



Organic Household Waste (OHW) Management Technology Options in the Kingdom of Bahrain

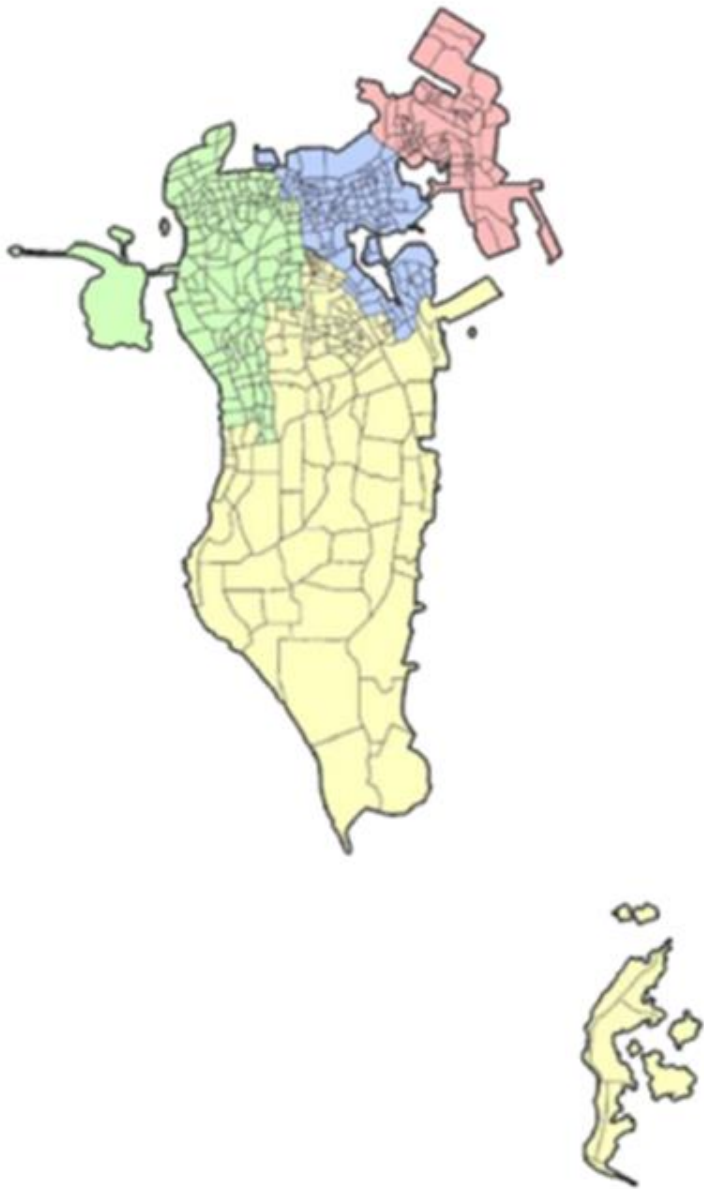
ESCWA Group Meeting
Amman, Jordan

30-31 July, 2019




By
Dr. Sumaya Yusuf

Introduction

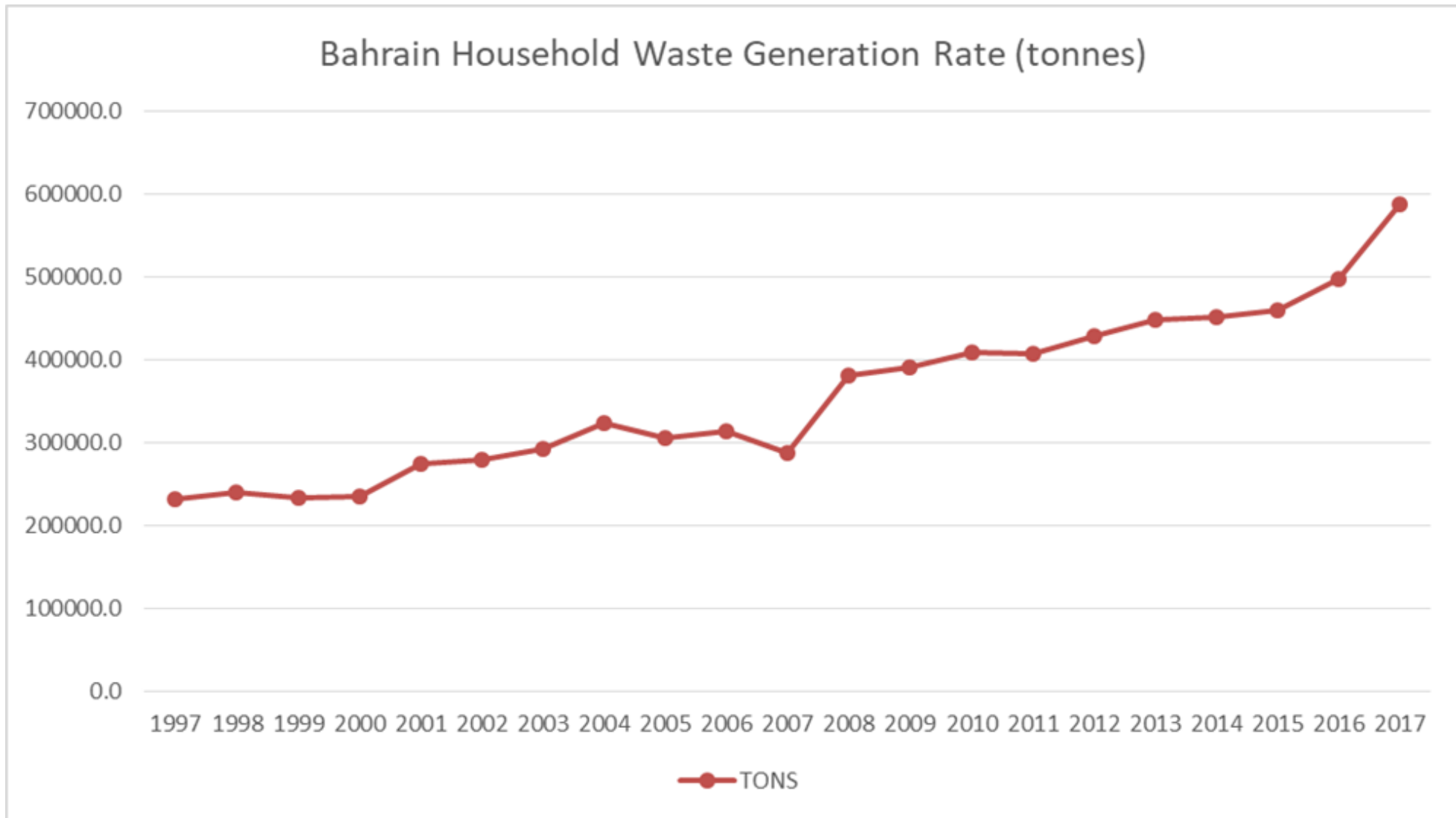
- The increase in economic and developmental activities leads to an increase in waste generation.
- MSW, including household waste which mostly consists of organic waste, poses a serious threat to the sustainability of cities worldwide.
- Implementation of suitable waste management technology is important to mitigate the harmful impacts on environment, economy, and society.



Legend

| | |
|---|----------------------|
|  | Capital Governorate |
|  | Muharraq Governorate |
|  | Northern Governorate |
|  | Southern Governorate |

