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MANAGING FLOOD AND WATER-RELATED RISKS: A CHALLENGE FOR THE FUTURE

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ABSTRACT

This research presents a methodology to develop and apply global indicators as a proof-of-concept implementation to assess 'policy effectiveness' toward the achievement of national and international goals. Setting the target/goal as to reduce by 50% the proportion of economic losses due to water-related hazards by 2015, three measurable indicators have been defined and applied to Tonegawa River basin, Japan. The Target-indicators modeling aims to explain the risk target to be reduced and to enable decision-makers to measure progress in policies to achieve risk reduction. Despite the number of challenges to overcome, the methodology aims not only at evaluating the effectiveness or deficiency of applied policies but furthermore advises on the immediate and future actions necessary to be undertaken by decision makers in order to ensure progress toward the defined goals and mitigate risk from water hazards.

1. INTRODUCTION

Japan archipelagoes are continuously threatened by various water hazards such as flood, typhoon and mudslide among others. Through history, flood management in Japan has become an emerging concern concretely materialized through outstanding achievement of a number of structural and non-structural measures including river law enactment, detention basins and reservoirs, and development of hazard maps among others. Since 2001, the Ministry of Land, Infrastructure and Transport (MLIT) in Japan, has launched a new policy evaluation system enforced by the Policy Evaluation Law (Yasuda and Murase [4]). As shown in Figure 1 (MLIT [2]), despite the success of the adopted policy in reducing the trend of flood damages (e.g., total inundated area etc.), the economic loss due to flood damages is severely fluctuating due to the increasing vulnerability to water hazards. In recent years, increasing concentration of population and high-tech property in flood prone areas and climate variability accompanying climate change etc. have placed additional pressure susceptible to increase the trend of water hazards risk.

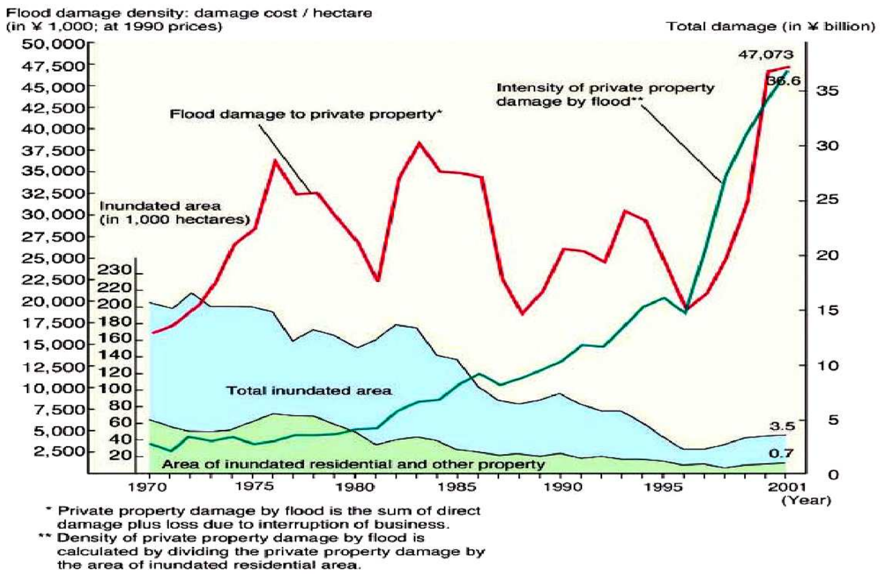

Figure 1. Evolution of Flood damages in Japan since 1970 to 2001

This research presents a methodology to define and apply appropriate indicators to assess "policy effectiveness" toward the achievement of national and international target goals (such as Millennium Development Goals (MDGs), Agenda 21, The Hague 2000 and so). The present work is developed as a contribution to the 2nd Phase of the World Water Assessment Programme (WWAP) for defining global indicators that can be used within the present limitations of data availability worldwide to assess the risk from water hazards. In this regard, the 1st World Water Development Report (WWDR [3]) proposed 15 indicators to measure progress toward mitigation of water related risk. Hereafter, setting the target/goal as to reduce by 50% the proportion of economic losses due to water-related hazards by 2015, three indicators have been defined and applied to Tonegawa River basin, Japan. The indicators have selected based on simplified framework to ensure globalization and flexibility to be adjusted to data availability.

2. JAPANESE EXPERIENCE IN MANAGING WATER RELATED RISKS

Along history Japan has successfully developed and applied outstanding measures to mitigate flood damages. Major governmental measures include Enactment of Flood Fighting Act and its amendments for flood mitigation and spread of flood warning system to small and medium rivers by non-structural measures such as Hazard Maps. In this regards residents' voluntary activities and utilization of information technology have proved to be effective to mitigating flood damage and reduce numbers of victims. As depicted in Figure 2, during the torrential rain of 1998, in Fukushima, people of knowledge of flood hazard maps evacuated 1 hour earlier than those who did not. Other countermeasures include the development of comprehensible Flood Risk Indicator (FRICAT), easily showing (Figure 3) the frequency of floods and inundation level expressed by a color and a height (compared to height of people and height of houses) to indicate the degree of safety/risk against flood damage.

