list-style-type: none"> <li>-Improved nutrient balance and digestion.</li> <li>-Additional biogas collection and fertilizer</li> <li>-Renewable biomass disposable for digestion in agriculture.</li> </ul>	<ul style="list-style-type: none"> <li>-Increased digester effluent COD.</li> <li>-Additional pre-treatment and Increased mixing requirements.</li> <li>-Wastewater treatment and Restrictions of land use for digestate.</li> </ul>	-Economic advantages of co digestion can result from shared equipment, easier handling of feedstock, and a more stable process in general
	Anaerobic digestion	<ul style="list-style-type: none"> <li>- Valuable products produced</li> <li>- Biogas can be used to power the plant and provide a renewable energy source. --- Digestate can be further matured into a valuable compost product.</li> </ul>	This technology is not suitable for the garden waste fraction of the waste stream	Can be financially viable at between 15,000-20,000 tpy – so a much smaller scale than incinerators Cheaper than incinerators and other “energy from waste” plants.
	Autoclaving	<ul style="list-style-type: none"> <li>-Modular</li> <li>-Less noxious emissions than incineration</li> <li>-Some materials are captured for recycling</li> </ul> <p>If steam is also collected within the autoclaves the process is energy efficient</p>	<ul style="list-style-type: none"> <li>-No front end recycling – everything put through the system including hazardous municipal waste</li> <li>-Quality of materials sent to recycling low</li> <li>-Likely to produce RDF to be sent somewhere else to be burnt</li> </ul>	Doubt over how cost effective autoclaving is and how beneficial it is in terms of improving the quality of recyclable materials, compared to source separated systems and MBT systems
	Bioreactor landfills	<ul style="list-style-type: none"> <li>- Accelerated waste stabilization.</li> <li>- Rapid landfills conversion</li> <li>- Environmental safety.</li> <li>- 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.</li> <li>- Expanded and concentrated production of methane gas</li> </ul>	<ul style="list-style-type: none"> <li>- A relatively new technology</li> <li>- The increased moisture content of bioreactor landfill reduces the structural stability of the landfill.</li> <li>- Rapid accumulation of landfill gases, primarily methane may cause explosion of pipes.</li> <li>- Excessive production of H<sub>2</sub>S</li> </ul>	<ul style="list-style-type: none"> <li>- Built bioreactor landfills have lower costs than traditional and retrofit bioreactor landfills, mainly because of air space recovery and leachate treatment</li> <li>- Cost of aerobic landfills is greater than anaerobic when gas recovery and use is possible</li> </ul>

# Innovative and appropriate waste technologies for the Arab region

Area	Technology	Strengths	Weaknesses	Cost
Waste to Energy (WtE)	RDF Incineration	<p>Substitutes primary energy)</p> <p>Reduces the amount of waste</p> <p>Saves landfill space</p> <p>Harmful content and reactivity of the waste is drastically lowered</p>	<p>Causes higher thermal stress</p> <p>Faster deterioration of the installations (corrosion)</p> <p>May possibly alter products (cement, bricks, steel)</p> <p>Requires additional investment</p>	Costs less than the operation of a standard waste incinerator
	Pyrolysis	<p>Flexibility to use different types of fuels, low emission, low environmental impact</p>	<p>No universally accepted specification or standards for bio oil</p>	-
	Gasification	<p>It takes place in a low oxygen environment that limits the formation of dioxins and of large quantities of SOx and NOx</p> <p>It generates a fuel gas that can be integrated with combined cycle turbines</p>	<p>During gasification, tars, heavy metals, halogens and alkaline compounds are released within the product gas and can cause environmental and operational problems</p>	<p>A base case scenario with a 680 ton/day would cost an estimated \$150 million.</p> <p>a tonne of waste may produce 0.8 MW of electricity, worth around \$70 per MW.</p> <p>Payback about 8 years</p>
	Plasma arc	<p>Cleaner and greener than incineration</p> <p>Plasma recycling can cope with virtually any kind of waste, including the most hazardous, high-grade, and hard-to-treat forms</p> <p>individual sub-systems are all very mature and established</p>	<p>Simply a new way of dressing up something that is little better than incineration</p> <p>The solid aggregate waste has been billed as a useful construction material, but !!!!!</p>	-