Bahrain map with the main Governorates

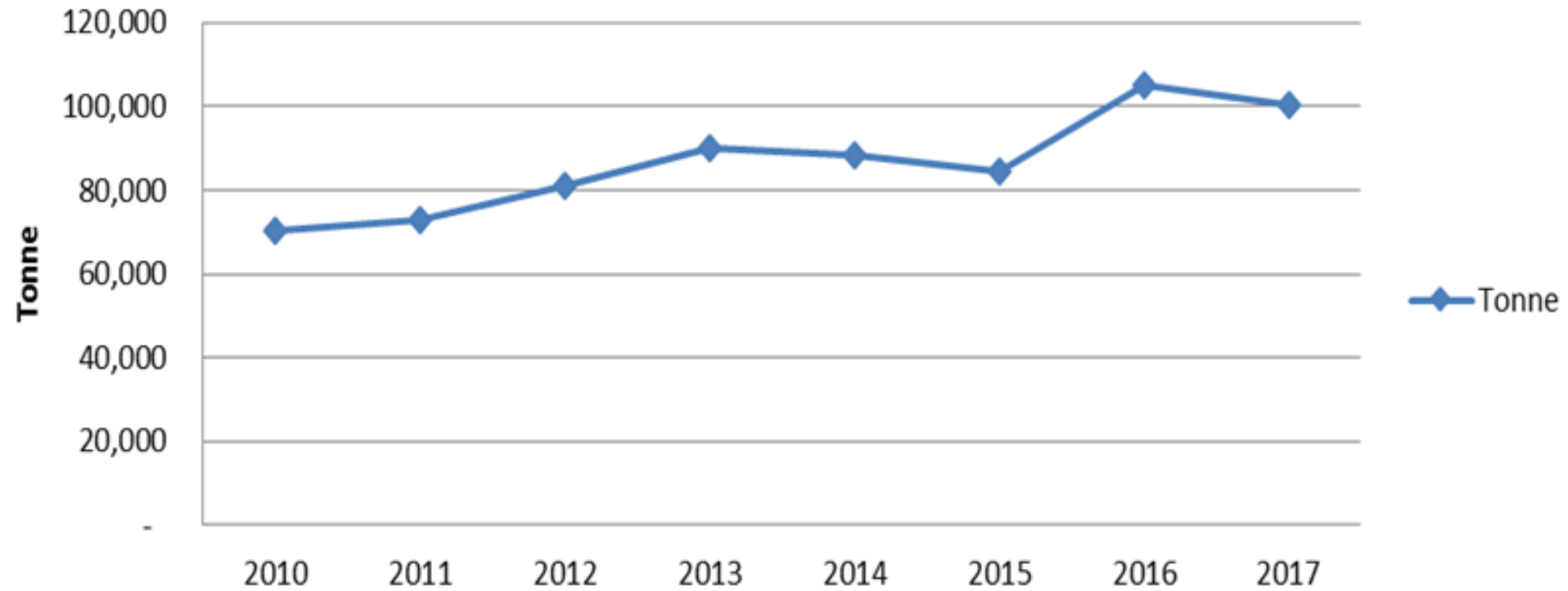


The annual generation rate of the household waste in Bahrain for the last two decades

