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3 **Flood Management Model In Digital Era, Using SAST (Strategic**
4 **Assumption Surfacing and Testing) and the Exponential Comparison**
5 **Method (ECM) : A Case Study in Jakarta**
6

7 **Abstract**

8 Flooding is a regular annual disaster in Jakarta, especially in December to
9 February. Geographical position of Jakarta which is 40% below sea level, causes
10 flooding not only from rain, but also from rob due to rising sea levels. In the last 5
11 years the impact of flooding became more serious, leading to economic and human
12 losses.

13 This study aims to determine the right strategy of flood mitigation by public
14 involvement in the digital era. The method used includes combination of quality
15 input data from experts representing BNPB (National Disaster Agency), Local
16 Government, Academics, Community Leaders, Businessmen, and Practitioners, in
17 addition to vulnerable field research. Data analysis uses the ECM (Exponential
18 Comparison Method) and SAST (Strategic Assumption Surfacing and Testing).

19 The result of the study indicates that the most appropriate strategy to mitigate
20 flood disaster is establishment of "Disaster Information Center" and "Disaster alert
21 groups" involving every stakeholder from the community. Utilization of social
22 media, especially WhatsApp, Facebook, and Instagram has been very helpful to
23 share information of flood, especially how to prepare an emergency action to
24 reduce economic and human losses .
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27 Keywords: Flood, Mitigation, Disaster management, Digital Community
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29 **Introduction**

30 Jakarta faces devastating routine flood almost every year. The height of the
31 flood waters in the last 5 years (2013-2017) on an average has reached 4 meters,
32 usually within a time span of 4-8 days. The most devastating flood occurred in 2013
33 with a maximum water height of 4 meters for more than 5 days. Economic losses
34 exceeded more than 20 trillion dollars (BNPB, 2015). Osti and Nakasu (2014) state
35 that one of the causes of human casualties during floods was drowning (44%).
36 Floods come without warning and they take lives of tens, hundreds and thousands of
37 people. The resulting loss depends on the vulnerability and lack of resilience of the
38 affected population to resist the hazard. If this type of disasters continue it would lead
39 to considerable socio-economic losses, leading to prolonged setbacks to a large
40 number of citizens of Jakarta .The flood conditions in Jakarta are getting worse
41 because 40% of the Jakarta area is below sea level. There are 3 types of Jakarta
42 floods: (1) overland flooding (2) flooding due to rain, and (3) Rob flooding. Overland
43 flooding usually originates in Bogor and the surrounding areas in the upstream.
44 Although it is not raining in Jakarta, the runoff water from Bogor will flow to Jakarta
45 via the Ciliwung River leading to Jakarta flooding. Overland flooding usually
46 occurs only in certain areas near the Ciliwung River. Floods due to rain have a wider

47 impact, usually around December-February. The impact can lead to more than 50%
48 of area submergence. Whereas rob floods occur when sea level rises. This type of
49 floods occur in northern Jakarta, where land topography is below sea level. In
50 addition to low lying topography the land is affected during floods due to
51 overflowing of 13 rivers crisscrossing Jakarta. The rivers include Ciliwung River,
52 Pesangrahan river, Kali Baru river, Krukut River, and others. When the rain falls,
53 the overflow of water from the 13 rivers submerges most of the area of Jakarta,
54 especially several densely populated villages.

55 Of the 13 rivers surrounding Jakarta, Ciliwung has the most extensive impact
56 during the rainy season, because it flows through the center of Jakarta and crosses
57 many villages, crowded markets, and densely populated slum residential areas.

58 The floods in Jakarta are getting worse in last 5 years, in addition to the
59 damaged watershed (DAS) in the upstream of Puncak and Bogor. The watershed in
60 Jakarta has also experienced narrowing and siltation due to illegal buildings along the
61 river. Flooding in 2013 was the worst and its impact was extensive; average
62 inundation height was 1-3 meter with duration of 20 days. Loss of economic potential
63 reached IDR 20 trillion, 20 people died and 33,500 people were displaced (National
64 Disaster Agency, 2017).