# Innovative and appropriate waste technologies for the Arab region

Area	Technology	Strengths	Weaknesses	Cost
<b>COMPOSTING</b>	 <b>Turned windrow</b>	Flexibility to vary the treated waste and the capacity	Requires a large area Can cause odour problems The choice of a location for any outdoor installation may be difficult politically	Relatively low investment costs Relatively low operating costs
	 <b>Aerated static pile</b>	_Forced ventilation reduces the required area and helps to avoid odour problems -Not necessary to turn piles -Spaces are less than for the windrows -Good odour control	-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) Lower operating costs
	 <b>Covered channels</b>	-Usually fitted in buildings, so normally no odour problems -Required space less than in the case of windrows	As the 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	Moderate investment and operating costs
	 <b>Closed container</b>	These systems are designed to create ideal composting conditions and produce compost as soon as possible.	requires a good level of technical and operational knowledge	They tend to offer the most cost solutions
	 <b>Vermi-composting</b>	-Effective of treating pathogen-rich waste materials and domestic solid and liquid -Wastes require little space in which to operate -Enriching soil	Takes Time Noticeable Odor	relatively inexpensive technology,



# Case studies :

## Paper and Cardboard- GPC-Morocco ISO 9001, ISO14001, ISO22000

GPC company has set up a collection, sorting and recycling of waste paper to reduce and recycle waste packaging manufactured and marketed the company.



### Recycling economic impacts:

- 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 .

# Case studies

## Paper and Cardboard- GPC-Morocco ISO 9001, ISO14001, ISO22000



### Environmental benefits:.

- Each tone of recycled paper saves: 1.41T of wood, 48.2 m<sup>3</sup> of water, 0.04 TeqCO<sub>2</sub>

### Lessons learned:.

#### Weaknesses:

- Unstructured collection Sector
- A collection rate in Morocco is among the lowest in the world(less than 30%).

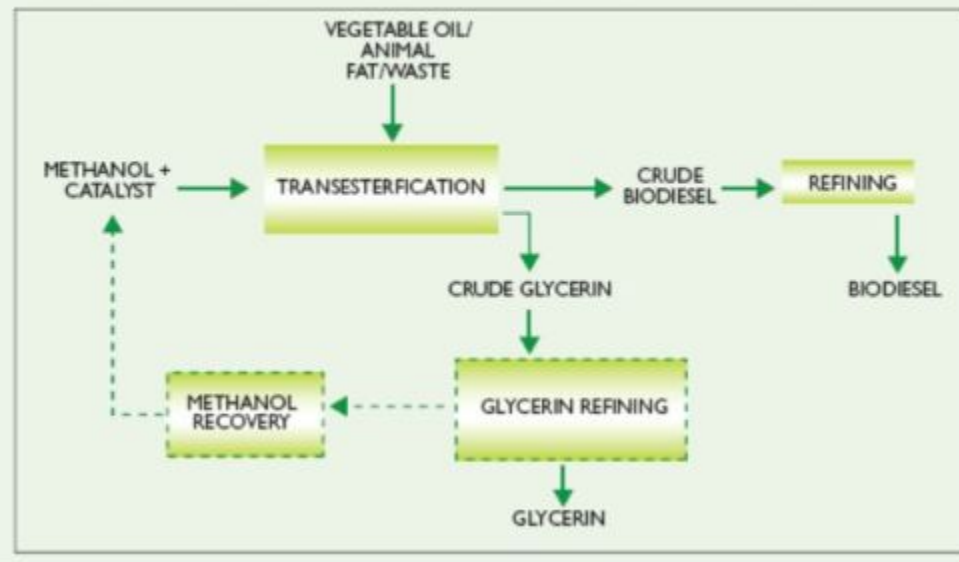
# Case studies

## Used Cooking Oil – Kilimanjaro Environnement-Morocco

"Kilimanjaro Environnement" is a green company specializing in the collection and recycling of used cooking oil.

Focus: on waste, called "liquid biomass" that are dumped every year by individuals, Industries, restaurants and hotels directly into sewers.

FIGURE I BASIC BIODIESEL PRODUCTION PROCESS



**Project: Extension to Home collection (Jan 2015)**

It 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.

