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10   UNDERSTANDING THE PERCEPTIONS, ROLES AND INTERACTIONS OF STAKEHOLDER

11   NETWORKS MANAGING HEALTH-CARE WASTE: A CASE STUDY OF THE GAZA STRIP

12

13   ABSTRACT

14   The sustainable management of waste requires a holistic approach involving a range of stakeholders. What

15   can often be difficult is to understand the manner in which different types of stakeholder networks are

16   composed and work, and how best to enhance their effectiveness. Using social network analysis and

17   stakeholder analysis of healthcare waste management stakeholders in the case study region of the Gaza

18   Strip, this study aimed to understand and examine the manner in which the networks functioned. The

19   Ministry of Health was found to be the most important stakeholder, followed by municipalities and solid

20   waste management councils. Some international agencies were also mentioned, with specific roles, while

21   other local institutions had a limited influence. Finally while health-care facilities had a strong interest in

22   waste management, they were generally poorly informed and had limited links to each other. The manner

23   in which the networks operated was complicated and influenced by differences in perception, sharing of

24   information, access to finance and levels of awareness. The lack of a clear legal framework generated

25   various mistakes about roles and responsibilities in the system, and evidently regulation was not an

26 effective driver for improvement. Finally stakeholders had different priorities according to the waste

27 management issues they were involved with, however segregation at the source was identified as a key

28 requirement by most. Areas for improving the effectiveness of the networks are suggested. The analysis

29 utilized an innovative methodology, which involved a large number of stakeholders. Such an approach

30 served to raise interest and awareness at different levels (public authorities, health providers, supporting

31 actors, others), stimulate the discussion about the adoption of specific policies, and identify the effective

32 way forward.

33

34 KEY WORDS

35 Health-care waste management; stakeholder social network analysis; medical waste; sustainability;

36 assessment method; identification of priorities.

37

38 HIGHLIGHTS

39 A combination of stakeholder analysis and social network analysis was applied to understand health-care

40 waste management in the Gaza Strip

41 The manner in which the networks operated was complicated and influenced by differences in perception,

42 sharing of information, access to finance and levels of awareness

43 The research approach employed served to improve stakeholder involvement and raised awareness about

44 the general situation of the system

45 The method could, with adaptation to the local context, serve to understand and enhance stakeholder

46 networks in other similar contexts

47

48 ABBREVIATIONS

49 EQA: Environmental Quality Authority; HCF: health-care facility; HCWM: health-care waste management;

50 JSC: joint service council; MoH: Ministry of Health; MSW: municipal solid waste; PPE: personal protective

51 equipment; SWMC: Solid Waste Management Council; UNRWA: United Nations Relief and Works Agency

52 for Palestine Refugees in the Near East; WHO: World Health Organization.

53

54 1. INTRODUCTION

55 It is widely accepted that the development and effective implementation of sustainable approaches to

56 global challenges such as climate change and resource security require a holistic approach, involving a

57 range of actors, including government, civic society, non-governmental organisations, and the community

58 (Stern, 2006; Marias and de Almeida, 2007; Bodin and Crona, 2009; Weber and Allen, 2010; Phillips *et al.,*

59 2011; Starkl *et al.,* 2013; Meadows *et al.,* 2014). However, there are several difficulties in achieving this

60 holistic approach, including the identification of appropriate stakeholders, their effective engagement, and

61 the achievement of some form of consensus during the development and implementation processes.

62 Deliberative approaches (e.g. stakeholder forums and focus groups), have gained increasing prominence as

63 a means of overcoming these limitations (Maclean and Burgess, 2010). They seek to gain the collective

64 views of stakeholders (e.g. policy makers and individuals from the community), and incorporate them

65 during the development of governance strategies (i.e. the overarching aims, objectives and mechanisms),

66 to effectively develop and implement sustainable approaches (Chambers, 2003; Dietz *et al.,* 2003; Guntman

67 and Thompson, 2004). While in theory there is an understanding of the mechanisms of deliberative

68 approaches, in practice, real world case studies are limited (Levänen and Hukkinen, 2013).

69

70 Scientific literature presents several approaches to stakeholder participation. The Planning-Oriented

71 Sustainability Assessment Framework (POSAF) utilises a constructivist approach (Roy, 2010; Starkl *et al.,*

72 2013). While the Active Management strategy involves stakeholders working as a collective and in a

73 structured way, to identify, implement and monitor selected strategies (Walters and Holling, 1990).

74 Decision-making is often undertaken using Bayesian Networks (also known as Bayesian Belief Networks), to

75 map out cause and effect scenarios, from different sources and data, which are then quantified to

76 determine the extent to which one variable is likely to impact upon another (Jensen, 2002; Henriksen *et al.,*

2007). Another concept is that of Adaptive co-management (an expansion of co-management), whereby

through collective discussion and negotiation, flexibility is built into the management of the social-

ecological systems, to allow for adaptation in response to environmental change, and the acquisition of

new knowledge by stakeholders (Carlsson and Berkes, 2005; Armitage *et al.,* 2009; Bodin and Crona, 2009).

There are also bottom-up approaches, whereby stakeholders decide on the assessment criteria, including

the Strategic Choice Approach (Friend and Hinckley, 2005; Lennartsson *et al.,* 2005), and Community-Led

Urban Environmental Sanitation Planning (CLUES) (Simon *et al.,* 2004; Lundie *et al.,* 2006; Lüthi *et al.,*

2011). However, various researchers argue that the fragmentation of stakeholders can often limit the

success of bottom-up strategies (Linert *et al.,* 2013; Starkl *et al.,* 2013).