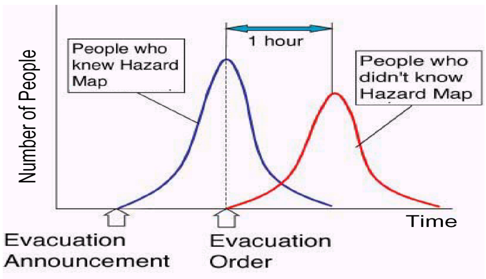

Figure 2. Effectiveness of Flood Hazard Map.

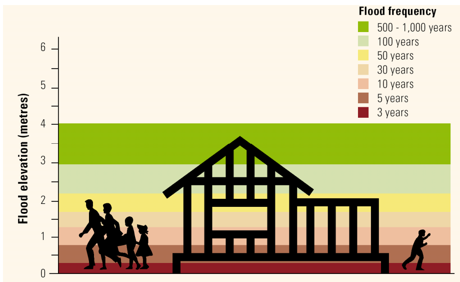

Figure 3. Expression of the safety degree against flood.

3. POLICY EFFECTIVENESS INDICATOR

Establishing sound indicators (i.e., representative, measurable and reliable) to assess policy effectiveness for sustainable flood management and related risks is a vital process for decision makers (WWDR [3], Yasuda and Murase [4]). The major indicator development models clusters around four approaches: the bottom-up approach, where the logic goes from data to parameters to indicators, the top-down approach, vision to themes to actions to indicators, the systems approach, which bases indicators on a comprehensive analysis of system inflows and outputs, and the cause-effect approach (known as the Pressure-State-Response (PSR) approach or the Driving force-Pressure-State-Impact-Resource (DPSIR) which subscribes to the logic of indicators denoting various causes and effects (WWDR [3]). To assess the risk from water related hazards, flood in particular, the present research proposes a simplified framework based on the proposed DPSIR approach. Reflections on the proposed indicators shown in Table 1, reveals that it

4. T-DSR FRAMEWORK MODEL

The simplified Framework DSR and Target proposed in Table 2 are selected in order to exclude ambiguity (Yasuda and Murase [4]) and respond to the following environment:

a) Respective indicators for DSR should be measurable and able in time and space to explain the risk target (T) to be reduced. In other words, it is considered ideal to establish a straightforward correlation between indicators based on data availability:

$$T = function\ (D, S, R) \qquad (1)$$

b) In order to prove the reliability of the proposed model, it is necessary to validate the method based on existing past record database such as the number of afflicted people, economic losses etc.

c) The method should enable to measure the progress in policies and propose sound actions to ensure sustainability toward the target under the acknowledge data scarcity.

The proposed expression is one sample for modeling the above-mentioned indicators as a cluster of measurable indices (Merabtene et al. [1], Yasuda and Murase [4]).

$$T = \frac{w_D * D + w_S * S + w_R * R}{w_D + w_S + w_R} \qquad (2)$$

where T: Target (define by its measurable Index, D: indicator for Driving forces, S: indicator for State, R: indicator for Response, respectively defined by their measurable indices, and w_D, w_S, w_R: are the respective weights for each indicator.

In order to investigate the validity of the model as well as the measurement of progress a study was conducted on the Tone River in Japan. Tonegawa River (Figure 4) is the major river of the Kanto Plain, Honshu, Japan. It rises in the volcanic area of northwestern

Table 1. Definitions and proposed indicators under DPSIR framework (WWDR [3]).

DPSIR	Implication	Indicator
Driving force (D)	Driving force of water use; e.g. poverty, population growth, urbanization, globalization, industrial expansion, agricultural development, energy production and use, recreation and tourism)	* List of sever natural disasters since 1994. * Major drought events and their consequences in the last century. * Trends in causes of food emergencies, 1981-1999. * Trends in great natural catastrophes.
Pressures (P)	Pressures on water system as a result of human activities (e.g. use of natural resources, discharges of waste)	* Population exposes to water-related risk (number of people /yr, income groups). * Other than water-related risks (% of losses from seismic, fire, industrial and civil risk).
State (S)	The quality/quantity change in the 'state' of water as a result of the pressure	* Number of people living with100-year flood
Impact (I)	Impacts on ecosystems, resources, human health, social conditions and amenities caused by the change in state	* Vulnerability map: proportion of land within 1km of river with slope of less than 1 degree. * Losses in human life (number/yr) (country and basin level data, by region and globally). * In real and relative social and economic values (total losses % of GNP, growth, investments and development benefits).
Response (R)	Societal response to these changes and coping mechanisms, which are reflected in institutions, environmental, economic and sectoral policies. The response can be directed at different parts of the cause effect chain (e.g. Driving force, pressure, state or impact)	* Legal and institutional provisions for risk-based management (established yes/no). * Budget allocation for water risk mitigation (total and % of total budgets / yr). * Risk reduction in flood plains (% of total flood plain populations). * Risk reduction and preparedness actions plans formulated (% of total countries). * Risk-based resource allocation (country, international organizations (yes/no)).

