TRAINING

"COMMUNITY PARTICIPATION FOR FLOOD MITIGATION IN BANDUNG CITY"

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THE POLICIES OF THE BANDUNG CITY GOVERNMENT IN MITIGATING FLOOD DISASTER PROBLEMS

BACKGROUND

The city of Bandung as the capital of the West Java Province has a certain attraction that is able to invite various activities. This will promote numerous rural problems, such as population migration from the surrounding areas, reduction of open space in the city, over-exploitation of ground water, traffic congestion, waste disposal problems, illegal settlements, a decline of quality of the air, ground and water, and so on. Other than its attractions, Bandung City also has its limitations and physiographical problems that may influence and determine the continuance of life in the city. The main limitation and physiographical problem are that the northern part of Bandung is intended to be a reservation area to absorb water while the east and south-east part of Bandung is flat, lower and close to the Citarum River.

Since the application of PP (Government Regulation) No. 16/1987 about the expansion of the administration area from 8,098 Ha to 16,729.65 Ha, the development activities was redirected to East and South-east Bandung according to the RUTRK. The population settlement distribution has shown a tendency to shift to the east and south-east part according to the evaluation of the RUTRK. However, in general the development activities still wander from the outlines defined in the RUTRK, especially in North Bandung that has resulted in worse conditions for the east and south-east part of Bandung. The permission to use an area of 140 Ha for services in the conservation area of North Bandung and more houses being built above the 750 m altitude is one indication from the mistakes referred to above. These deviations disturb the hydrology system causing worsening conditions in the southern area that is already often experiencing flood. There are 50 flood/inundation areas in Bandung, both caused by drainage canals and rivers (**illustration is enclosed**).

Flood management will not yield satisfactory results if it is done partially, considering each area has its own flood characteristics. Another reason is that the flood itself is a system interconnecting with one another. This is the reason we need to handle the problem integratedly. So far the plan for flood management is not integrated in the document of Bandung City Plans.

In relation to the above problem, together with a new paradigm that recently surfaced in the field of development planning (in a conference in Nairobi, 1994), the need for good governance with a founding component of good citizen, good business and good government, and the modification to the regulations (ie. UU No. 22 and 25 1999, etc.), the need to revise the RUTRK became inevitable. Many results from various studies will be available for consideration during the revision of the RUTRK, such as the Earthquake Risk Management Plan for Bandung City that is not yet integrated in the RUTRK. Also there is the possibility that the results of community-based flood mitigation study will be available for considerations also.

BANDUNG CITY DEVELOPMENT MACRO POLICY

The objectives of development in the City of Bandung as written in the RUTRK are:

1. Solve problems and develop the city gradually, especially developing the eastern area with its available potentials of natural resources, man and capital, efficiently, effectively and productively.
2. Support the increase of national and regional revenue and the convenience of regional product distribution.
3. Increase the quality and level of life of the people, support regional expansion efforts for equilibrium and equal distribution of development especially Bandung Raya.

In order to achieve those objectives, the strategies applied are:

1. Increase the efficiency and effectiveness of developed city areas and expansion efforts to the eastern area.
2. Control and direct areas according to their potentials whenever spatial approach becomes a problem.
3. The development of developed areas by observing the dominant potentials and activities and determining apparent usage status.
4. Steer and arrange areas of the city still in development, especially the rural areas near the city limit.
5. Guide activity areas that have negative effect to the environment.
6. Provision of city facilities and utilities evenly through out the area of the old city and the city expansion areas.

