Disaster Recovery Index: Measuring Aceh Post Tsunami Recovery

Ni Wayan Suriastini, Bondan Sikoki, Cecep Sumantri, and Ika Yulia Wijayanti

SurveyMETER

Abstract

Since the Indian Ocean Tsunami in 2004, Aceh has experienced rapid change on a massive scale. Aceh was the region most devastated by the 9.3 magnitude earthquake and a massive tsunami. Over 130,000 people died and more than 30,000 were reported missing. At that time, Aceh had been experienced a separatist conflict for 30 years. The conflict caused multiple problems such as human rights violations, social and economic structure devastation, and weak institution. It became more severe because of the natural disaster impact. The need for massive recovery brought an official end to the conflict and opportunity for future development. This paper aims to measure the recovery in Aceh by constructing an indicator named Disaster Recovery Index (DRI). The Index uses five sector recovery indices based on Post Disaster Need Assessment (PDNA) Guidelines by The National Disaster Management Agency (*Badan Nasional Penanggulangan Bencana*, BNPB), i.e. Housing, Infrastructure, Livelihoods, Social, and Environment sector to calculate sector recovery indices and its composite index. The first wave of the Study of Tsunami and Aftermath Recovery (STAR) data is used to measure the recovery process. It had been collected in several months after the disaster. In order to compare the recovery amongst different affected areas, we calculate the indices in three groups affected area, i.e. light, medium, and heavy. As a result, in general, Aceh post-tsunami recovery reached 62.24% at the time of the survey. Livelihoods sector achieved the fastest recovery, while the environment sector became the slowest one. In conclusion, the remaining recovery requires a sustainable program since the livelihood sector's fast recovery was reached by temporary cash transfer assistance and the impact of climate change might affect the recovery of the environmental sector in the long run. The community support is also important to accelerate progress.

Keywords: tsunami, conflict, recovery index, affected area

Introduction

Over the decade since the 2004 Indian Ocean tsunami, tremendous progress has been made. The redevelopment in Aceh is not only reconstructing the housing, infrastructure, institutional, social and economic, but it also built the disaster preparedness facilities and system (Suppasri et al., n.d.) The security of lives, livelihoods, possessions, and communities in Aceh had already been shattered by 30 years of armed conflict between the Indonesian military and the Free Aceh Movement (*Gerakan Aceh Merdeka*, GAM). Over the past 25 years, poverty had increased dramatically in Aceh even as the GDP of the province rose steadily as a result of natural resource exploitation. According to the government's statistics, in 2002, nearly half of the population had no access to clean water, one in three children under the age of five was under-nourished, 38% of the population had no access to health facilities, and the poverty rate in Aceh doubled from just under 15% in 1999 to nearly 30% in 2002 (Thorburn, 2009).

On 26 December 2004, the 9.3 magnitude earthquake rocked the coast of Sumatera(Frankenberg, Sikoki, Sumantri, Suriastini, & Thomas, 2013). The earthquake was followed by a massive tsunami that was up to 20 meters high and wiped out a third of the densely populated city in Banda Aceh and hundreds of villages in Aceh's west coast region (Daly, Feener, Jauhola, & Thorburn, 2016). Aceh was the most devastated among regions affected by the 2004 Indian Ocean tsunami. Over 130.000 were dead and more than 30.000 were missing (Frankenberg et al., 2013). The severe devastation is not only addressed to the natural disaster, but it also related to the prior conflict. Indeed, the region that has experienced an armed conflict are more vulnerable to disaster deaths (Marcus, 2015).

The need for cooperation among all elements of society in the massive recovery effort instigated a renewal of peace negotiations between the Indonesian Government and the GAM. These talks led to a Memorandum of Understanding being signed in Helsinki on 15 August 2005, bringing an official end to three decades of armed conflict during which some 15,000 people lost their lives and tens of thousands were displaced (Fan, 2006). Reconstruction and recovery supported by national and international agencies became a new opportunity for Aceh's future development. Moreover, Aceh pre-tsunami situation was not a suitable return point due to problematic conditions caused by the past conflict. It is common to frame the disaster and its recovery process as an opportunity to change, to hit the reset button, to reduce vulnerabilities, and to promote a higher level of development across sector known as "build back better". (Daly et al., 2016).