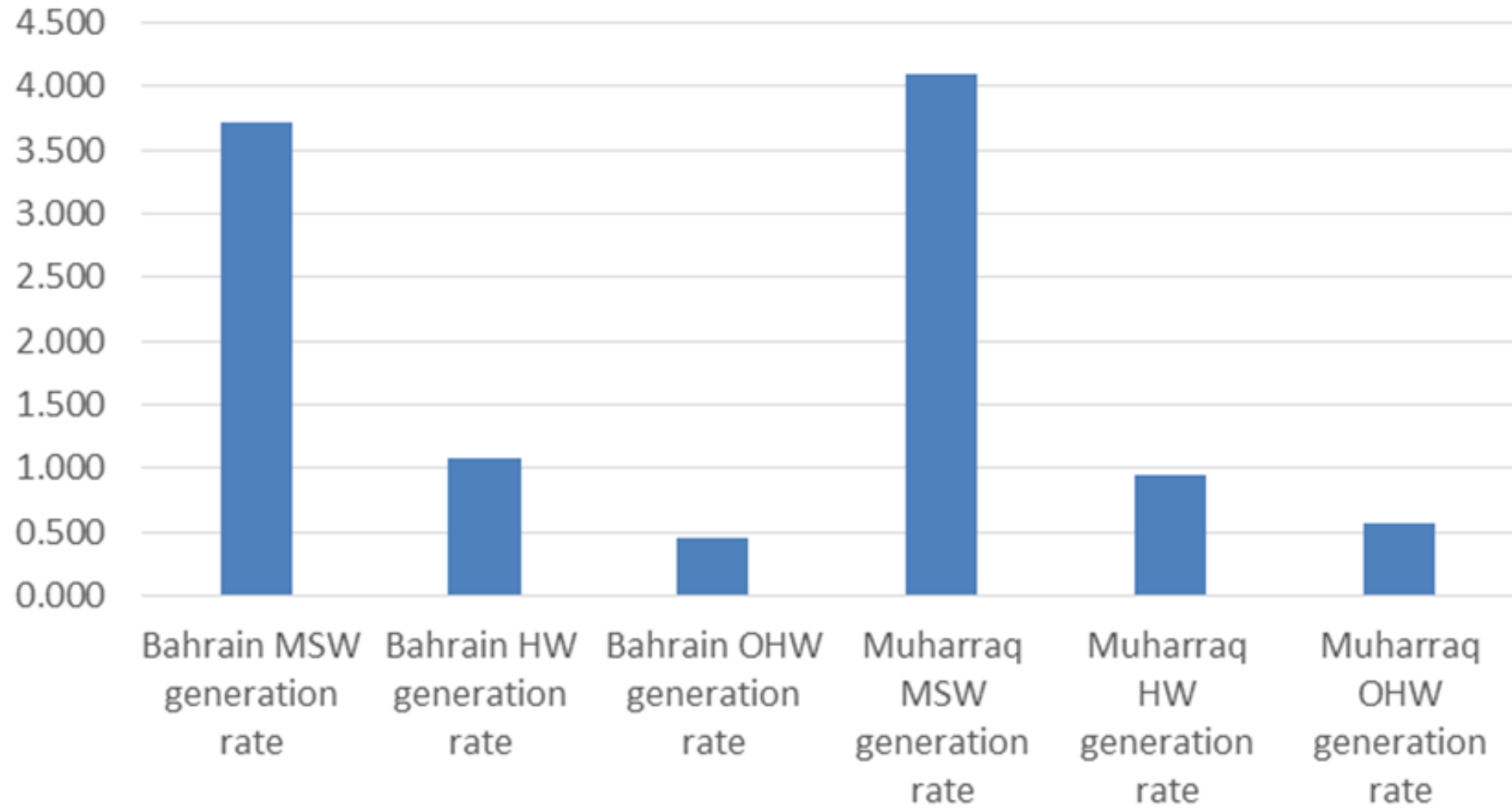


Muharraq official Arial map with total residential blocks (CIO, 2016).

Total Annual Domestic Waste in Muharraq City (tonne)



kg/capita/day



Overarching Aim

To explore the opportunity for the OHW management technology options based on OHW characteristics of Muharraq Governorate, and explore the enablers and barriers to the selected technologies adoption in Bahrain

Theoretical Phase

Develop an OHW characteristic parameter/technology matrix from the literature review
(Chapter 2 & 5)

Objective 1

Empirical Phase

OHW Characterization:
Random sampling for OHW in Muharraq Governorate and send samples to the laboratory for analysis