65 To anticipate flooding, the Government of Jakarta has built East Flood Canal
66 (BKT) and West Flood Canal (BKB). BKT with a length of 23.5 km was built with
67 the aim of protecting the East Jakarta and North Jakarta areas from the overflow of
68 Ciliwung, Cipinang, Sunter, Buaran, Jatikramat, and Cakung rivers, due to water
69 flow discharges at the peak of the rainy season, which was not accommodated.
70 Whereas BKB, with a length of 17.4 km, was built to drain water through the Angke
71 River through the Krukut Canal to accommodate water overflows from Ciliwung,
72 Krukut River and Cideng River, which will then be channeled to the sea.

73 Along with the development of the city of Jakarta and its surroundings, the
74 construction of the two canals to drain rainwater is found not adequate. Water
75 overflows caused by overland floods or due to heavy rains still submerge some parts
76 of Jakarta. In addition there are around 400 business activities that directly or
77 indirectly dispose of their wastewater including solid waste into Ciliwung River
78 (Ministry of Environment, 2012). There are 26,818 households, who inhabit the
79 banks of the Ciliwung River are also throwing garbage into the river every day. This
80 causes sedimentation, narrowing of the river, and high rates of pollution in the river.
81 To handle flooding in Jakarta, government have built western canal flood, and east
82 canal flood. But the increase of population and urban development, the two canals
83 are no longer able to accommodate the flow of water when it rains.

84 A major problem facing Jakarta residents is the handling of yearly floods have
85 not been integrated and well planned. This lapse has made the people clueless
86 regarding the application of appropriate flood management. This vulnerability has
87 resulted in loss of hundreds of human lives and millions of infrastructure's damage.
88 The people are always confused when they are facing flood. In turn the overall chaotic
89 situation has resulted in ill planned area specific shelter homes by the government,
90 leading to adhoc last minute temporary shelters making the entire mitigation process
91 an useless costly exercise. To make the disaster mitigation works useful and cost

92 effective, well planned right mitigation strategies are needed so that the impact of the
93 flood can be reduced.

94 Along with the development of digital technology, anticipation of flooding by
95 involving the community can be improved through social media. If flood disaster
96 occurs, the public must immediately get information about the dynamics of floods,
97 including the magnitude of the flood to quickly migrate in an orderly manner to the
98 well planned area specific shelter homes. Some of the vital details can be provided by
99 social media. Chang Ngai Weng (2010) states that social media can be used to
100 support flood mitigation, so the people are quickly informed of the status and actions
101 that must be taken. Social media has become a valuable means of communication in
102 many places affected by a natural disaster, which allows people to keep in touch with
103 family and friends and access important information. Velev, D and Plamena Zlateva
104 (2018) state that social media has emerged as a popular medium for providing new
105 sources of information and rapid communications, particularly during natural disasters
106 .

107 This study aims to determine the most appropriate mitigation strategy by
108 involving the community at every stage, in accordance with objective condition of
109 the peoples, in digital era.

110 **Methods**

111 This research is expert based. Data collection is done through expert
112 discussions. In these discussions it is essential to include all the stakeholders,
113 including policy makers, disaster experts from BNPB (National Disaster Agency),
114 Academics and Community Leaders. In addition to high level experts' discussions,
115 members of the study team should gather additional information by interviewing local
116 influential leaders, and affected common people. During this study 75 representative
117 respondents were interviewed who were randomly selected to find out the types of
118 social media used in flood disaster communication and their perception to disaster
119 management system.
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121 Data analysis uses SAST (Strategic Assumption Surfacing and Testing) and
122 ECM (Exponential Comparison Method). SAST and ECM are experts based
123 method. SAST selected for mapping the most important and Certainty aspects
124 through the picture, while ECM method selected for determining priority
125 strategy based on multi criteria; the formula of ECM is as below:

$$126 \text{Value Total (TN}_i) = \sum_{j=1}^m (RK_{ij})^{TKK_j}$$

127 Where :

128 TN_i : Total alternative value to - i

129 RK_{ij} : The degree of relative interest jth in choice decisions i

130 TKK_j : Degree of interest of criteria jth decision; TKK_j > 0; even

131 N : Number of decision choices

132 M : Number of decision criteria

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138 **Literature Review**

139 Disaster can be defined as a source of danger, and its consequences can
 140 adversely affect humans in terms of life, property and environment when the level of
 141 danger, and the consequences, exceed the ability of the affected society to cope using
 142 its own resources (Alexander 1997). The Flood disaster is a puddle in an area due to
 143 overflow of water, which causes material and non-material losses (Indonesian Law
 144 No. 24 of 2007).