The ecosystems-based management (EBM) approach to resource management involves an understanding

of the entire ecosystem and the manner in which the social and environmental factors influence the

resilience of the system and its ability to provide the required goods and services (McLeod and Leslie, 2009;

Kidd *et al.,* 2011). An examination of the governance structures and the institutions involved in managing

the ecosystem forms a key component of the EBM approach (Folke *et al.,* 2007; Hagedorn, 2008; Carollo

and Reed, 2010; Cárcamo *et al.,* 2013). Within this context, identifying and understanding the perceptions

and expectations of stakeholders plays a significant role in effective implementation of the EBM approach

(Gelcich *et al.,* 2005; Pomeroy and Douvere, 2008).

The development of strong networks can significantly enhance sustainable management of resources. For

example, such networks have been shown to lead to more sustainable management of land resources,

increased knowledge and motivation amongst stakeholders (Kilgore *et al.*, 2007; Larsen *et al.,* 2011;

Meadows *et al.,* 2014), as well as enhanced engagement with marine protection areas (Heck and Dearden,

2012; Lopes *et al.,* 2013; Cárcamo *et al.,* 2014), and mobilisation and allocation of resources (Carlsson and

Berkes, 2005; Newman and Dale, 2007). Indeed, some argue that social networks are more important than

formal governance structures for the effective enforcement and compliance with environmental

103   regulations (Scholz and Wang, 2006). For example, the development of effective health-care waste

104   management (HCWM) policies at the national levels requires full stakeholder participation (de Titto *et al.*,

105   2012). Indeed, by being proactive and working together, stakeholders, and in particular health-care

106   facilities (HCFs), can improve their performances even if there is no legislative framework in place

107   (Rushbrook and Zghondi, 2005).

108

109   Use of deliberative strategies has been extensively employed within the field of environmental

110   management (Hajer and Wagenaar, 2003; Baber and Bartlett, 2005; Dryzek, 2010). However, there is

111   limited information about the 'feedback mechanisms' between institutions developing environmental

112   governance or how best to facilitate a shift away from a spontaneous, self-organising model (Levänen and

113   Hukkinen, 2013). Moving towards such an approach requires not only the effective sharing of information,

114   but also that this knowledge is actively integrated into the new approaches. This is particularly true about

115   engaging with relevant stakeholders for sustainable management of environmental resources during

116   constrained circumstances (e.g. during armed conflicts or major disasters) (Mendenhall, 2014).

117

118   Using the implementation of a new system to manage waste from health-care facilities in the Gaza Strip as

119   a case study, this project set out to examine the strategies via which various stakeholders could best be

120   engaged with the process. The Gaza Strip was chosen as there is limited empirical data on waste

121   management in the area (Caniato and Vaccari, 2014). In addition, the decision was taken to focus especially

122   on healthcare-waste management, due to the wider socio-economic and public health impacts of its

123   management. For example, the ineffective management of health-care waste can lead to the risk of needle

124   stick injuries and blood borne infections (WHO, 2011), as well as the spread of healthcare associated

125   infections (Tudor *et al.*, 2010). The contribution of the study also lies in the methodological approach taken.

126   Understanding how best to integrate the various actors across hierarchical levels and sectorial boundaries

127   has traditionally been undertaken using either stakeholder analysis (Grimble and Wellard, 1997), or social

128   network analysis (Kenis and Schneider, 1991; Crona and Bodin, 2006; Adam and Kriesi, 2007), or a

129   combination of the two (Reed *et al.,* 2009; Lienert *et al.,* 2013). Caniato *et al.* (2014) introduced a novel

130   approach of stakeholder engagement and analysis, through the integration of stakeholder analysis and

131   social network analysis. Such an approach was developed and tested for research purposes during the

132   analysis of the infectious HCWM system in Bangkok, Thailand. This study employed an amended and

133   improved approach to that used in Thailand. COOPI, an Italian NGO, asked CeTAmb to assess HCWM in the

134   Gaza Strip, as evidence of ineffective management of the waste, linked in part to the on-going geo-political

135   conflicts and the resulting humanitarian and public health impacts were present. This case study therefore

136   offered the opportunity to improve the methodology, and to test it in a particularly complex environment.

137   This paper describes this part of the assessment.

138

139   2. STUDY AREA: THE GAZA STRIP

140   The Gaza Strip is a narrow strip of land, bordered by Israel to the east and north, and Egypt to the south

141   (Figure 1). It occupies a total area of 365km^2. In 1948, it had a population of less than 100,000 people, but

142   by the time of this study had 1.6 million and is expected to grow to 2.1 million by 2020, and 3.2 million by

143   2040 (UNoPT, 2012; PCBS, 2013).

144

145   FIGURE 1

146

147   As a result of the armed conflicts in the region, management of the physical environment in the Gaza Strip

148   has been severely neglected. Waste management faces a number of restrictions, including (UNDP, 2012;

149   Salem, 2013):

150

151   -   Limited national and local legislation

152   -   Political and security instability

153   -   Limited funding

154   -   Inadequate infrastructure, including space for facilities

155

In addition, household waste arisings are expected to rise from around 1,506 tonnes per day in 2011, to

approximately 3,383 tonnes per day in 2040 (UNDP, 2012).

158

At the time of the study, waste was being managed by five main providers, namely: (i) North Gaza Joint

Service Council (JSC), (ii) the Municipality of Gaza, (iii) Deir al Balah JSC, (iv) the Municipality of Rafah, and

(v) the United Nations Relief and Works Agency (UNRWA). The JSCs are also called solid waste management

councils (SWMCs). Waste was primarily collected using donkey carts, in addition to tractors, tipper cranes

and trucks. The salaries of the collection crews were paid by the municipalities, with additional support

from the JSCs, and international agencies (Salem, 2013).