(Chapter 5)

Objectives 2

Matching the results with the matrix for the preferred technology/ies selection
(Chapter 5)

Objective 3

Socio-economic Phase

Economic feasibility:
Cost-benefit analysis for the selected technologies in Bahrain
(Chapter 6)

Objective 4

Survey 1: Exploring the enablers and barriers to the selected technologies adoption in Bahrain
(Chapter 7)

Objective 5

Survey 2: Measuring the public awareness toward the household waste management in Muharraq Governorate
(Chapter 8)

Objective 6

Quantitative approach using Microsoft Office EXCEL

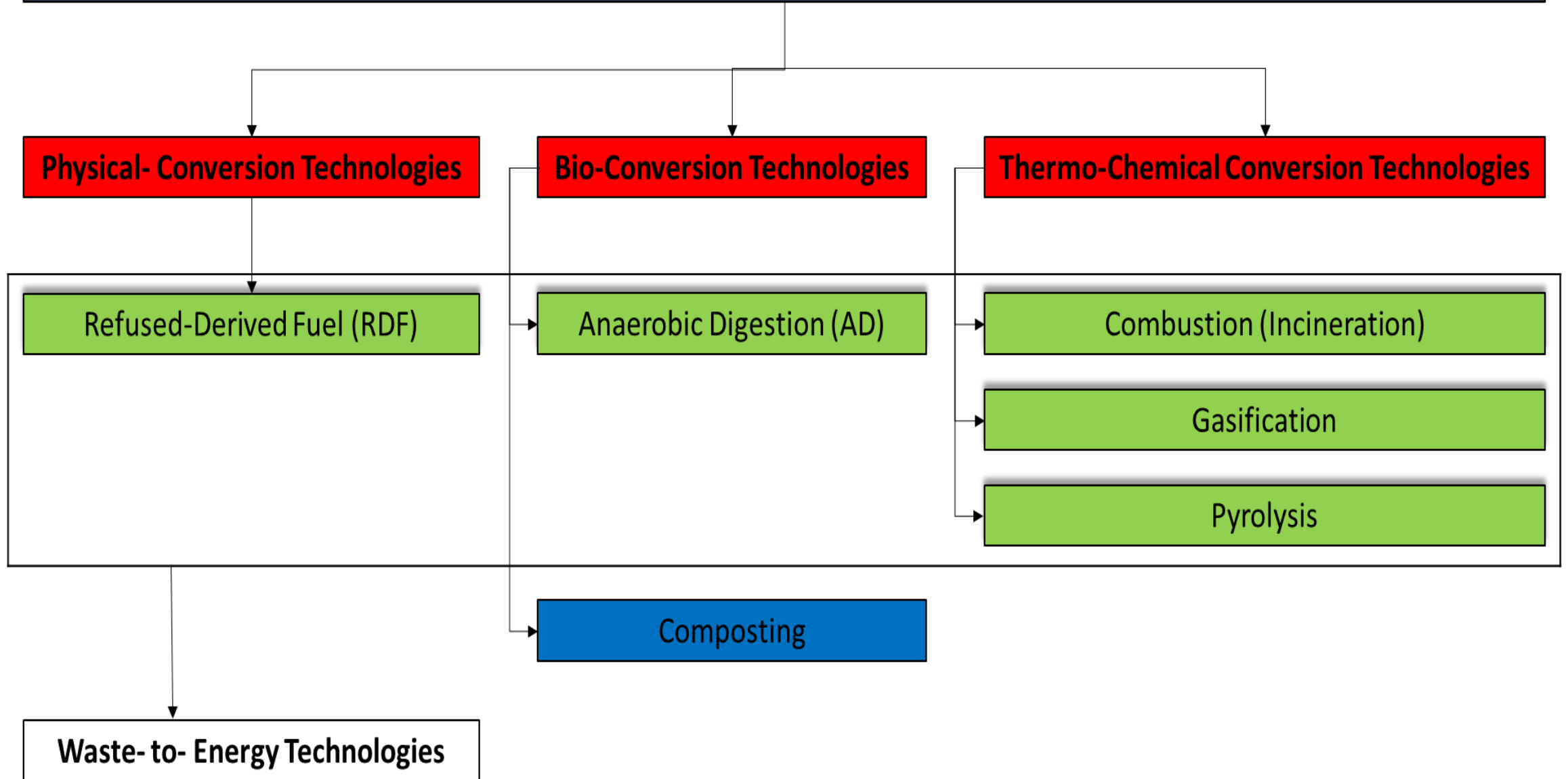
Qualitative approach: semi-structured interviews analyzed by nvivo 12