Despite the large sum of aid and complexity works in the post-disaster recovery process, there is currently no standard and well-accepted method to monitor and evaluate the success of post-disaster recovery programs (Brown et al., 2010; Hettige, 2018; Horney, Dwyer, Aminto, Berke, & Smith, 2016). Therefore, a useful and validated method to measure how the survivors are recovering from a disaster is needed (Horney et al., 2016). Furthermore, robust recovery indicators can assist the government to create a high-quality recovery plan in the future, to increase disaster resilience, and to reduce disaster vulnerability (Horney et al., 2016; Song, Huang, & Li, 2017).
An important step in understanding disaster recovery is to define and measure it (Hettige, 2018). Disaster recovery is defined as the process of restoring, rebuilding, and reshaping the physical, social, economic, and natural environment through pre-event planning and post-event action (Smith, Gavin P., and Wenger, 2007). In a post-disaster recovery study, it is important to adopt the accurate measurement of recovery processes and recovery benchmarks (Yi & Tu, 2018). The robust indicators in recovery measurement must be easy to appraise, cost-effective, and useful for decision-making policy, practice, or research setting (Horney et al., 2016)

This study is intended to examine the state of the recovery of 2004 tsunami survivors by developing a measurement indicator named Disaster Recovery Index.

Concept and Methodology

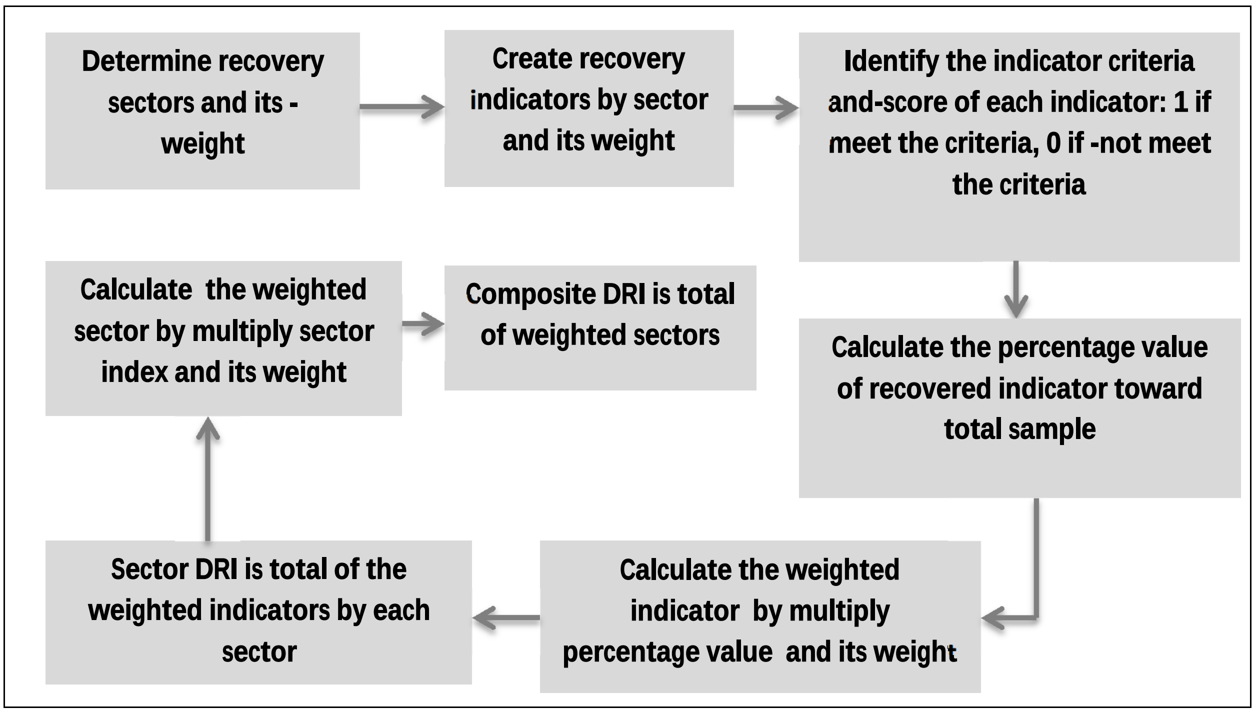
DRI firstly used to measure the progress of recovery and resilience in communities affected by Merapi volcano eruption in 2010 and Lahar floods in 2011. It synthesizes 22 indicator variables to determine how communities recovered from the volcanic eruption in terms of restoring housing, infrastructure, livelihoods, social structure, and among other things (Kawuryan, Suriastini, & Purwanto, 2013; Winderl, 2014). The index uses longitudinal survey data to compare the situation in the community before a disaster to that after the disaster and to the situation following the implementation of rehabilitation and reconstruction programs (Winderl, 2014).