165

Out of the three main disposal sites in use, only one was lined and equipped with a leachate treatment

system. Unfortunately the landfill had already exceeded its maximum capacity. Several dumpsites were

used as transfer stations, where waste was temporary stored waiting for the money for the haulage.

Recycling and composting activities are very limited (Caniato and Vaccari, 2014). Few data are available

about industrial and health-care waste, and only a small part of the waste is segregated and properly

treated (UNDP, 2012). In particular the HCWM system is inadequate in all the hospitals, and it is generally

open dumped with MSW (oPt Health and Nutrition Cluster, 2012). The legislative framework is incomplete,

and at the HCF level, policies are not well defined (Al-Khatib *et al.*, 2009). In addition, the health staff lack

awareness and training (Sarsour *et al.*, 2014).

175

3. MATERIAL AND METHODS

Based on Caniato *et al.* (2014), semi-structured interviews were first conducted with stakeholders who

were evidently involved, like public authorities and the largest hospitals and clinics. Other participants were

then identified using a snowball method (Alameddine *et al.*, 2011). A total of 16 structured and two semi-

structured interviews were conducted. The interviewees were drawn from six public HCFs, three non-

181   governmental HCFs, five public authorities, three international actors, and one private non-health actor.

182   None of the academics working in the field of HCWM could be clearly identified, and so they were not

183   included. The HCFs chosen had among the largest number of patients according to World Health

184   Organization (WHO) data (unpublished) and represented all five governorates in the Gaza Strip, and the

185   different service providers.

186

187   Local staff translated all the questions from English to Arabic, when required, and gave explanations, where

188   required. Both the interviewer and the translator took notes and debriefed after each interview, and at the

189   end of the data collection process. Stakeholders were grouped into four main categories, namely: (i) public

190   authorities; (ii) health providers (e.g. from HCFs); (iii) supporting actors (e.g. from the international

191   community); (iv) others. The last category includes all the stakeholders not previously considered, but

192   involved in HCWM due to other reasons, such as on contract (e.g. private contractors), education/research

193   (e.g. academia), and due to the potential health impact (e.g. local community).

194

195   The following four key research tools as proposed by Schmeer (1999) were adapted to the case study

196   according to Caniato *et al.* (2014): (i) Questionnaires; (ii) Stakeholder tables; (iii) Definitions of stakeholder

197   characteristics with instructions to complete the stakeholder table; and (iv) Scoring scales for

198   quantitative/close questions (Table 1). Thus interviewees had to give scores to different topics according to

199   their point of view.

200

201   TABLE 1

202

203   However, in this case study some modifications were introduced in the methodology. For example, some

204   questions were simplified, and fewer scores were requested; the scoring was limited to a scale of 1-5; each

205   interviewee drew his own stakeholder network, and information network; and a draft program of

206   intervention for infectious healthcare waste (HCW) was proposed and discussed with each stakeholder,

207 who gave his opinion of it, and evaluated the priority of each HCWM step. These HCWM steps were

208 nominally classified as: (i) HCW production (waste minimization, green procurement), (ii) waste segregation

209 (procedure and training), (iii) material for first storage and cleaning (e.g. bins and sacks for colour coding,

210 trolley and personal protective equipment (PPE)), (iv) onsite storage (closed and protected containers), (v)

211 collection and offsite transport (dedicated vehicle, clear collection schedule), (vi) treatment plant (possibly

212 outside the community), and (vii) appropriate residue disposal. The program was explained using a visual

213 description of the waste management flows suggested, and the actions required. Each stakeholder

214 expressed their priority by placing between 1-9 tokens on each step. On average, five tokens were used,

215 thus giving a total of 35 tokens. The higher the number of tokens on each HCWM step, the higher the

216 priority attributed to the step.

217 Based on Caniato et al. (2014), stakeholders were analysed with respect to their: knowledge about HCWM

218 and the situation in the Gaza Strip; interest in HCWM and the program proposed; attitude towards such a

219 program; power and leadership; and level of interaction with other actors. The scores were triangulated

220 with qualitative answers, and some modified to ensure consistency. Then scores about some topics were

221 recoded to facilitate visual representation (Table 1).

222 Finally some stakeholders were grouped together and considered as a unique actor (e.g. different MoH'

223 HCFs). The overall social network map of information and contacts were created by merging all the maps

224 drawn by the interviewees. Such networks considered both the sources of information and stakeholders as

225 nodes, and the relationships between them as 'oriented ties'. These arrows indicate the direction of the

226 flow of information/relation. In some cases, they were double-headed, and report the scores as declared by

227 the interviewees. Thus the ties are oriented from the interviewee to those who were nominated, while the

228 information is oriented from the source to the receiver (i.e. the interviewee). When some actors were

229 merged to represent one group (e.g. MoH HCFs), the strengths of each tie was the mean of those

230 attributed by these interviewees, thus some calculations resulted in decimal numbers. Social networks

231 were graphically represented with the use of UCINET (Borgatti et al., 2002), a well-know and regularly used

232 software (Long et al., 2013). Priorities declared were aggregated in two ways, namely: (i) with the

9

233   calculation of the arithmetic mean of all the scores attributed, and (ii) counting how many times the highest

234   priority was attributed to each step.