Based on the above strategies, in the development of spatial development, we need to consider the following points:

1. The function as a center of governing, industry, commerce, education, tourism and attention of the West Java Province.
2. The emphasis of development is the West-East Corridor on one hand, and on the other hand it must be capable to contain the existing developing tendencies and potentials. In other words, city development is not only the physical aspect of land use, but also paying attention to economic interests of its population.
3. Development is not encourage to expand to the northern area, which is a conservation are with a dominant slope above 25 %, but socially and economically possessing the potential of beautiful view, comfort for settlement, and high price of land.
4. The development of the city to the south must be controlled because the area is a buffer zone and the land is allocated for city sanitation.
5. The Primary City Center is developed from various existing activity centers. The development of Secondary Centers are considered from the existing activities, the potential of development possibilities and policies implemented.
6. City areas that have developed as an area with a combination of functions must be removed as development priority. Definitive usage of the area will be determined when there is clarity of the activities that will be developed.

7. The borderline areas that have started to develop must have a development constraint. Areas not yet developed, especially in the northern area and along the Toll road, need more intensive replantation.
8. Development is directed to the role as a service center of product distribution for the surrounding areas.
9. Development is directed in such a way that it realizes an integrated system and rural pattern between the old city with the expansion city areas.

Results from the RUTRK evaluation shows that the objectives of Bandung City development outlined in the RUTRK have not been accomplished due to:

1. activity concentration is still focused on the North-South , especially the northern area. The city structure in the city plan is also not paying much attention to development of the eastern area, with secondary centers still being allocated to the North and South of the old city (2 center locations each) while the East (expansion area) received only one secondary center.
2. the city plan is not yet able to facilitate tendencies and potentials of city development.
3. the policy to limit development in the North-South corridor is not enforced by the establishment of a spatial structure plan that tend to focus development to these areas. Development in the North and South is still continuing especially with the development of commercial and residential activities.
4. secondary centers resoluted in the plan were not realized because they were not supported with sufficient facilities and infrastructures.
5. the intensive replantation plan in the North and along the Toll road is not implemented as they should be because those areas have developed into residential, commercial and service provision areas.

GEDEBAGE AREA DEVELOPMENT POLICY

Within the constellation of Bandung city, the Gedebage area acts as an area for settlement, industry and office services, and container terminal (RDTRK 1992-2003). As a consequence of that role, the Gedebage area must be capable to create a balance between local services with services for greater scope (the city of Bandung). Based on the development of the existing Gedebage area and the activities promoted by the primary activities for this region, the Gedebage regional development policies are as follows.

- Direct allocation of development activities and investment in the Gedebage area to comprehensive and balanced development between local and city/regional services.
- Direct the regional development to support expansion of job opportunities and business growth can increase the income percapita.
- Arrange the spatial layout of the Gedebage area according to the characteristics of community services and need for expansion of services in the future.

Deriving from the regional characteristics and its position in the constellation of Bandung City and its development policies, the primary functions of Gedebage area are:

- As an area for assembly industry, automotive and (wooden) furniture.

- As an area for secondary services for the city of Bandung that support social-economic activities for its own and surrounding areas.
- As an area for container terminal for Bandung city and the surrounding areas.
- As a residential area to satisfy the population boom in Bandung city.
- As an area of office/services for Government Sectoral Agencies of the West Java Province. Viewed from a smaller scope of area, the Rancasari Sub-district is contained in BWK C thus functioning as an industrial area, container terminal, local-scaled office area for the Gedebage area, and a settlement area.

From the evaluation results of the RUTRK, the direction of regional development for the Gedebage area is not in line with the plans outlined in the RUTRK. The appointment of the Gedebage Development Area as an area for regional services and industries until 1999 is not yet accomplished. The usage of undeveloped-land (rice fields, terraced rice fields, open space, fish ponds) is still dominating, that is around 26.64%. The Gedebage Development Area is still large enough to contain development that could not be done in the old city. Considering the geographical problems, it is believed necessary to review the RDTR (Rencana Detail Tata Ruang = Detailed Spatial Layout Plan) for the Gedebage area in order to anticipate the development from the old city, for examples: the plan to build integrated regional terminal, regional butchery house, and sport stadium.