145 Mitigation means reducing risk of loss from the occurrence of any undesirable
 146 event. (BNPB, 2015). There are two types of mitigation, structural and non structural
 147 (Indonesian Geography Center, 2016). Structural mitigation means flood
 148 prevention with physical development (dam, levees, reservoir), while non structural
 149 mitigation is an effort to reduce the impact of flood other than structural, it included
 150 public awareness, establishment of flood alert group, zoning and mapping of
 151 flood prone area.

152 There are 6 important aspects of mitigation strategy : (1) prevention (planning
 153 and zoning, drainage system maintenance, beach maintenance); (2) property protection
 154 (elevation, relocation, flood proofing, storm shutters, insurance) ; (3) public education
 155 and awareness (Real estate disclosure, hazard information center, flood map and data)
 156 ; (4) natural resources protection (sediment and erosion control, stream corridor
 157 restoration, watershed management); (5) emergency services measure (emergency
 158 response planning, evacuation, and critical facilities protection) ; (6) structural project
 159 (flood walls, levees, dams); Wetmore and Jamieson (1999). Grigg (1996) stated
 160 there are 4 aspects of flood control: (1) Modification of flood vulnerability and losses
 161 by determining of zones of land use arrangements, (2) Normalization of reservoir or
 162 river (3) Modification of the impact of flooding with the use of technical mitigation
 163 such as insurance, flood proofing, and (4) regulation of maintaining natural capacity,
 164 including reforestation.

165 Indonesia is one of the countries with the high disaster risk, as several types
 166 of disasters are most likely to arise. They include: floods, landslides, earthquakes,
 167 Tsunamis, volcanic eruptions, Tornados, forest fires, etc. National Disaster Agency
 168 (2017) has identified disaster events in 2016 as the following (table 1):

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 170 Table 1. Disaster events in Indonesia in 2016
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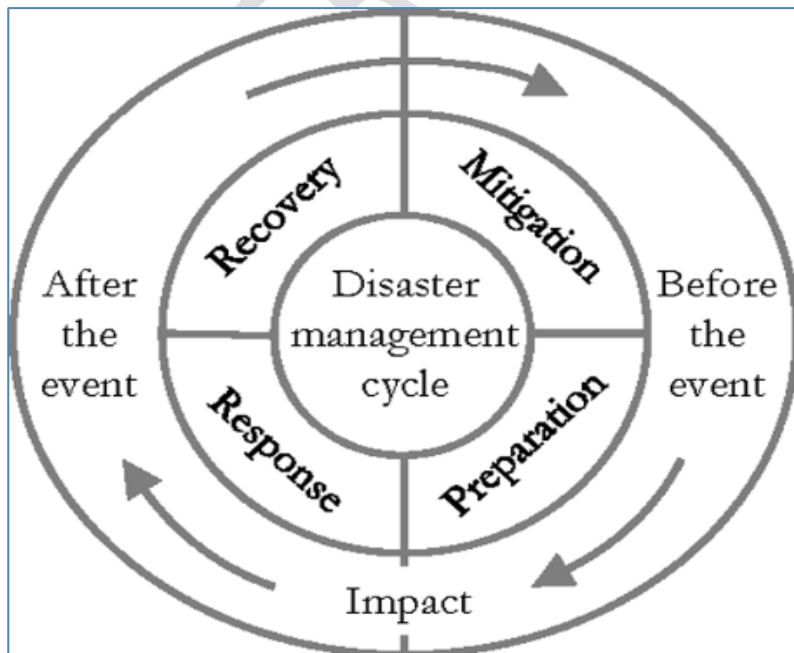
No	Type of Disasters	Number of events	Damage Facilities		
			Education	Worship	Health
1	Flood	850	1.119	265	81
2	Tornado	687	62	36	4
3	Landslide	626	49	47	18
4	Forest fire	178	na	na	na
5	Tidal Wave	23	1	na	na
6	Earth quake	13	254	258	127
		2384			