Table 2. Indicators used to assess policy effectiveness of flood countermeasures.

Target (**T**)	Framework	Perspective	Selected Indicator
Targets (Hague): 'to reduce by 50% the proportion of the population threatened by water-related hazards by 2015'. **【Index】** * Losses in economic values	Driving forces (**D**)	Indicators on water use and pressures on water system that would trigger disasters as a result of socio-economical conditions (poverty, urbanization, etc.) and human activities	* Increase in land cover area
	State (**S**)	Change in state as a result of pressure	* Change in river peak discharge
	Response (**R**)	Response (measures) to address changes in DPSIR	* Transition in budget allocated for risk mitigation

Table.3. Weights for each DSR indicators for Tonegawa River basin.

	D	S	R
Indicator	Land cover area	River peak discharge	Investment on flood mitigation
Weight	0.1	0.7	0.8

Kanto region in Gumma prefecture. The river flows for 320 km south and southeast through the centre of the Kanto Plain to enter the Pacific Ocean at Choshi in Chiba prefecture. The associated data to measure the target and respective indicators are depicted in Figure 5.a., 5.b, 5.c. and Figure 7, respectively. The trend of future estimate values of prospective indicators is calculated as shown in Figure 5. The future evolution of trends is very sensitive to data availability and socio-economical changes etc. and therefore reliable evaluation is still a challenge, especially for indicators characterized by sever fluctuations in time and space such as precipitation, river discharge and water level.

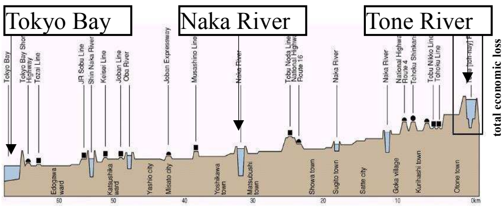

Figure 4. Location of Tonegawa River within the Kanto plain in Honshu, Japan

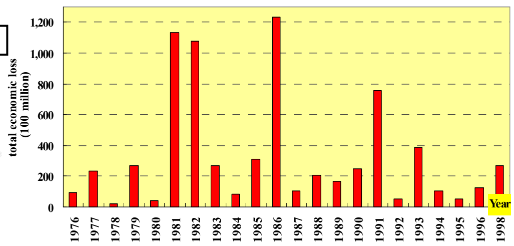

Figure 5.a. Target T: Economic loss due to flood in Tonegawa since 1976 to 1998.

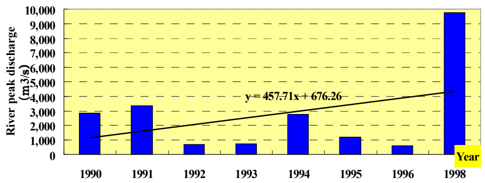

Figure 5.b. Indicator S: trend of Tonegawa peak river flow since 1990 to 1998.

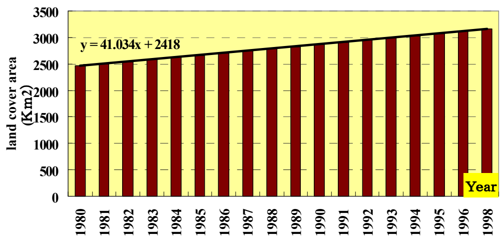

Figure 5.c. Indicator D: trend of Land Cover in Tonegawa river basin since 1980 to 1998.

The dimensionless values used in the model are obtained by dividing respective yearly data of DSR by the maximum value (within the selected period). As mentioned above and depicted in the validation period of Figure 6 (result from a 5-year moving average), the reliability of the model is very much sensitive to data quality and data availability. Other important issues are the weight values that should be selected to indicate sufficient conformity and respond to actual trends of indicators. The higher weight is assigned to investment as major action to mitigate flood (Table 3). The high weight value of 0.7 for river peak discharge indicates that urbanization resulted from human activities is assumed to cause an increase in flood discharge triggering flood damage.