FLOOD DISASTER MANAGEMENT POLICIES

In general, the causes of flood are topographical conditions, high precipitation, a change in climate (ie. La Nina), inadequate drainage system and structures, garbage disposal into drainage canals and rivers, transformation of land function in the river area, physical development resulting in the decrease of catchment area and the increase in surface run-off, river sedimentation, and so on.

Flood disaster management can be implemented by using technical and non-technical actions. Technical actions are more like physical development, such as construction of flood control system and canals, drainage canals, dams and reservoirs, the normalization of the River Network, etc. while non-technical actions are non-physical, such as flood mitigation or the effort to reduce the negative effects caused by the flood.

TECHNICAL ACTIONS

A. Policies in the Fundamental Pattern for 2000 – 2004 (Local Government Regulation No. 7/2000)

- Improve performance of the northern part of Bandung as a water conservation area and environmentally friendly integrated tourism area.
- Build, maintain and provide facilities and infrastructures for binamarga (public works), ciptakarya, and irrigation.
- Increase the utilization of natural resources and the environment by implementing environmentally friendly technologies for conservation, rehabilitation and utilization of the natural resources.

- Aim toward optimum ratio between Green Open Spaces and natural environment by involving the community through continuous monitoring and management activities.

B. Policies in the RUTRK for 1992 – 2003 (Local Government Regulation No. 2/1992)

The flood management plan is directed to the development and rehabilitation of drainage canals and flood control.

Goals and Objectives:

- Free the areas inundated by water by functioning and integrating macro, semi-macro, and micro drainage networks.
- Reducing the inundation area with a target to relatively free Bandung City from flood by the year 2005

Natural drainage systems are planned to convey rainfall naturally to available rivers. Conservation of rivers is planned to cover the width of the riverbanks. In order to avoid local inundation, conservation of the North Bandung Catchment Area to retain its function to absorb rainfall must be planned. For the eastern part of Bandung, the primary canal must be supported with rivers, which is planned to be the Cisaranten, Cinambe, and Cipariuk Rivers. The monitoring of those rivers are currently the responsibilities of the Upstream Citarum Project. The long term plan in managing the primary drainage canal is the normalization of the Citarum River, while for the short term is the plan to construct pool/ponds to contain water at every small river, and sediment excavation as a part of Prokasih (Program Kali Bersih = Clean River Program).

Policies for flood management:

- Rehabilitation of the city drainage canals and creating new networks in inundation areas
- Normalization of the rivers that run through the city by excavation, short-cutting river course, widening narrow part of the rivers, and constructing embankment at the banks.
- In the expansion area, irrigation canals are turned into drainage canals by deepening and extending the canal to reduce inundation.
- River control to prevent rivers from becoming garbage disposal area.
- Inspection of riverside buildings to prevent the river from narrowing.
- Replantation in the Citarum River Network to reduce weathering and sedimentation.

The procedures taken in conveying rainfall and controlling flood are:

- Coordinate with other Regional Government, in relation to normalization of rivers that run from/to outside of the area of Bandung City.
- Normalization of a number of rivers located in the old city area, especially those that cause local inundation.
- Construct flood evasion embankment/structure at the Cisaranten and Cipamokolan River as an alternative solution to flood problems in eastern Bandung area.

- Construct cascade structures for rivers in the north to increase flow time thus reducing flood possibilities in the south.
- Establish an organization responsible for the operation and maintenance of drainage canals and flood control.

C. Policies in the RDTRK for 1992 – 2003 (Local Government Regulation No. 2/1996)

Flood management policies in the RDTRK is related to the policy of environment quality improvement. The Gedebage area in the South-east area of Bandung is a potential floods area vulnerable to epidemic. This is one reason why it is important to improve the environment by normalizing the Cipamokolan and Cisaranten Rivers and normalization of the upstream and downstream area of both rivers. The area along the river course must be conserved meaning that there should not be any building within 5 meters from the riverbank. Garbage disposal and condition of sewers must be monitored for integrated environment conservation. Efforts to improve the environmental health and replantation for the Gedebage area is a must. We must plant trees that will provide protection and conserve the environment, secure the hydrologic areas, prevent soil damage and critical vegetation.