172 National Disaster Agency (2017)

173 The table displays that flooding is the highest occurring disaster with the
174 most severe impacts on education, religious and health facilities. Floods can be
175 classified into several types: (1) Flash flooding, which is large and occurs suddenly
176 and lasts only for a short period of time; (2) Groundwater flooding occurs due to the
177 overflow of very heavy rainwater, especially if the riverbanks are fragile and unable
178 to withstand enough water; (3) River/overland flooding, which occurs due to water
179 delivery from other regions, and may extend for a long time; (4) Coastal flooding
180 (ROB), due to rising tides in areas near the coast; and (5) Headwaters flooding,
181 which occurs in residential area near the upper reaches of the river. Flooding usually
182 occurs due to the high flow of water, which can have destructive effects. Some of the
183 factors that cause flooding include: (1) Illegal logging leading to deforestation, (2)
184 Waste dumped carelessly into rivers, (3) Residential area on river banks, (4) Dense
185 rainfall, (5) Poor drainage system, (6) Broken dams, (7) Spatial errors and (8)
186 Tsunamis. Floods can cause damage to infrastructure, buildings, and the
187 environment, which causes huge economic losses and human casualties (BNPB,
188 2016). One of the causes of flooding is changes in land use, and low community
189 participation (Kodoatie et al, 2002; and Aminudi, 2013). The role of the community
190 in handling floods is very much needed (BNPB, 2015), both in planning,
191 implementing and supervising the development.

192 Disasters occur rapidly, instantaneously and indiscriminately. Generally there
193 are four steps of disaster. Disaster always closed with civilization and poverty, the
194 way the people respond and deal with disaster depends on local culture. There are
195 four phases of disaster management (Khan, 2017) : Mitigation, preparation, response,
196 and recovery. The four disaster management phases do not occur sequentially and
197 separately. Often phases of the cycle overlap and the length of each phase greatly
198 depends on the severity of the disaster. From these 4 stages , mitigation is an
199 important stage before disaster (Sutopo, 2015), as shown in figure below :

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Figure 1. Disaster management cycle (Khan, 2017)

In general, there are two approaches to the problem discussed, including the structural and non-structural methods dealing with flood mitigation (BNPB, 2016). The core of structural method is a physical approach, such as normalization, dam building, channel construction and others, while the non-structural method is a non-physical approach, such as socialization, erosion control, watershed utilization arrangements, and so on. Included in non-structural approach is the use of information technology for disaster mitigation, to involve the wider community.

Flood handling in several developed countries, including in Japan, has used information technology. Disaster management in Japan is under the Ministry of Land, Infrastructure and Transportation (MLIT/Ministry of Land, Infrastructure, Information and Technology), which oversees the problem of flooding (irrigation problems), sediment deposits, volcanic eruptions, earthquakes, by using information technology (IT) for reducing the impact of natural disasters in Japan. The infrastructure handled includes rivers, roads, sea and airports, sewage systems and parks. Similar to what already exists in Indonesia, the basic elements of disaster management in Indonesia consist of regulatory aspects, management systems, plans, preparation, emergency response and recovery. Information technology greatly helps disaster mitigation management (Mukhopadhyay, Buddhadev Bhattacharjee. 2015), especially in terms of public awareness and education.

There are five priorities of Hyogo Framework for Action/ HFA 2005-2015 (Apec, 2009) : 1) Make Disaster Risk Reduction as Priority; 2) Know The Risk and Take Action; 3) Build Understanding and Awareness; 4) Reduce Risk; 5) Be Prepared and Ready to Act. While Sendai Declaration for disaster mitigation (2015-2030) stated four important aspects : (1) Understanding disaster risk; (2) Strengthening of risk governance (3) Investment for Resilience; and (4) strengthening of risk management (BNPB:2015).