Quantitative approach: designed questionnaire analysed by SPSS: ANOVA, t-test, descriptive statistics

Selection of the most preferred OHW Technology Option for Bahrain:

1. **Technical Criteria:** Waste characterization
2. **Economic Criteria:** Cost - Benefit Analysis
3. **Social Criteria:** Enablers and Barriers, and Public Awareness

Organic Household Waste (OHW) Management Technology Options



Results of Technical Criteria:

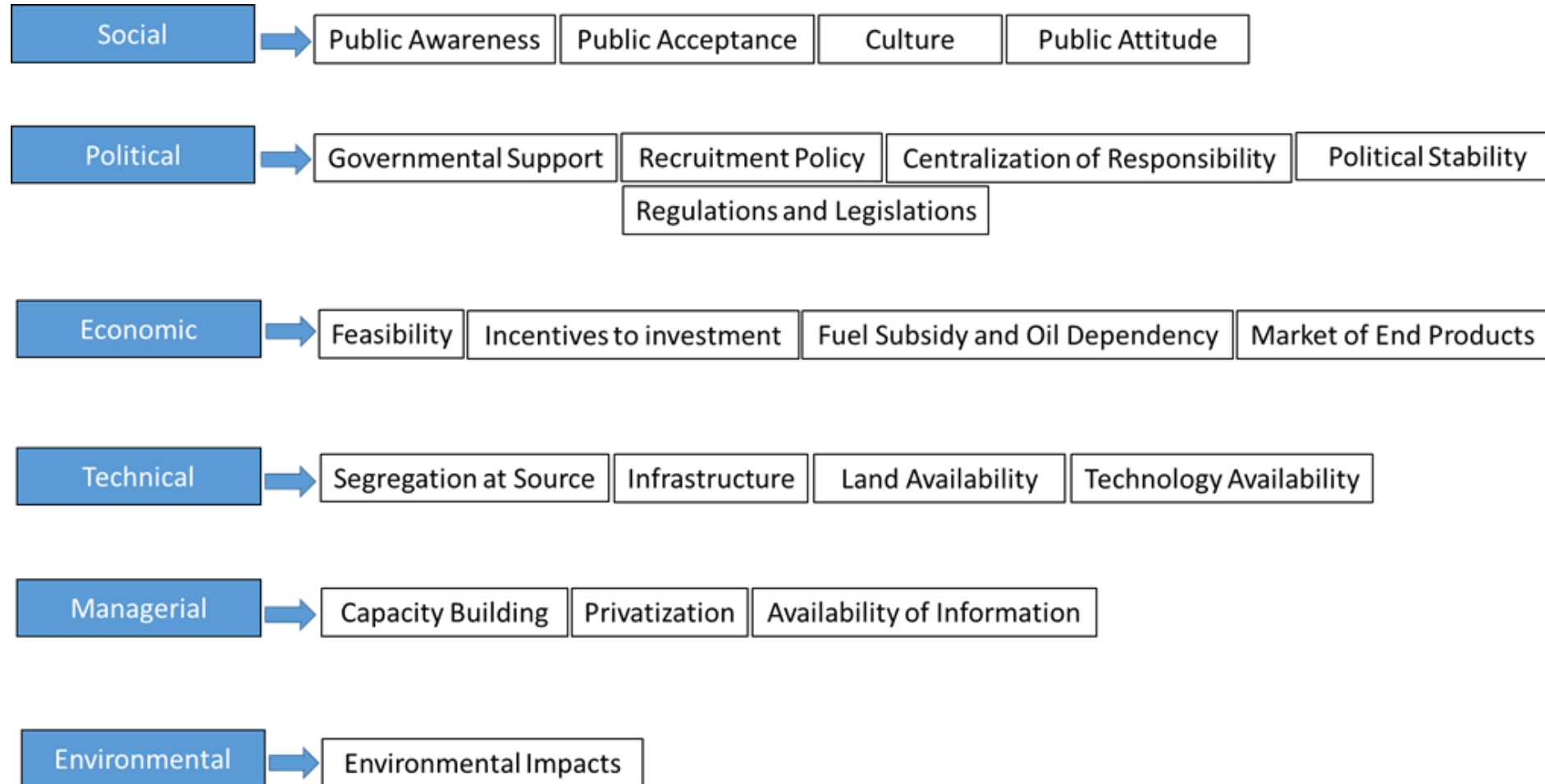
- Parameter/Technology Matrix Developed
- Optimal Operating Conditions Required by each technology were specified.
- Most preferred technologies were ranked as follows:
 1. Anaerobic Digestion (with pretreatment)
 2. Thermo-technologies (Incineration, gasification, Pyrolysis)
 3. Composting
 4. RDF