NON-TECHNICAL ACTIONS

Foundation for Disaster Management Regulations and Authority

Disaster management for the national level is coordinated by the Bakornas PB (Badan Koordinasi Nasional Penanggulangan Bencana = National Disaster Management Coordinating Agency), established based on the Presidential Decree No. 43/1990. The duties of this agency are: (1) Formulate disaster management policies and provide guidance or directions and coordinate disaster management integratedly in every phase: before, during and after the disaster; (2) Provide guidance and direction for policy outline concerning disaster management efforts, preventively, repressively, or rehabilitatively covering the prevention, mitigation, rescue, rehabilitation and reconstruction activities. The details on the organization, duties, and function of the Bakornas PB, Satkorlak PB, and Satgas PB, the work system of Bakornas PB, disaster management funding and assistance is resolved based on the Decree from the Coordinating Minister for Public Welfare (Chairman of Bakornas PB) No. 17/Menko/Kesra/X/1995.

At the regional and local level, disaster management is coordinated by the Satkorlak PB (Satuan Koordinasi Pelaksana Penanggulangan Bencana = Disaster Management Executive Coordinating Unit) for the Province of West Java. The organization and work system of this agency is founded on the Decree of the West Java Governor No. 29/1997. The establishment of the SATLAK PB (Satuan Pelaksana Penanggulangan Bencana = DM Executive Unit) at the municipality/city level, Sub-district (DM Operational Unit) down to the kelurahan (Community Protection Units), their job description and technical guidance, are all founded on the Decree of the Mayor of Bandung No. 360/SK/634-Mawil Hansip/1998, while the Standard Operating Procedure for Disaster Management was founded on the Decree of the Mayor of Bandung No. 360/SK/638-Mawil Hansip/1998. The DM SOP defines the DM

organization structure, duties and responsibilities of Satlak elements in disaster management, work mechanism of the SATLAK PB, covering the coordination mechanism of SATLAK PB before, during, and after the disaster, administration and logistic mechanism, reporting mechanism, funding mechanism, Information and Communication System mechanism, procedures to give an early warning of a disaster and the mechanism of search and rescue of the victims.

Community-Based Flood Mitigation Study

Flood disaster management implemented to the present is still limited to the relief activities during the flood occurrence, thus permitting a large number of lives being lost and enormous possession losses. Flood mitigation study implemented in Rancasari Sub-district of the Gedebage Development Area is intended to identify the existing problems and potentials of the area often experiencing flood in order to collect those potentials, especially human resources, to make them capable to plan, implement, evaluate and maintain flood disaster management efforts. The study is also held to improve coordination between various institutions related to flood mitigation to create an integrated and complete system for flood management.

Flood Prone Areas and the Causes in Gedebage Area

1. Cisaranten Kidul Village. The causes are: the location is lower than the Padaleunyi Toll Road and Soekarno-Hatta Road, shallowing of the drainage canals (inadequate drainage canal) and the Cisaranten River has not been normalized.
2. Derwati Village: the location is below the Padaleunyi Toll and the existing drainage canals are not sufficient.
3. Kujangsari Village: insufficient drainage canals.
4. Margasari Village: insufficient drainage canals.
5. Margahayu Raya Real Estate: lowland, the drainage canals have accumulated sediment.
6. Mengger Village: flood conveyed from the Cikapundung River and insufficient drainage canals.

From the Detail Engineering Design (DED) of Gedebage drainage network, the causes of flood in Rancasari Sub-district are: obstruction of the drainage canal, the water level in the irrigation canal is higher, transferred flood from Ujung Berung, the irrigation canals have turned into drainage canals, the culverts are too small and too few to convey water, and the water level in the river is higher (as an irrigation/conveyance canal).