235

236   4. RESULTS

237   4.1 Stakeholder analysis

238   The interviewees stated that the Ministry of Health (MoH) was the most important stakeholder. It has a

239   very complicated and branched structure, thus it was difficult to identify specific Directorates involved in

240   HCWM, even after asking MoH employees. Other evident public stakeholders were municipalities and the

241   SWMCs, as the authorities in charge of waste collection, and the Environmental Quality Authority (EQA),

242   which replaced the Ministry of the Environment. Some ministries were only nominated once. Municipalities

243   were sometimes also considered as the authority in charge of community wellbeing. Interviewees also

244   nominated the hospitals and clinics of other health service providers (e.g. NGOs), private companies, and

245   the United Nations Relief and Works Agency for Palestine Refugees in the Near East (UNRWA). Finally, the

246   WHO, other international supporting actors (e.g. UNDP, NGOs), the media and local community, and

247   private contractors in charge of cleaning within the HCFs were sometimes mentioned. The WHO was

248   considered separately to other international organizations because it was viewed as a reference for

249   standards and guidelines by the interviewees. Only two stakeholders acknowledged universities and other

250   sources like pharmacies.

251

252   None of the stakeholders identified looked to have any significant power regarding HCWM, and only the

253   MoH and the municipalities/SWMCs had both resources and strong leadership. However, both of these

254   agencies lacked financial resources. The MoH's power was limited by its fragmented structure, and the lack

255   of a clear distribution of duties and responsibilities about HCWM. Among all the others, WHO had some

256   influence, due to the technical support provided to the MoH and HCFs, as well as its coordination role. Non-

257   governmental HCFs could affect at least their own practices, and tried to establish some cooperation with

258   the governmental ones. The local community had some influence over the decisions of public authorities,

259 and were quite interested about HCWM, and in particular about incineration and the presence of sharps in

260 the general waste street containers. Indeed, frequent complaints were received by the Al Shifa and Nasser

261 Hospitals, where the majority of segregated HCW were incinerated. Despite the evident interest, all the

262 other stakeholders had limited power, and did not feel able to affect HCWM. UNRWA was focused on its

263 own roles, without paying attention to the general HCWM situation. Health NGOs provided regular training

264 about specific aspects to both MoH and HCF staff, but they were neither particularly interested, nor

265 coordinated about HCWM practices, thus their impact was limited. Private contractors involved in cleaning

266 and HCW collection were very keen to be involved, but were bound by the contract signed, and did not

267 have any influence on the system. Some actors (e.g. other ministries), were secondary, without any

268 practical role. Academia could potentially affect health staff education, and provide technical support to

269 the MoH, but HCWM was not a topic that the universities in the Gaza Strip had any significant expertise in

270 or knowledge of. Finally all the stakeholders, except the municipalities/SWMCs did not have a clear picture

271 of the situation, and had information only about some parts of the system (Figure 2).

272

273 FIGURE 2

274

275 All the interviewees had a positive opinion about the program of intervention. The EQA stated that HCWM

276 was important, but not one of their top priorities, while the health NGOs expressed some interest, but this

277 was dependent on their required level of involvement. However, all the HCFs expressed both an interest

278 and very good opinions, despite their limited level of theoretical knowledge about HCWM. None of the

279 interviewees stated that they had a sound knowledge about practices and impacts of HCWM, and all

280 required more training and information. The stakeholders showed an interest and a positive attitude

281 towards the improvement program, as they were involved in practical activities, like producing HCW or

282 being in charge of some management aspects. The need for interventions was strongly recommended by

283 all, as confirmed by their enthusiasm about the program proposed (Figure 3).

284

285 FIGURE 3

286

287 4.2 Social network analysis

288 The interviewees acknowledged only a limited set of actors as HCWM stakeholders, and some were

289 nominated just once. Thus they probably had a very marginal role, confirming the stakeholder analysis

290 results. Indeed, the Ministry of Transport was nominated by a stakeholder that had never met any of its

291 representatives. The interactions were concentrated with the MSW service providers, the MoH, and the

292 MoH' HCFs. However, the MoH's HCFs stated that they had very infrequent contacts, while for other

293 interviewees they were much more regular (Figure 4). Indeed, MoH's HCFs not only considered some

294 interactions to be solely informal, they also perceived their contacts with stakeholders about HCWM to be

295 limited. In general, this difference of perception was valid also for other stakeholders, such as the UNRWA,

296 EQA, health NGOs, WHO, and private contractors. Only the MoH, the MSW service providers and the health

297 NGOs noted that they had some internal interactions about the topic (e.g. between different MoH

298 Directorates, municipalities, or NGOs). While for example neither MoH' HCFs, nor private and NGO' HCFs

299 had any significant interactions.

300

301 FIGURE 4

302

303 Information circulated quite poorly between stakeholders, and only a few (e.g. the MoH and the WHO),

304 noted that they had several reliable sources about both the theoretical aspects, as well as the existing

305 situation in the Gaza Strip. Municipalities had a good picture of what was taking place, but required a

306 theoretical understanding. On the contrary, HCFs had limited knowledge and information about the issue,

307 and did not communicate with others, even those in the same category (e.g. the MoH, private hospitals,

308 NGOs and the UNRWA). Moreover, they largely relied on the internet and and any training for information

309 (Figure 5).

310

12

311   FIGURE 5

312

313   Indeed, HCFs argued that they possessed only limited information, and needed much more. Only the public

314   authorities shared a satisfactorily high level of information. The other stakeholders wished to increase the

315   information circulated, although it was not as pressing a need as for HCFs (Figure 6).

316

317   FIGURE 6

318

319   Stakeholders had different points of view about HCWM, thus they declared different priorities as well.

320   However, the top three priorities noted were "waste segregation", "material for first storage and cleaning",

321   and "on-site storage", respectively. This order was confirmed by considering only the first priority declared,

322   and in particular an intervention directly "within the ward" was required. This opinion was shared by both

323   health providers and HCFs, while other actors would have liked to first tackle other factors, such as

324   appropriate disposal of residues (Figure 7).