Economic Criteria:

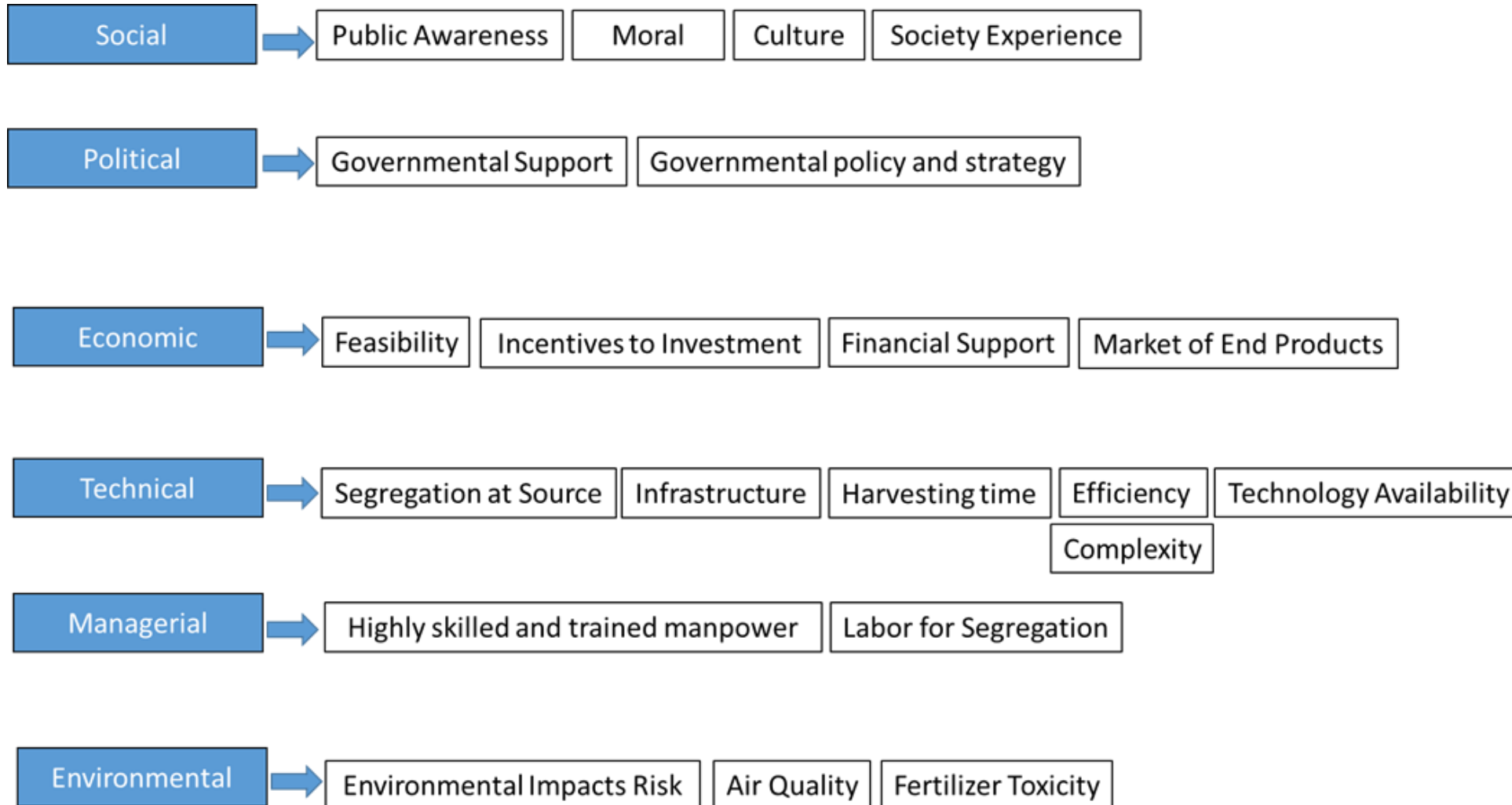
The technologies can be ranked from most to least economically feasible premised on the economic criteria signified by the CBA as follows:

1. Anaerobic Digestion (AD)
2. Incineration
3. Gasification
4. Pyrolysis
5. Composting
6. RDF

Social Criteria: General Enablers to Technology Adoption



General Barriers to Technology Adoption



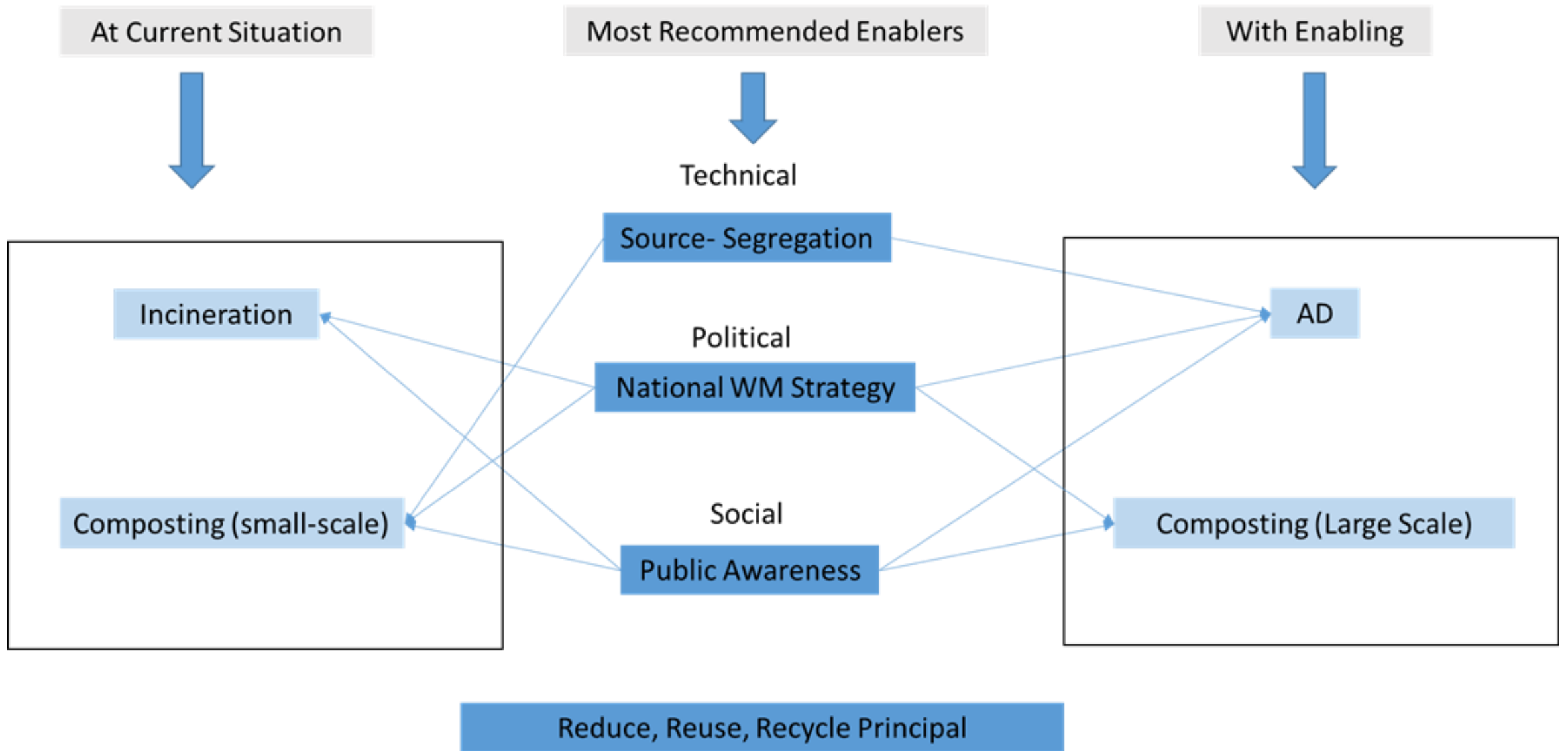


Figure 4: Most recommended technologies and their most effective enablers according to the experts

Comparison of the most preferred technologies based on the technical, economic, and social criteria, as resulted by this research:

| Rank | Technical Criteria (OHW Characterization) | Economic Criteria (Cost-Benefit Analysis) | Social Criteria (Enablers and Barriers) |
|-------------|--|--|--|
| 1 | Anaerobic Digestion(AD) | Anaerobic Digestion (AD) | Incineration |
| 2 | Incineration | Incineration | Anaerobic Digestion (AD) |
| 3 | Gasification | Gasification | Composting (small-scale) |
| 4 | Pyrolysis | Pyrolysis | Composting (large-scale) |
| 5 | Composting | Composting | - |
| 6 | RDF | RDF | - |

Public Awareness Survey Conclusion

- Results show a high public awareness toward household waste management among people in Muharraq Governorate, which indicated that the society has the basics for enabling technologies adoption, which may help everyone to overcome the social barrier represented by low public awareness.
- Males tended to have a better knowledge and attitude about household waste management than females in Muharraq Governorate.
- Married people have a better attitude toward household waste management than single people.

- The government should prioritize females and singles in order to promote knowledge on effective household waste management, as well as prioritize singles to promote attitude.
- Also, the age group of 21-30 must be prioritized to promote behavior, attitude, and total awareness in Muharraq Governorate, since the age groups of 18-20 years and 41-50 years are shown to have a higher positive behavior than those belonging to the 21-30 age group.
- While the age group of 18-20 is prioritized to promote the knowledge

Overall Conclusion

- Anaerobic Digestion (AD) is the most suitable technology to treat OHW using the pre-treatment of OHW prior adoption (by increasing pH and C:N ratio to optimum level).
- AD is a feasible, viable and profitable solution to manage the OHW in Muharraq Governorate regardless of whether the government invests in it or the private sector expressed by the second or the first scenarios respectively, considering the high fertiliser cost (140USD/ton), beside its viability under the second scenario considering the low cost of fertiliser (6USD/ton).

- Incineration and gasification were both economically feasible under the second scenario, but not in the first scenario
- low heavy metals content, low sulfur content (mainly attributed to incineration, pyrolysis and gasification) and possible options with low expected environmental impacts.
- To enable thermochemical conversion, the high amount of moisture can be reduced through solar drying or using driers prior to combustion since the higher moisture content weakens the combustion process.
- Muharraq OHW incineration leads to generate 126.5 GWh which represents 2.2 % of Al-Hidd power plant annual generation, and contributes to Bahrain total power generation with 0.74 % and if be applied to Bahrain's MSW, the yield is maximized.

- Lack of the incentives to investment, national capacity building, market of the end products, lack of centralization of WM responsibility and privatization, and lack of the source segregation are the main barriers to WM technologies adoption in Bahrain.
- People are aware in that almost half of them agreed that burning household waste in a modern and safe facility is a very effective way of lowering its size and produce energy, compared to only 23.7% who disagreed, which might be an indicator of public acceptance of incinerator adoption.



Never stop dreaming.
Yesterday's dream can become
the reality of tomorrow, and
the innovation of the future

- Luna Adriana Ardiansyah

Thank you