By acknowledging the flood characteristics, including the causes, we can create physical and non-physical action plan. Physical action plans have been implemented into the Detail Engineering Design (DED) of the Gedebage Drainage Network (**design drawing included**).

(BAGIAN PRESENTASI)

BANDUNG CITY GOVERNMENT POLICIES TO MANAGE FLOOD PROBLEMS

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MACRO POLICIES

- **CITY DEVELOPMENT OBJECTIVES (RUTRK):**

- Resolve problems and develop the city gradually (the east area)

- Support national and regional revenue growth, and convenience of distribution

- Improve the life of the people, balance and equally distribute development between regions

- **STRATEGIES IMPLEMENTED:**

- Improve efficiency and effectiveness of developed areas and the development of the east area

- Provision of city facilities and utilities evenly (old city and expansion)

PRINCIPLES OF SPATIAL DEVELOPMENT

- Based on city functions
- Development of the West-East Corridor while considering economic interests of the people
- Restrain development to the north (for conservation)
- Contain development to the south (as buffer zone)
- Develop secondary centers
- Stop combined areas
- Restrain expanding borderline areas
- Direct the city role to become center of distribution service
- Directed to realize a harmony between the old city with the expansion

RUTRK Evaluation Results

- Activities still focused on North-South corridor
- City structure in the city plan does not contemplate eastern area development (only 1 secondary center)
- City plan has not accommodated development tendencies and potentials
- Restraining policies for the development of North-South corridor is not supported by plans
- Secondary centers could not be establish due to lack of adequate facility and infrastructure support
- Intensive replantation plan in the north and along the toll road could not be realized due to the area being developed into settlement, commerce and service area.

GEDEBAGE DEVELOPMENT POLICIES

- **MAIN FUNCTION**
  - As an area for assembly industry, automotive and (wooden) furniture.
  - As an area for the city secondary services
  - As an area for container terminal for the city and surrounding areas.
  - As a residential area
  - As an area of office services
- **EVALUATION RESULTS**
  - Direction of development is not as outlined in RUTRK
  - Has not achieved establishment as regional service and industry area

FLOOD MANAGEMENT POLICIES

- **FLOOD TRIGGERING FACTORS:**
  - Topographical conditions, high precipitation, climate change (ie. La Nina), drainage system, garbage disposal into drainage canals, transformation of land function in the river system, decline of catchment area, river sedimentation
- **FLOOD MANAGEMENT:** Technical and non-technical Actions
- **TECHNICAL ACTIONS**
- **Fundamental Patterns**
  - Improve the performance of North Bandung functions
  - Build, maintain and provide facilities and infrastructures for binamarga (public works), ciptakarya, and irrigation.
  - Increase the utilization of natural resources and the environment
  - Optimize Green Open Spaces (RTH) by involving the community

- **RUTRK**

- Construct and restore drainage canals and flood control

- **OBJECTIVES AND GOALS:**

- Free inundated areas by refunctioning macro, semi-macro, and micro drainage network; reducing inundated areas (target: end of 2005)

- **RDTRK For Gedebage Area**

  ✈ Environment quality improvement policies: normalize Cipamikolan and Cisaranten River (up-down stream)

  ✈ Protection of riverbanks (no buildings allowed within 5 meters range)

  ✈ Garbage monitoring for sewers

  ✈ Replantation

Non-Technical Actions

- Establishment of Bakornas PB, Satkorlak PB, Satlak PB, and Satgas PB
- **Duties:**
- Formulate DM policies, coordinate during the three phases: before, during and after the disaster
- Provide guidance/direction in DM efforts: prevention, repression, or rehabilitation
- **Community-based Flood Mitigation**
- Identify potentials and problems of the flooded region, facilitate potentials (especially HR) to be able to plan, implement, evaluate and maintain flood DM efforts
- Promote coordination between various parties to realize a complete system of flood management