Flood preparedness needs to be done in stages, starting from prevention, handling during flood (response/intervention), and recovery after flood. These stages are cycles of continuous flood preparedness, including several types of activities as shown in Table 2.

Table 2 Stages of Flood Preparedness

Cycle	Activities
Prevention	Structural strategies In-Stream strategies Off-Stream strategies Non-structural strategies Long-term flood prevention strategies Short-term management strategies of floods
Intervention /Response	Notification and information with regard to forecast of floods Immediate Reaction and Emergency Support when floods occur Handling of the flood

Cycle	Activities
Recovery	Immediate Assistance for Daily Life Needs and Repair of Facilities and Infrastructure Post-Flood Mop-up and Reconstruction Rehabilitation and Recovery of Physical and Non-Physical Conditions Damage/Loss Assessment and Flood Disaster Insurance Review of the Causes of Floods

239 Source: Directorate of Research and Community Service – UI (2006) ,

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Flood prevention activities follow a life cycle, which begins at flooding, then studies it as input for prevention before a flood occurs. Prevention is carried out thoroughly, in the form of physical activities such as the construction of flood control in river areas (in-stream) to floodplain areas (off-stream), and non-physical activities such as land use management to early flood warning systems. The result of **Osti and Nakasu (2014)** study in Japan showed that 44% human casualties were caused by drowning. Flood mitigation can be done not only by physically protecting buildings through the construction of dams, but also by making appropriate spatial plans.

There are **3 most** famous social media in Indonesia : facebook (41 %), WhatsApp (40 %), and Instagram (38 %); (Supratman, 2018). Most of social media users are for gaining information (46 %), virtual communication (25%), on line shopping (15 %), culture adoption (8 %) and others (6%), (**Mulawarman and Aldila Dyas Nurfitri, 2017**). Social media has a very significant role in disaster mitigation (Lestari , B. Ramadhaniyanto , and D. Wardyaningrum, 2017).

Stakeholders in flood prevention are grouped into **three categories**: (1) beneficiaries, communities that receive benefits/impacts directly or indirectly; (2) intermediaries, community groups or individuals who can provide consideration or facilitation in flood mitigation, including: consultants, experts, NGOs, and professionals in the natural resources sector; (3) decision/policy makers, institutions authorized to make decisions and legal basis, such as government institutions and water resources councils. The type and level of community participation will differ depending on the type of policy or activity.

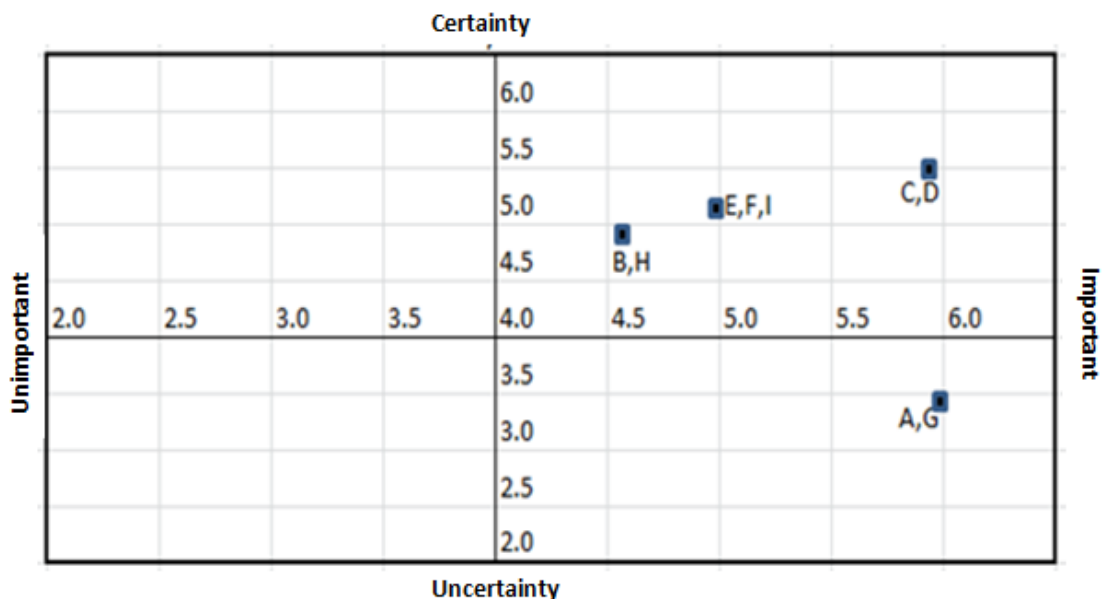
Digital era has changed the whole situation of people's lives, even including social life and behaviour (Rahma, 2015). The impact of digital age on the social life of the society today is connected with one's position in the society, his social class and also his social background. **Nowadays**, there are so many changes in the social aspect of our lives. What's up, Instagram, facebook, line, email are the most popular for dissemination of news, information, images and video (Ministry of Informatic, 2016), so this social media is also possible to support mitigation of flood.