325

326   FIGURE 7

327

328   5. DISCUSSION

329   5.1 About the case study

330   The system of HCWM in the Gaza Strip was complicated, with generally limited knowledge and sharing of

331   information amongst the various stakeholders. All the challenges identified evidently affected several

332   aspects of HCWM, but the stakeholders declared that financial constraints was the key limiting factor. Even

333   though the Ministry of Health was highlighted as a key player and various other organizations were also

334   mentioned, none had significant power, thus theoretically their capacity to effectively affect the system

335   was limited. Nevertheless, several actors thought that something could be done. Despite the shortage of

336   material resources, they could use human resources, and introduce best practice and a better organization

337   as a means of improving the system. Such a positive approach was possible, probably due to the time spent

338   discussing about HCWM during the interviews. Despite the generally limited knowledge, sharing of

339   information and influence, many, HCF in particular, expressed an interest in HCWM. The level of interest

340   was generally high, but the lack of a proper discussion platform inhibited any potential action. During the

341   interviews a global picture of a HCWM system was shared, and HCFs' representatives felt finally involved,

342   with a better understanding of their role, and the importance of their activity. Indeed they felt that they

343   now had the ability to positively influence the system. Thus similarly to previous studies, these findings

344   demonstrate the importance of building knowledge and awareness (Carlsson and Berkes, 2005; Armitage *et*

345   *al.,* 2009; Bodin and Crona, 2009), as well as motivation (Kilgore *et al.*, 2007; Larsen *et al.,* 2011; Meadows

346   *et al.,* 2014), to enhance stakeholder networks. Indeed, it looks even more important in the absence of the

347   driver for improvement constituted by the local legislation (Wilson, 2007).

348

349   Attitudes towards the intervention proposed were very positive, but the knowledge about both the existing

350   situation and theoretical aspects of HCWM were limited (Sarsour *et al.*, 2014). Interest and knowledge

351   were evidently linked (Figure 2), as well as attitudes and theoretical knowledge (Figure 3). In addition, the

352   interest for the proposed project also appeared to be related, however, this may have simply be that the

353   proposal was well-defined and meeting the stakeholders' needs. The limited communication between

354   stakeholders was evident, and particularly perceived by HCFs (Figure 6). Only public authorities (e.g.

355   municipalities and MoH), and the most powerful and informed stakeholders were satisfied with the existing

356   circulation of information, while all the others felt that it could be improved. However, the absence of any

357   actor with a high theoretical knowledge (Figure 3) suggested the lack of any local expertise about HCWM.

358   The socio-political situation had an impact on the functioning of the system. Indeed, technical capacity was

359   lacking in the Gaza Strip. Thus if the system and the capacity, expertise and knowledge of the networks are

360   to improve, external support from international experts and organizations is required. In addition, the need

361   for more information sharing is evident. Interactions were quite polarised between only a few

362   stakeholders. However, the stakeholders each had different perceptions. For example, HCFs felt quite

363   isolated, despite being nominated by several others (Figure 4). In particular technical staff from different

364   HCFs, especially in public facilities, did not feel free to officially share their knowledge and experiences.

365   WHO had an interesting 'hub' position, which could be used to share information, facilitate the

366   establishment of collaborations between stakeholders, and build the capacity and resilience of the

367   networks. For example, an official technical platform, facilitated by the WHO, could identify the challenges,

368   and appoint a task force to develop solutions. In such a way, stakeholders would have regular and official

369   opportunities to meet and cooperate.

370   The difference between stakeholders' perception was suggested also by the information network (Figure

371   5). Not all the interactions identified were considered sources of information, but some new sources (e.g.

372   the internet) were noted. This finding confirms the lack of a reliable local source of information. This is an

373   issue that needs to be addressed, maybe with the support of a reliable and trusted stakeholder such as the

374   WHO. Finally, the sources of information were quite specific, dealing only with either theoretical

375   information or updates about the existing geo-political situation in the Gaza Strip. The information network

376   was almost composed of two different networks, with just three ties in common. Only three stakeholders

377   (i.e. WHO, the MoH, and private contractors) gave and received information in both these networks. Thus

378   these three agencies could be important link points to improve knowledge circulation, using the

379   interactions and sources of information already in place. Indeed the adaptation best practice could suggest

380   fit for purpose local solutions, and indicate an appropriate way forward. HCF personnel, and in particular

381   technical staff, are the most suitable actors, due to the fact that they deal daily with HCW. However, they

382   evidently need technical and institutional support, in order to improve their capacity and competencies.

383   Identification of priorities reflected the stakeholders' knowledge and work. Actors mainly focused attention

384   on what they knew, thus they highlighted the risks they perceived the most during their activities (Figure 7).

385   It was particularly evident for health providers, who focused their attention on HCWM within HCFs, while

386   public authorities tried to consider also waste production and treatment. Finally, other stakeholders, not

387   directly involved and with a limited knowledge about practical aspects of HCWM, had difficulty in

388   identifying priorities. Thus the focus and effectiveness of the network for sustainable management of waste

389   and resources are evidently heavily dependent on understanding the perceptions and expectations of

390   stakeholders, as this plays a significant role in the effective implementation of an ecosystem-based

391   approach (Gelcich *et al.,* 2005; Pomeroy and Douvere, 2008).

392

393   5.2 About the methodology

394   The initial list of stakeholders was carefully developed based on the available information, thus the

395   snowball method was required to identify just a few other important actors (Costa and da Cunha 2010).