FLOOD PRONE AREAS AND FLOOD CAUSES IN GEDEBAGE

- **Cisaranten Kidul Village:** lower than the Padaleunyi Toll Road and Soekarno-Hatta Road, shallowing of the drainage canals (inadequate drainage canal) and the Cisaranten River has not been normalized
- **Derwati Village:** below the Padaleunyi Toll, insufficient existing drainage canals
- **Kujangsari Village:** insufficient drainage canals
- **Margasari Village:** insufficient drainage canals
- **Margahayu Raya Real Estate:** lowland, drainage canals have shallowed
- **Mengger Village:** flood conveyed from Cikapundung River, insufficient drainage canals
- **Rancasari Sub-District** (from Gedebage DED)**:** drainage canals obstructed, higher water level in irrigation canal, transferred flood from Ujung Berung, irrigation canals have turned into drainage canals, culverts are too few to convey water, and water level in the river is higher (as an irrigation/conveyance canal)

Guidelines to Constructing Flood Control Structures

Introduction

A flood is a phenomenon closely related with the condition of the community's activities because the flood obstructs the social and economical activities. Floods also occur due to human interaction with the environment. In order to reduce the burden caused by flood disaster we must hold a complete study covering the natural environment, repetitious processes (ie. hydrological cycle), human interaction with the environment and all efforts that may be implemented to reduce the suffering caused by flood. This paper addresses the above points.

The Hydrological Cycle

Rain, river flow, and ground water are all part of the hydrological cycle. Hydrological cycle may be considered to start from the sea where seawater evaporates due to the heating of the sea surface by sunlight. Evaporation also occurs to surface water on land, such as lakes, rivers, swamps, reservoirs, ponds etc. The vapor will accumulate in the atmosphere, condense and cool down, and after reaching a state of saturation and a certain size will fall to the earth as rain. Rain may fall over sea or land. Some of the rainwater that fell over land will fall directly to the ground and be absorbed to the permeable layer creating groundwater flow. When the layer is saturated with water, some of the water will run as surface flow, accumulate and form a river.

Flood Causes

A flood is an occurrence where water flows/inundates at a certain elevation that can disturb routine activities of the community. Floods can be caused by water flowing in the river/canal exceeding the canal's existing capacity thus overflowing to the surrounding area, or because activities are held at an area that collects water because it is lower that its surrounding. Floods can also be caused by a reduction in a river/canal's capacity due to sedimentation, narrowing, waste accumulation, etc.

The Topographical Condition of Bandung Municipality in General

The topography of Bandung Municipality in general can be classified into three categories: the northern part where the slope is steep, the middle part that is the transition area, and the southern part where the surface is relatively flat. From these facts we can conclude that when there is surface flow due to rain, the flow will have high velocity in the northern area and inundation will quickly subdue. However, in the southern part, flow velocity will be slower and a rise in water elevation will cause longer-lasting inundation. The initial condition of South Bandung was largely rice fields and swamps. This is why developing this area into settlements can create drainage problems, which is very closely related to floods.

Types of Flood Control Activities and a General Description of its Technical Implementation

Flood control covers every activity aimed to reduce the losses caused by flood. The types of flood control activities may be classified into three:

1. Protection aganst flood for relatively vast areas (Flood Protection)
2. Protection aganst flood for smaller areas or for individuals (Flood Proofing)
3. Preparation for flood risk (Flood Preparedness)

This paper will discuss the first and second point in the above classifications.

Protection aganst flood for relatively vast areas (Flood Protection)

This action is the provision of relatively large-scale physical infrastructures, or activities covering a relatively vast area that functions to prevent entry of a part of or the complete amount of flood to a certain area. This protection aims to ensure continuity of social and economic activities in the protected environment, during and after the flood occurrence.

Examples of physical infrastructures or activities are:

1. Flood control reservoirs

   Flood control reservoirs function to contain excess water from upstream and release it gradually. This reservoir can help to avoid high and irregular discharge flows. Water stored in the reservoir may be used for other needs such as irrigation, clean water, or fishery.