272 **Result and Discussion**

As the capital of Indonesia, flood handling in Jakarta involves many agencies , they are : BMKG (Bureau of meteorology, Climatology and geophysics) , BNPB(National disaster agency) , BASARNAS (National Search and **rescue** agency), BPBD (Regional disaster agency), PMI (Indonesian Red Cross), Local governments, and Community Organizations (Youth groups, religious groups, students, and the

278 general public). BPBD is local disaster agency that is organizationally responsible to
 279 the governor. Over **lapping** between agencies always occurs **during** every flood. There
 280 is no coordination. **Individual organizations** carry out their main duties but do not
 281 cooperate with other organizations. As a **result** flood disaster management **has**
 282 **become inefficient and costly**. As the institution that is responsible for meteorological
 283 and geophysical information, the BMKG only informs about the weather and the
 284 possibility of heavy rain, but not details of places/shelters for evacuation. BMKG does
 285 not include level of water and flooded area. PMI and BASARNAS **carry out** almost
 286 the same task of helping victims, but there is no mutual **coordination, so that**
 287 **information overlaps with the voluntary works carried out by community group and**
 288 **youth organizations**. Based on experts interviews involving BNPB, BMKG, PMI ,
 289 community leaders, and academics; a disaster information center needs to be
 290 established that involves all **components**, to provide and share an official information
 291 of flood disaster online. Only information released by this center can be used as a
 292 reference. Most respondents (68.9 %) stated that they need official information from
 293 the government ,which is distributed digitally, so that the community will quickly
 294 access through mobile phone via WA, facebook or instagram to get the latest
 295 information about flood.

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 297 Based on **experts'** discussion, there are 8 important aspects that need **to be**
 298 **considered** in flood control operations ,in Jakarta : (A) Facilities; (B) Collaboration;
 299 (C) Coordination; (D) information; (E) Public Involvement ; (F) Public awareness; (G)
 300 Technology; (H) Institution; and (I) Disaster management. The results of **SAST**
 301 **analysis** showed that Important **and certainty** aspects based on experts discussion is
 302 showed in **figure 2** .
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 306 **Figure 2. Certainty and important aspects of flood management in Jakarta**
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 308 Descriptions :

309 A : Facilities D : Information G : Technology
 310 B : Collaboration E : Public involvement H : Institution
 311 C : Coordination F : Public awareness I : Disaster Management

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314 The most strategic **assumptions** (figure 2) are coordination (C) and information
 315 (D). **These** two aspects have the highest level of certainty and **importance**.
 316 Coordination is the **biggest** problem. Various agencies work with their own methods
 317 and expertise, there is no cooperation and certain competency standards that must be
 318 possessed; so there are often misunderstandings and even **increased** property damage
 319 that must be saved. This **means** that coordination is very important aspect. The
 320 involvement of various agencies will cause overlap **without** good **coordination**. This is
 321 confirmed by the opinion of most respondents (78.6 %), that flood handling in Jakarta
 322 always overlaps **management, rehabilitation and mitigation** works from the various
 323 institution involved.