Figure 6. Model validation and risk prediction under
the same trend of indicators and investment policy for Tonegawa River Japan

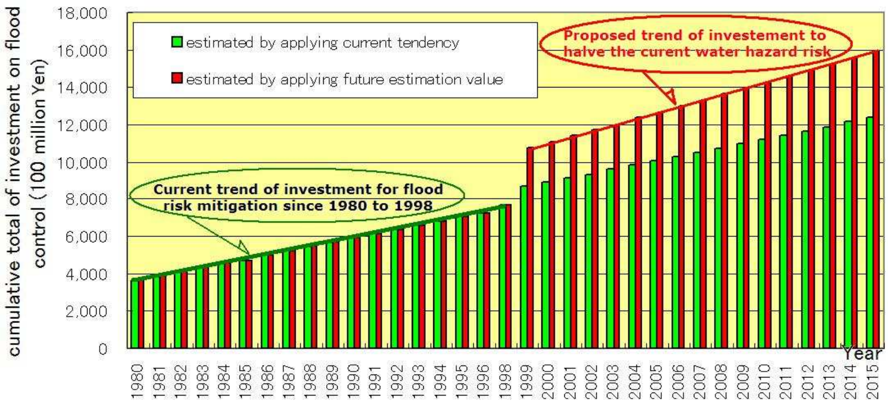

Figure 7. Current amount of required investment for achieving risk-reducing target by 2015

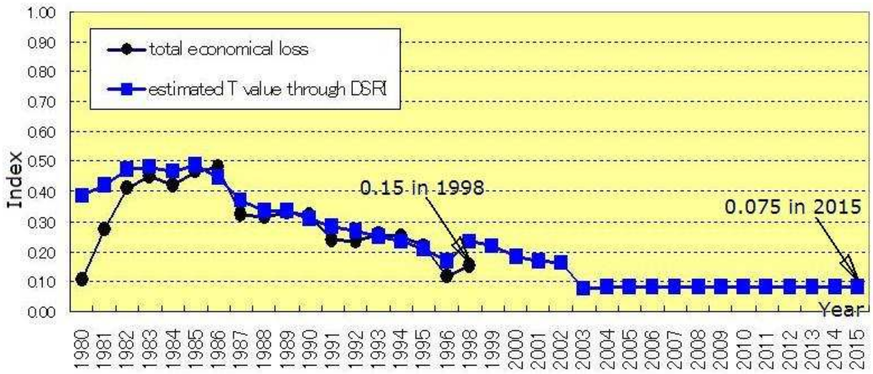

Figure 8. Effectiveness of policy investment measure to reduce by 50% flood risk by 2015

As shown in Figures 6, the T-DSR model was applied for the future horizon 2015. The results shows that if we assume that the current level of investment for flood control will be maintained, under the current assumed trends, the projected tendency of total economic loss due to flood by 2015 will nearly double from 0.15 (as indicator) in 1998 to

0.3 by 2015. Therefore, to achieve the target as to halve flood risk (i.e., economic loss) from 0.15 as in 1998 to 0.075 in 2015, it is proposed to increase in the total investment for flood mitigation. In other words, if an increase of investment is introduced in the policy planning as an action to mitigate flood risk, for example as in Figure 7, it will be possible to evaluate the effectiveness and degree of progress of countermeasures as depicted in Figure 8. Figure 7 depicts the evaluated new investment policy necessary to be introduced in the in the short and long-term policy planning as an action to mitigate flood risk. If the decision is isolated from other relevant constraints, Figure 8 illustrates the effectiveness and degree of progress in risk reduction as direct results of the new policy. Other relevant indicators shall be measured similarly and integrated within a consolidated framework susceptible to be applied at global level and easily adjustable to data are available (e.g. consider affected people instead of economic loss).

CONCLUSION

The proposed methodology undoubtedly bridges the gap between water professionals and decision makers. Although there are still a lot of challenges to overcome regarding future estimation of indicators, targets and trends, the decision tool aims not only at evaluating the effectiveness or deficiency of applied policies (e.g., middle and long-term investment plan) but furthermore advise on the immediate and future actions necessary to be undertake by decision makers (e.g., future trend of investment) in order to ensure sustainable progress toward the defined goals. The methodology should be flexible and easily adjustable to respond to the worldwide acknowledge data scarcity and availability.

REFERENCE

[1] Merabtene, T., Jinno, K., Kawamura, A. and Olson, J. “Risk assessment for optimal drought management of water supply systems using genetic algorithm”, Hydrologic Processes, Vol. 16, (2002), pp 2189-2208.

[2] MLIT, “Outlines of river works”, Publication of the Ministry of Land Infrastructure and Transport, in Japanese, (2002).

[3] WWDR, “Water for People Water for Life: Water World Water Development Report”, 1st Edition, UNESCO Publishing/Berghahn books, (2003), pp 29-60, 265-290 & 481-498.

[4] Yasuda, G. and Murase, M. “Flood risk indicators” Paper Presented at World Water Assessment Programme Workshop in Rome 6-8 February 2002.