2. Flood embankment

   Flood embankment is used to prevent river from overflowing when the water elevation rises. The construction material for the embankment is usually taken from the land around the river that is waterproof.

3. Flood canal

   Flood canals act as temporary storage canal and is used to reduce the burden of the primary canal.

4. Normalization of rivers/canals

   This activity is intended to increase the capacity of the canal thus improving flow and reducing the possibilities of a flood occurring, and also speed inundation subjugation time. Activities contained in normalization of river/canals are:

   - Straightening, excavation and expansion of the river/canal.
   - Clear all obstructing vegetation or sediment/debris from riverbank collapse.
   - Reducing the roughness of the canal surface/riverbed with plaster.
   - Elevating bridges or other traffic structures to prevent them obstructing riverflow when water elevation rises.
   - Clean anything that disturbs the flow.

5. Land exploitation

   Land exploitation covers conservation of forests and catchment area. We must realize that conservation of forests can only affect small relatively small-scale floods. During larger scale floods, the earth is already saturated with water that the area does not have significant effect in reducing the flood. However, the existance of forests will reduce sudden flooding and prevent other disasters such as landslides. Similarly, catchment areas can only affect flood control for the areas downstream that is close to it. Areas located far downstream from the catchment area will not be greatly affected.

6. Flood plateau exploitation

   Exploitation of flood plateau will raise the consequence of losses during floods. Therefor, we must examine whether the losses caused by the flood will be less or more than the benefits gained from the exploitation.

7. Provision of drainage pumps

   Drainage pumps are used to pump rainwater that accumulates outside of the embankment to the primary canal.

Protection aganst flood for smaller areas or for individuals (Flood Proofing)

This activity is the provision of minimum physical infrastructure to reduce flood effects for smaller scale/individuals. This type of protection aims to avoid casualties and ensure continuity of daily routines during and after the flood, and providing a sense of security and promote motivation needed by the community to carry on with their social and economic activities to achieve welfare in an environment frequently experiencing floods. Activities integrated into flood proofing are:

1. Elevating building floors

   Raising the building floor above flood level can be done by constructing the building on columns, or by filling the floor. It is also necessary to see whether the roof or ceiling needs adjustments if the floor was refilled.

2. Constructing waterproof temporary buildings around houses

   Construction of a temporary waterproof structure can be done around a building using plastered rock pieces or bricks. The average save height to protect against flood is 1 meter with regards to hydrostatic pressure. If the flood flows slowly or inundates with shallow depth, sand sacks may be used instead.

3. Permanent closure

   Permanent closure of openings (ie. windows, ventilations) that are not needed is one way to prevent entry of flood-water into houses.

4. Protection against opening

   Necessary openings can be secured by strengthening them from the inside. This restraint is built approximately 1 cm behind the glass and is secured into the window frame sealed with waterproof sealer/rubber. The gap is provided so that water fills both sides of the glass, thus creating equal pressure. The front side of the glass can be protected from debris (pieces of wood, etc.) by installing mosquito screen.

5. Protection against short circuitry

   The installation of electric wires, switches, or other appliances is adjusted to the level of water during floods. This is important to reduce the possibility of an electrical short-circuit should water reach the installation.

6. Clean water services

   In order to prevent the water conveyed through the pipe network from getting polluted by the flood water, the distribution pipes must be free of leaks. Leaking faucets must be closed.

7. Selection and maintenance of wooden material

   Wood is used for construction and may undergo expansion or shape deformation when submerged in water. If the wood is used for the structure frame, the building will be damaged. That is why it is necessary to select wood types that is not too sensitive to water.

8. Waterproof storage facilities or positioning them out of reach from flood

   Waterproof storage facilities are used to store things that are sensitive to water such as food. These facilities can be styrofoam boxes or tall shelves that cannot be reached by the water during floods.

9. Tying down things that may get carried by flood

In order to prevent material from being carried away by the flood, we can construct poles from wood or stell to tie them down to.