### Lessons learned:

**Weaknesses:** Non existent local market\_ Better yield with less Energy

**Strengths:** Growth market, cheap technoloy  
Transferability to other Arab region countries,

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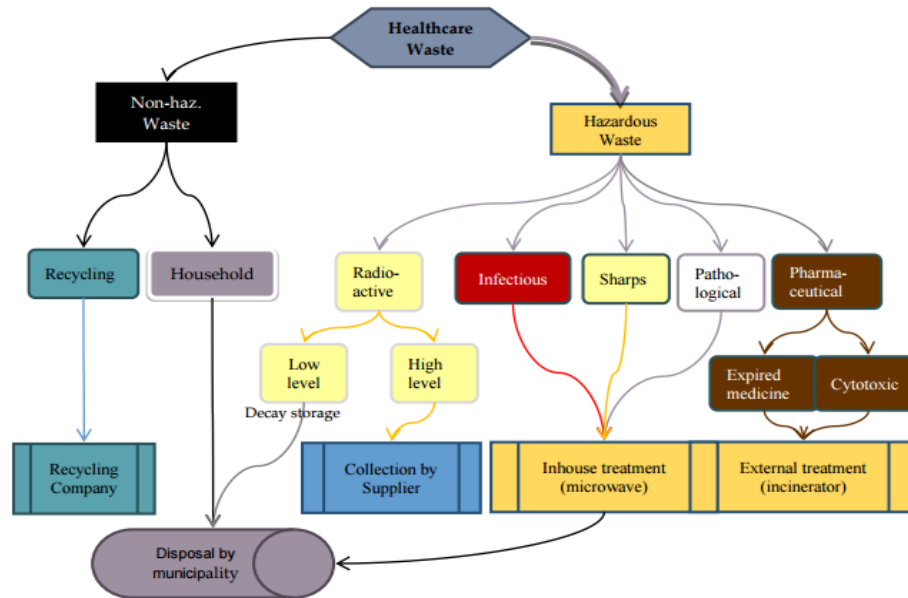


# Case studies

## Mohammed VI Hospital- Marrakech-Morocco

-Committed to improving its waste management system both internally as well as regionally.

- SWOT Analysis



M&P waste that go to municipal landfills,

	2012		Difference	%
	Before sorting	After sorting		
Production (kg)	9,781.13	5,756.82	4024,31	41



# Case studies

## Mohammed VI Hospital- Marrakech-Morocco



Collection system in the wards



Segregation poster



Interim storage in the wards



Central storage of non-hazardous waste



New microwaving system at the hospital

### ***Lessons learned:***

- Develop a standardized Operating Procedure for the handling of healthcare waste
- Set up of a certification system for the responsible persons on healthcare waste management,



# Case studies

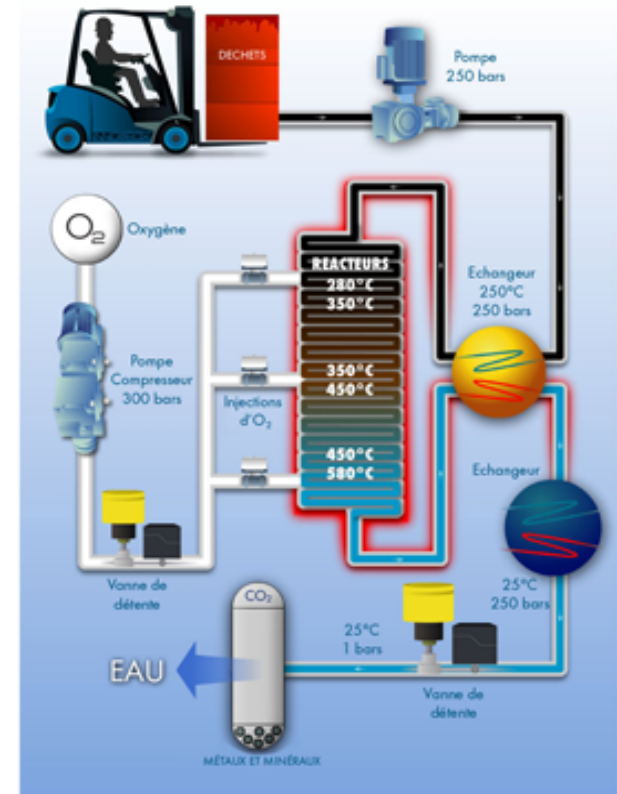
## Toxic industrial waste

Hydrothermal Oxidation (HTO) is a high-performance **ecological waste treatment** method which is finding commercial application in the treatment of aqueous organic residues, and is particularly relevant for breaking down synthetic oils (including industrial cutting fluids and engine oil).