396   The benefit of utilizing such an approach is also supported by the social network diagrams of both

397   interaction and information sharing. No new primary stakeholders were identified, considering both the

398   ties and their strength (Henriksen *et al.,* 2007). The identification of such networks and their challenges can

399   be employed to suggest which resources and actions are required (Carlsson and Berkes, 2005; Newman and

400   Dale, 2007), in order to improve the sustainability of environment management (Kilgore *et al.*, 2007; Larsen

401   *et al.,* 2011; Meadows *et al.,* 2014).

402

403   The methodology proposed was appropriate to put a deliberative approach in practice (Levänen and

404   Hukkinen, 2013). The case study showed that the integration of stakeholder analysis and social network

405   analysis is possible in practice not only in high-income countries (Reed *et al.,* 2009; Lienert *et al.,* 2013), but

406   also in complex settings like the Gaza Strip. It also demonstrated that the methodology proposed in Caniato

407   *et al.* (2014) could be improved. The topics in Table 1 were modified to make them clearer; questions were

408   revised to ensure a smoother flow during interviews, and better adaptability to the local context;

409   interviewees gave score on a 1-5 scale and drew their own networks, reducing the need for data recoding

410   and processing; and evaluation of priorities was introduced, thus interviewees could give their opinion

411   about the future of the HCWM system in a quick and easy way.

412

413   6. CONCLUSIONS

414   Using stakeholder and social network analyses, this study has examined the manner in which a range of

415   socio-economic (e.g. perceptions and access to finance) and logistical (e.g. information sharing and

416   interactions) factors impacted upon the effectiveness of stakeholder networks involved in the management

417   of health-care waste in the Gaza Strip. The interaction of these factors was found to be complicated and

418   significantly impacted upon the effective functioning of the system, particularly given the constraints of the

419   geo-political situation in the case study region. Despite these complications and limitations, potential

420   options for improvement were identified. These options included capacity building of local stakeholders,

421   improving the sharing of information and using 'hubs' comprised of local and external support. It is only

422   through such a holistic and deliberative approach that a more resilient system can be developed and

423   sustained. This is particularly crucial given not only the environmental benefits to be accrued from a more

424   sustainable approach to managing healthcare-waste, but also the wider socio-economic and public health

425   benefits. Indeed, more effective management would lead to reduced risks to the population, thereby

426   improving public health and enabling targeting of financial resources. In addition, better sharing of

427   information about waste management should also lead to co-operation on other issues amongst key public

428   and private sector agencies in the country, as well as between these organizations and the community, and

429   the organizations and international agencies. Finally, the findings should also serve to contribute to the

430   literature on the management of resources and stakeholder networks in countries facing similar issues.

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439

440 REFERENCES

441 Adam, S., Kriesi, H. 2007. The network approach. In: Sabatier, P. (ed.). The theories of the policy

442   process. Westview Press. Boulder. Co. 129-154.

443 Alameddine, M., Naja, F., Abdel-Salam, S., Maalouf, S., Matta, C. 2011. Stakeholders' Perspectives

444   on the Regulation and Integration of Complementary and Alternative Medicine Products in

445   Lebanon: A Qualitative Study. BMC Complementary and Alternative Medicine 11, 71.

446 Al-Khatib, I.A., Al-Qaroot, Y.S., Ali-Shtayeh, M.S. 2009. Management of healthcare waste in

447   circumstances of limited resources: a case study in the hospital of Nablus city, Palestine.

448   Waste Management & Research 27 (4), 305-312.

449 Armitage, D.R., Plummer, R., Berkes, F., Arthur, R.I., Charles, A.T., Davidson-Hunt,I.J., Diduck, A.P.,

450   Doubleday, N.C., Johnson, D.S., Marschke, M., McConney, P.,Pinkerton, E.W., Wollenberg,

451   E.K. 2009. Adaptive co-management for social–ecological complexity. Frontiers in Ecology and

452   the Environment 7 (2), 95-102.

453 Baber, W.F., Bartlett, R.V. 2005. Deliberative environmental politics: democracy and ecological

454   rationality. MIT Press. Cambridge.

455 Bodin, Ö., Crona, B.I. 2009. The role of social networks in natural resource governance: what

456   relationship patterns make a difference? Global Environmental Change 19 (3), 366-374.

457 Borgatti, S.P., M.G. Everett, and L.C. Freeman. 2002. Ucinet for Windows: Software for Social

458   Network Analysis. Harvard, USA: MA: Analytic Technologies. http://www.analytictech.com/.

Caniato, M., Vaccari, M. 2014. How to assess Solid Waste Management in armed conflicts? A new methodology applied to the Gaza Strip, Palestine. Waste Management & Research *published online on 8 August 2014, DOI: 10.1177/0734242X14543553.*

Caniato, M., Vaccari, M., Visvanathan, C., Zurbrügg, C. 2014. Using Social Network and Stakeholder Analysis to Help Evaluate Infectious Waste Management: A Step towards a Holistic Assessment. Waste Management 34 (5), 938-951.

Cárcamo, P.F., Garay-Flühmann, R., Gaymer, C.F. 2013. Opportunities and constraints of the institutional framework for the implementation of an ecosystem-based management: the case of the Chilean coast. Ocean and Coast Management 84, 193-203.

Cárcamo, P.F., Garay-Flühmann, R., Sueo, F.A., Gaymer, C.F. 2014. Using stakeholders' perspective of ecosystem services and biodiversity features to plan a marine protected area. Environmental Science and Policy. In Press.

Carlsson, L., Berkes, F. 2005. Co-management: concepts and methodological implications. Journal of Environmental Management 75 (1), 65-76.

Carollo, C., Reed, D.J. 2010. Ecosystem-based management institutional design: balance between federal, state, and local governments within the Gulf of Mexico Alliance. Marine Policy 34 (1), 178-181.

Chambers, S. 2003. Deliberative democratic theory. Annual Review of Political Science 6, 307-326.