324 Disaster information is a very important **component** in disaster management,
 325 84.3 % respondents said that they don't know how to save themselves when flooded,
 326 only a small percentages (15.7 %) can save themselves because they have information
 327 how to save and what to do, information technology is very important for the
 328 distribution of disaster information to reduce disaster risk (Vyas and Aneri Desai,
 329 2007).

330 Other strategic **assumptions** in flood handling are Facilities (A) and Technology
 331 (G). Flood handling requires a lot of equipment such as boats, water suction machines,
 332 transport vehicles, communication equipment etc. Without adequate facility and
 333 technology support, handling floods **is difficult** .

334 Strategic priority based on multi criteria (Economic, Social, Environment and
 335 institution) according to ECM analysis results are showed in **table 3**.

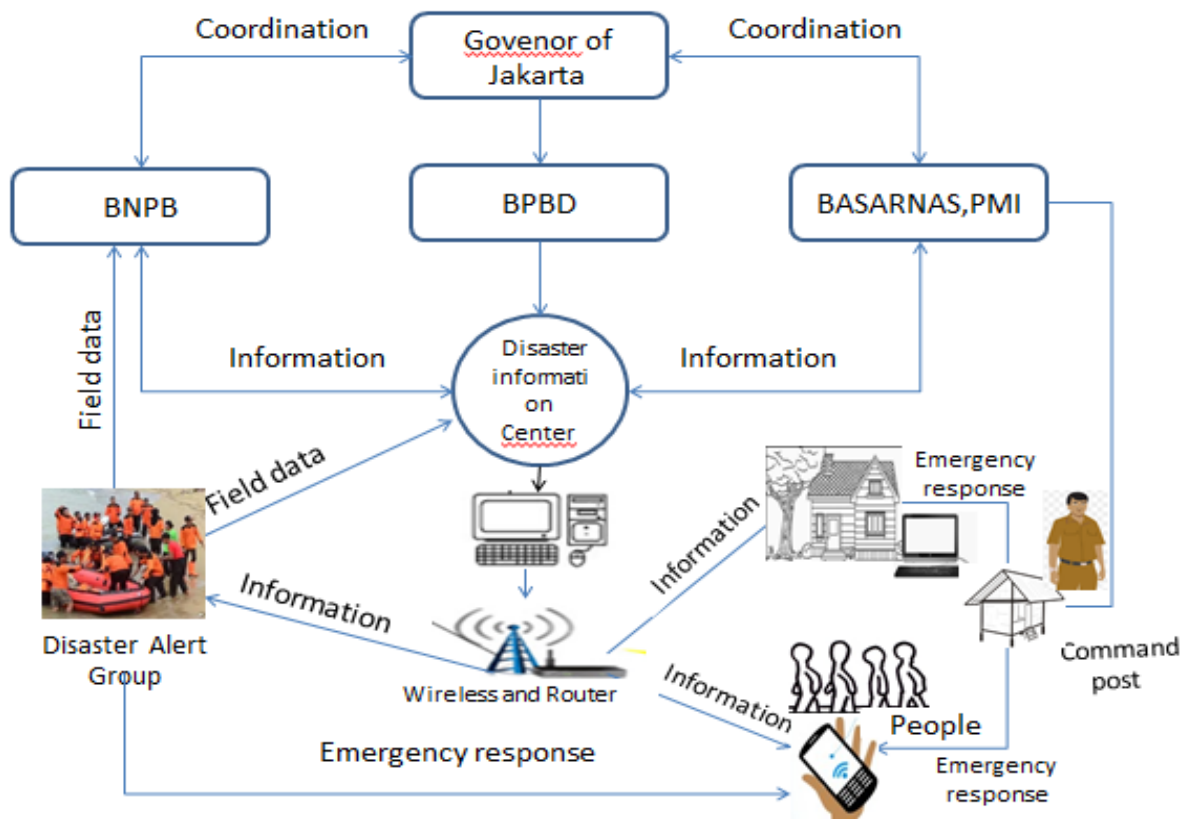
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Tabel 3. Strategic priority to flood handling in Jakarta (ECM analysis result)