The technique exploits the **extreme oxidation** characteristics of supercritical water, (defined as 221 bar and 374 °C). Under these conditions oils become **soluble**

**Instantaneous break down** of organic substances into harmless products, essentially water and CO<sub>2</sub>

**This technology offers improved operational flexibility, including treatment of insoluble wastes, and is now available for commercial exploitation.**



# Case studies

## Agro-food sector: Examples of waste minimization technologies



### Time-temperature intergrators(TTIs)

- Effective and cost-efficient monitoring of temperature conditions of food products in the chill chain can be fulfilled by TTIs.
- Inexpensive, active “smart labels” based on physicochemical, chemical, or biological principles of operation and exhibiting an easily measurable response that integrates the temperature history of the product.



### Bioconservation

- Concept of food preservation which consists of adding **lactic acid bacteria** on fresh or cooked, packaged under vacuum or modified atmosphere
- It is already used industrially on fresh and fermented products in Europe. The biopreservation market is fully extended.
- Risks: requires a good bacteriological control, lack of legislative framework

# Financing appropriate and innovative technology for waste management in the Arab region

## Nationally



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. This includes the promotion Profitable Environmental Management (GEPrec), which supports resource efficiency

**FODEP**

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.

**MVDIH**

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. **CMPP** 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



# Financing appropriate and innovative technology for waste management in the Arab region

## Internationally: examples



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



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

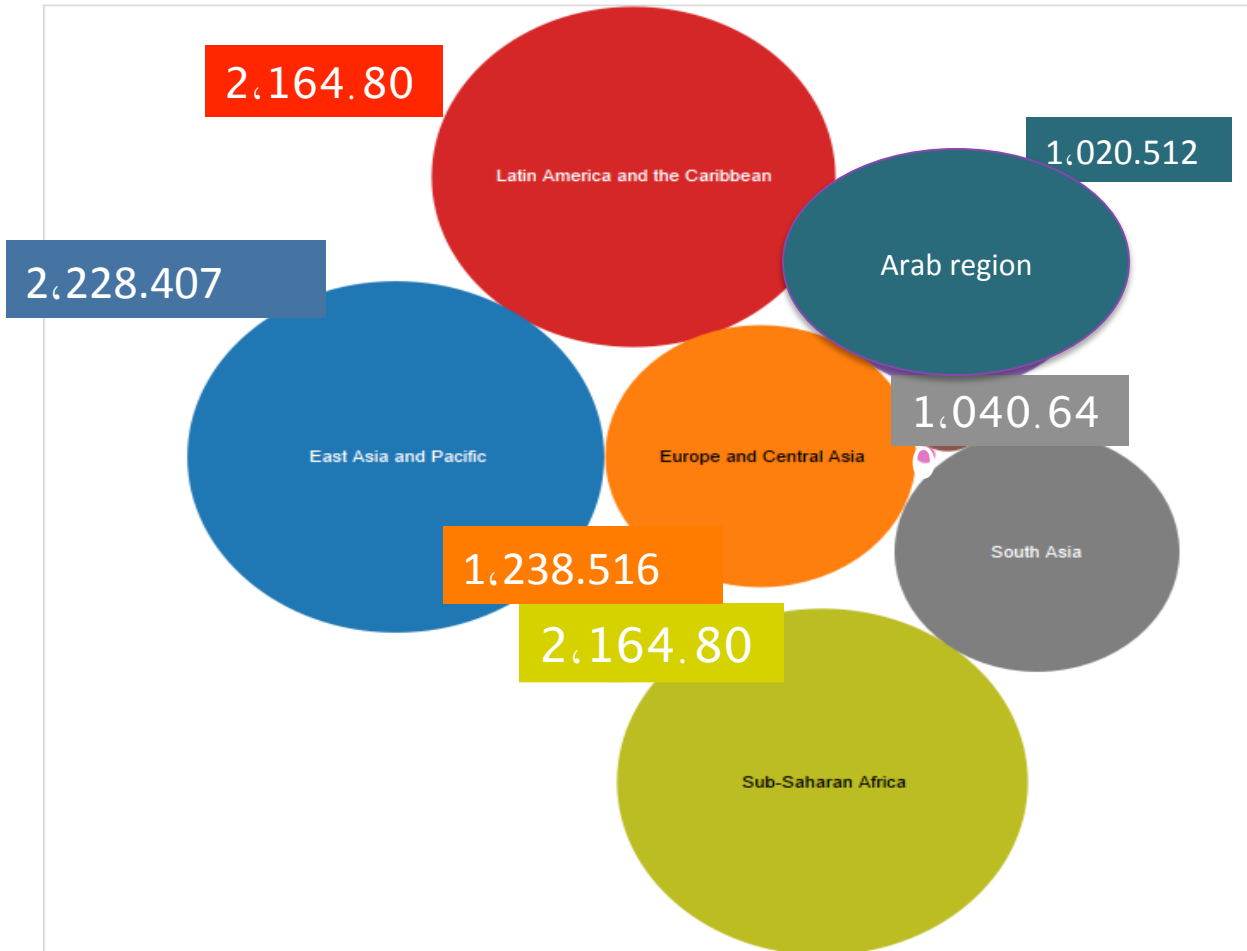


The distribution of Climate Finance is concentrated in Egypt and Morocco, with total amounts approved of USD 195 million and USD 640 million, respectively. 88% and 96% of Egypt and Morocco's respective approved finance has been for mitigation projects.

## كيف إستفادت البلدان العربية من التمويلات المرتبطة بالمناخ مقارنة بالمناطق الأخرى بالعالم؟ التمويلات المرصودة

<http://www.climatefundsupdate.org/about-climate-fund/global-finance-architecture>

Approved Funding by Region and Focus



التمويلات المصادق عليها  
لفائدة  
البلدان العربية بما قدره  