Costa, C.C., Da Cunha, P.R. 2010. Who Are the Players? Finding and Characterizing Stakeholders in Social Networks. Proceedings of the Annual Hawaii International Conference on System Sciences 5428684.

480   Crona, B., Bodin, Ö. 2006. What you know is who you know? Communication patterns among

481   resource users as a prerequiste for co-management. Ecological and Society 11 (2), 7.

482   Dietz, T., Ostrom, E., Stern, P.C. 2003. The struggle to govern the commons. Science 302 (5652),

483   1907-1912

484   de Titto, E., Savino, A., Townend, W.K. Healthcare waste management: the current issues in

485   developing countries. Waste Management & Research 30 (6), 559-561.

486   Dryzek, J. 2010. Foundations and frontiers of deliberative governance. Oxford University Press. NY.

487   Folke, C., Pritchard, L., Berkes, F., Colding, J., Svedin, U. 2007. The problem of fit between

488   ecosystems and institutions: ten years later. Ecology and Society 12 (1), 30.

489   Friend, J., Hinckley, A. 2005. Planning under pressure. The strategic choice approach. Taylor &

490   Francis. Amsterdam.

491   Gelcich, S., Edwards-Jones, G., Kaiser, M.J. 2005. Importance of attitudinal differences among

492   artisanal fishers toward co-management and conservation of marine resources. Conservation

493   Biology 19 (3), 865-875.

494   Google Earth 7.1.2.2041. 2013. The Gaza Strip 31°23'55.83"N, 34°44'37.76"E, eye alt. 69.44 km,

495   SIO, NOAA, U.S. Navy, NGA, GEBCO. U.S. Dept. of State Geographer. CNES/Astrium 2014,

496   DigitaGlobe 2014. http://www.google.com. Accessed on 26/6/2014.

497   Grimble, R., Wellard, K. 1997. Stakeholder methodologies in natural resource management: a

498   review of principles, contexts, experiences and opportunities. Agricultural Systems 55 (2),

499   173-193.

500 Guntman A., Thompson, D. 2004. Why deliberative democracy? Princeton University Press.

501   Princeton.

502 Hagedorn, K. 2008. Particular requirements for institutional analysis in nature related sectors.

503   European Review of Agricultural Economics 35 (3), 357-384.

504 Hajer, M., Wagernaar, H. 2003. In: Hajer, M., Wagernaar, H. (eds.). Deliberative policy analysis:

505   understanding governance in the network society. Cambridge University Press. Cambridge. 1-

506   30.

507 Heck, N., Dearden, P. 2012. Local expectations for future marine protected area performance: a

508   case study of the proposed national marine conservation area in the Southern Strait of

509   Georgia, Canada. Coastal Management 40 (6), 577-593.

510 Henriksen, H.J., Rasmussen, P., Brandt, G., Bulow, Dv., Jensen, F.V. 2007. Public participation

511   modelling using Bayesian networks in management of groundwater contamination.

512   Environmental Modelling and Software 22 (8), 1101-1113.

513 Kenis, P., Scheider, V. (1991). Policy networks and policy analysis: scrutinizing a new analytical

514   toolkit. In: Marin, B., Mayntz, R. (eds.). Policy networks: empirical evidence and theoretical

515   considerations. Westview Press. Boulder, Co. 25-59.

516 Kidd, S., Plater, A., Frid, C. 2011. The ecosystem approach to marine planning and management

517   Earthscan. Washington, D.C.

518 Kilgore, M, Greene, L., Jacobson, M., Straka, T., Daniels, S. 2007. The influence of financial

519   incentive programs in promoting sustainable forestry on the nation's family forests. Journal of

520   Forestry 105 (4), 184-191.

521   Jensen, F. 2002. Bayesian networks and decision graphs. Statistics for Engineering and Information

522   Science. Springer. New York.

523   Larsen, S., Foulkes, M., Sorenson, C., Thimpson, A. 2011. Environmental learning and the social

524   construction of an exurban landscape in Fremont County, Colorado. Geoforum. 42 (1), 83-93.

525   Lennartsson, M., Kvarnström, E., Lundberg, T., Buenfil, J., Sawyer, R. 2009. Comparing sanitation

526   systems using sustainability criteria. SEI, Stockholm. Sweden.

527   Levänen, J.O., Hukkinen, J.I. 2013. A methodology for facilitating the feedback between mental

528   models and institutional change in industrial ecosystem governance: a waste management

529   case-study from northern Finland. Ecological Economics 87, 15-23.

530   Lienert, J., Schnetzer, F., Ingold, K. 2013. Stakeholder analysis combined with social network

531   analysis provides fine-grained insights into water infrastructure planning process. Journal of

532   Environmental Management 125, 134-148.

533   Long, J.C., Cunningham F.C., Wiley J., Carswell P., Braithwaite J. 2013. Leadership in Complex

534   Networks: The Importance of Network Position and Strategic Action in a Translational Cancer

535   Research Network. Implementation Science 8 (1), 122.

536   Lopes, P.F.M., Rosa, E.M., Salyvonchyk, S., Nora, V., Begossi, A. 2013. Suggestions for fixing top-

537   down coastal fisheries management through participatory approaches. Marine Policy 40 (1),

538   100-110.

539   Lundie, S., Peters, G., Ashbolt, N., Lai, E., Livingston, D. 2006. A sustainability framework for the

540   Australian water industry. Water 33 (7), 83-88.

541   Lüthi, C., Morel, A., Tilley, E., Ulrich, L. 2011. Community-led Urban Environmental Sanitation

542   Planning. EAWAG/SANDEC, Duebendorf.

543   MacLean, S., Burgess, M. 2010. In the public interest: assessing expert and stakeholder influence in

544   public deliberation about biobanks. Public Understanding of Science, 19, 486-496.