No	Strategy	Weight (1-5)	Indikator (1-5)				Total	Ranking
			Economic	Social	Environment	Institution		
1	Development of disaster alert groups	(4,1)	(3,2)	(2,9)	(3,8)	(3,3)	568,4	2
2	Public awareness Development	(3,6)	(3,3)	(3,4)	(3,5)	(3,1)	305,1	5
3	Revitalization of the West and East Flood Canals	(3,6)	(3,4)	(3,4)	(3,4)	(3,4)	327,6	3
4	Public Involvement	(3,5)	(3,3)	(3,5)	(3,5)	(3,5)	305,9	4
5	Development of Disaster Information Center	(4)	(3,6)	(4,2)	(4)	(4)	991,2	1
6	Construction of Flood Control Center	(3,5)	(3,1)	(3,4)	(3,4)	(3,4)	269,9	6

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339 The table above showed that the highest priority of flood handling in Jakarta is
 340 the development of Disaster Information Centre (ranking-1), and then development
 341 of disaster alert groups. Through this centre all information about flood disaster and
 342 the role of each group/ elements **can be coordinated** : BMKG (National Agency of
 343 Metereology and Geophysics), BNPB (National Agency of Disaster Management),
 344 BPBD (Local Agency of Disaster Management), BASARNAS (National Agency of
 345 Reach and Rescecu) and PMI (Indonesian RedCross); community groups and local
 346 government can be coordinated. **So**, the people can receive official information
 347 about the flood in a complete and reliable manner. In addition **overlapping of works**
 348 between groups can be avoided. Community involvement is done by utilizing social
 349 media. Local leadership have to provide an SOP (**standard** operating Procedure),
 350 how to distribute information about flooding to the community through social media.
 351 Most respondents (87.6%) stated that communication through social media is very
 352 effective in disseminating information on disasters faced. **The** most common social
 353 media uses for disater communication are WA (45.4 %), Youtube (32.5 %),
 354 Instagram and Line. The use of social media will be very effective if the news
 355 delivered is accurate and pictures are attached. Through social media, the public can
 356 find out about the current conditions, so that they can quickly anticipate what to do.
 357 Broadly speaking, the utilization of information technology in disaster mitigation can
 358 be described as follows:
 359



360 **Figure 3.** Disaster Information Center Model (***Please give the source details***)
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363 Actions that must be taken **in this centre** include:

- 364 • Update information about flood profile and affected area
- 365 • Distribute information online to affected community, and Disaster alert groups
- 366 • Provide direction to disaster alert groups to rescue victims and secure areas with
- 367 security forces

368 Disaster alert groups is a flood **conscious** group that formed in each region
369 under supervision of **sub-district in charge**. This group consists of young people
370 and some community members who must be trained in disaster management and
371 action to save victims. **The trained** can be deployed when the annual disaster flood
372 comes. **For** activities to run optimally, a management organization needs to be
373 developed, taking into account the organization's structure, functions and governance.

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375 Based on the reality, the most crucial phase is the emergency response,
376 including the rescue of goods and the people. **Therefore, community groups**
377 **identified need to be able to contribute their best**. So, they have to be trained how to
378 save human lives and help the **victims**. **They** also must know how to manage and
379 distribute aid effectively.

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382 **Conclusion**

- 383 a) The priority strategy for flood mitigation according to the objective conditions of
384 Jakarta is development of disaster information **centre** and Formation of Disaster
385 Preparedness team (disaster alert groups), involving all components of society
- 386 b) Community involvement becomes a key success factor in flood disaster mitigation
- 387 c) The use of digital technology through social media will increase the effectiveness
388 of the flow of information about floods, so that people can find out the current
389 situation.
- 390 d). Official information from the government is very important when flooded, to
391 avoid **fake** news , which actually confuses the public

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393 **Suggestion:**

- 394 a) It is necessary to map the potential and capability of the community in
395 their respective regions, and to socialize the plan to involve the
396 community in mitigation through the formation of disaster preparedness
397 team.
- 398 b) To avoid overlapping and emerging conflicts from community groups,
399 disaster information **centre** **needs** to be formed by involving relevant
400 **agencies**.

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