512.1020 مليون دولار  
من التمويلات المرتبطة بالمناخ

التمويلات المصادق عليها  
لفائدة  
البلدان الأعضاء بالإسكوا:  
962.46 مليون دولار

التمويلات المصادق عليها  
بالنسبة لكل البلدان  
9857.675 مليون دولار

# Recommendations

## Innovation in waste management in the Arab region:

### - Opportunities

\* **Enhancing the recovery and recycling of waste streams** can improve the efficient use of materials, save waste and reduce GHG emission : [Innovation in waste recovery and recycling?](#) Case of Ewaste

\* **Better management of organics** would offer opportunity to deliver sustainability and innovation benefits: [Innovation in WtE- Anaerobic digestion \(biogas\) waste for energy production is a promising solution](#)

### - Policy level

\* Waste Policy Framework should put waste into the national/regional context.

\* Focus on ‘fit-for-purpose’ [technology, facilities and business models](#).

\* 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 markets...](#)

\* The policy should also promote ‘[tailoring solutions](#)’ that build capacity at regional level

\* Waste management policy [should have a clear focus on prevention and resource efficiency](#), Arab region countries should establish [national plans and/or programmes](#), dedicated to efficient waste management and more generally to resource efficiency. ( PROGRESS, Germany....)

# Recommendations

**Creating business opportunities:  
matching research and business to create solutions and accelerate innovation:**

## **- Opportunities**

- \* Research into **improving recovery and reprocessing** technologies, adapt technologies to **small scale waste processing** ( organics) and 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
- \* Developing **waste exchanges** (the waste of one could be the input of the other)

## **- 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**

# Recommendations

**As a solution for better improvement of waste management in the Arabic region, we can recommend these approaches:**

- Laws, organisation, responsibility,
- Introduction of waste fees and regulation of the finances,
- Encouraging multi-stakeholder involvement in every stage of Waste management,
- Realisation of pilot projects to gain practical experience,
- Integration of the private industry out of financial and organisational aspects,
- Construction and modification of utilisation plants,
- Construction of hazardous waste treatment plants,
- Mobilizing more Arab Region partners for better coordination in the exchange of experience and innovative technologies.