545   Marias, D.C., de Almeida, A.T. 2007. Group decision-making for leakage management strategy of

546   water network. Resources, Conservation and Recycling 52 (2), 441-459.

547   McLeod, K.L., Leslie, H.M. 2009. Ecosystem-based management for the oceans. Island Press,

548   Washington, DC.

549   Meadows, J., Herbohn, J., Emtage, N. 2014. Engaging Australian small-scale landowners in natural

550   resource management programmes - perceptions, past experiences and policy implications.

551   Land Use Policy 36, 618-627.

552   Mendenhall, M.A. 2014. Educational sustainability in the relief-development transition: challenges

553   for international organizations working in countries affected by conflict. International Journal

554   of Educational Development 35, 67-77.

555   Newman, L., Dale, A. 2007. Homophily and agency: creating effective sustainable development

556   networks. Environment, Development and Sustainability 9 (1), 79-90.

557   OPt Health and Nutrition Cluster 2012. CAP 2012-13 Needs Analysis Framework. Available at

558   http://www.emro.who.int/images/stories/palestine/documents/Health.Nutrition_Cluster.ne

559   eds_analysis_framework.pdf?ua=1. Accessed on 20/4/2014.

560   PCBS (Palestinian Central Bureau of Statistics) 2013. Population of Palestine. Available at

561   www.pcbs.gov.ps/site/881/default.aspx#PopulationA. Accessed on 14/4/2014.

562   Phillips, P.S., Tudor. T.L., Bird, H., Bates, M.B. 2011. A critical review of a key Waste Strategy

563   initiative in England: Zero Waste Places Projects 2008-2009. Resources, Conservation and

564   Recycling 55 (3), 335-343.

565   Pomeroy, R., Douvere, F. 2008. The engagement of stakeholders in the marine spatial planning

566   process. Marine Policy 32 (5), 816-822.

567   Reed, M.S., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., Prell, C., Quinn, C.H.,

568   Stringer, L.C. 2009. Who's in and why? A typology of stakeholder analysis methods for natural

569   resource management. Journal of Environmental Management 90 (5), 1933-1949.

570   Roy, B. 2010. Two conceptions of decision aiding. International Journal of Multicriteria Decision

571   Making 1 (1), 74-79.

572   Rushbrook, P., Zghondi, R. Better Health Care Waste Management: an integral component of

573   health investment. World Health Organization, Amman:

574   http://www.who.int/water_sanitation_health/medicalwaste/bhcwmeng.pdf.Accessed on

575   22/06/2014.

576   Salem, R. 2013. Gaza's challenge. Chartered Instutition of Wastes Management (CIWM) Journal

577   April. 48-49.

578   Sarsour, A., Ayoub, A., Lubbad, I., Omran, A., Shahrour, I. 2014. Assessment of Medical Waste

579   Management within Selected Hospitals in Gaza Strip Palestine: A Pilot Project. International

580   Journal of Scientific Research in Environmental Sciences 2 (5), 164-173.

581   Schmeer, Kammi. 1999. Guidelines for Conducting a Stakeholder Analysis. Bethesda, USA:

582   Partnerships for Health Reform, Abt Associates Inc.

583   http://www.who.int/management/partnerships/overall/GuidelinesConductingStakeholderAn

584   alysis.pdf. Accessed on 14/4/2014.

585   Scholz, J.T., Wang, C.-L. 2006. Cooptation or transformation? Local policy networks and federal

586   regulatory enforcement. American Journal of Political Science 50 (1), 81-97.

587   Simon, U., Brüggemann, R., Pudenz, S. 2004. Aspects of decision support in water management

588   example Berlin and Potsdam (Germany) II-improvement of management strategies. Water

589   Research 38 (19), 4085-4092.

590   Starkl, M., Brunner, N., López, E., Martínez-Ruiz, J.L. 2013. A planning-oriented sustainability

591   assessment framework for peri-urban water management in developing countries. Water

592   Research 47 (20), 7175-7183.

593   Stern, N. 2006. The Stern review on the economics of climate change. HMSO. London. UK

594   Tudor, TL., Woolridge, AC., Phillips, CA., Holliday, M., Laird, K., Bannister, S., Edgar, J., Rushbrook,

595   P. 2010. Evaluating the link between the management of clinical waste in the National Health

596   Service (NHS) and the risk of the spread of infections: a case study of three hospitals in

597   England. International Journal of Hygiene and Environmental Health 213 (6), 432 - 436

598   UNDP. 2012. Feasibility study and detailed design for solid waste management in the Gaza Strip.

599   Palestine: Gaza. (unpublished).

600   UNoPT. 2012. Gaza in 2020, a liveable place? Available at

601   http://www.unrwa.org/userfiles/file/publications/gaza/Gaza%20in%202020.pdf. Accessed on

602   14/4/2014.

603   Walters, C., Holling, C.S. 1990. Large scale management experiments and learning by doing.

604   Ecology 71 (6), 2060-2068.

605   Weber, T.C., Allen, W.L. 2010. Beyond on-site mitigation: An integrated multiscale approach to

606   environmental mitigation and stewardship for transportation projects. Landscape and Urban

607   Planning 96 (4), 240-256.

608   WHO (World Health Organization). 2011. Health-care waste management. Fact sheet N^{0}281.

609   Available at: http://www.who.int/mediacentre/factsheets/fs281/en/. Accessed on 15/9/2014

610   Wilson, D.C., 2007. Development drivers for waste management. Waste Management and

611   Resource 25 (3), 198-207.

612