In recovery policy, DRI has some important role (Kawuryan et al., 2013) i.e. (1). Assisting post-disaster policy-making; (2). Evaluating post-disaster recovery programs' effectiveness; (3). Assisting post-disaster reconstruction and recovery program planning. (4).Facilitating communication-related recovery progress with the public

Composite DRI is an aggregate of sector recovery indices. In this study, the sectors refer to Post Disaster Needs Assessment (PDNA) Guidelines by *Badan Nasional Penanggulangan Bencana*/The National Disaster Management Agency (BNPB, 2011). Using a national recovery policy as a guiding framework is important since monitoring programs with measurable indicators can be used to track the recovery status and the performance of policies across events and over time (Horney et al., 2016). Based on the guidelines, post-disaster recovery needs encompasses a range of Housing, Infrastructure, Livelihoods, Social, and Environment sectors.

The DRI framework is illustrated in figure 1.

Figure 1 The method used in the development of the Disaster Recovery Index



The first step to measure the recovery progress is specifying the five recovery sectors. For each sector, we determine the weight based on its priority in recovery needs. The total weight of the five sectors must be 100%. The recovery performance of each sector is indicated by several indicators. As for indicators, the weighting is created by two formulas. First, to measure the sector's index, the total weight of indicators in each sector must be 100%. Second, to construct

Composite DRI, the total weight of indicators should be consistent with each sector's weight; as a result, it will be 100% in all sectors.

DRI sets a dummy value for each indicator expressed as scores of 0 and 1. In each indicator, there are criteria to assess the recovery progress. An indicator is recovered if it meets the criteria and given a score of 1. In contrast, if it does not meet the criteria the score will be 0. The indicator's score is then used to calculate the percentage value of the recovered indicator toward the total sample.

$$Percentage\ value\ of\ recovered\ indicator = \frac{recovered\ indicator}{total\ sample} x\ 100\%$$

The following step is to calculate the weighted indicator by multiplying the percentage value of the recovered indicator with the indicator weight. The weighted indicator is used to calculate the sector index by summing up within each sector.

$$Weighted\ Indicator = indicator\ score\ x\ indicator\ weight$$

$$Sector\ DRI = \sum weighted\ indicator\ by\ sector$$

Composite DRI is an aggregation of sector indices. To calculate composite DRI, first, multiply the sector DRI with its weight to create weighted sector DRI. Afterward, Composite DRI can be obtained by summing the weighted sector DRI.

$$Weighted\ sector\ DRI = sector\ DRI\ x\ sector\ weight$$

$$Composite\ DRI = \sum weighted\ sector\ DRI$$

Data

The study of Tsunami and Aftermath Recovery (STAR) data is used to measure the recovery process. The STAR data are designed to provide evidence on the immediate and longer-term consequences of the 2004 Sumatran-Andaman earthquake and tsunami and recovery efforts (www.stardata.org). STAR data have identified the degree of damage of the affected area in three groups: (1) Light damaged area; (2) Medium damaged area; and (3) Heavy damaged area. We compare recovery indices amongst the three areas. People, groups, and communities were affected differently by the disaster. As a result, they often recover at different rates compared to pre-disaster conditions (Smith, Gavin P., and Wenger, 2007). Therefore, comparing the different affected groups will give more detail measurement.

DRI indicators

There are three primary criteria used by researchers to select community recovery indicators (Horney et al., 2016). First, it must be possible to measure and asses indicators repeatedly over time. Second, indicators should be variables that are sensitive to change the community recovery status over time or within the key of demographic and geographic subpopulations, which allows for the exploration of interaction. Third, the effects of community –and individual level experiences also should be considered concurrently.

In order to match with the STAR data availability, we modify variables, criteria, and priority-setting of previous research conducted by Kawuryan et al (2013). For each sector index, we have a set of indicators used to measure the progress of The Aceh tsunami recovery presented in table 1. The indicator’s weight represents its priority in recovery compares to the other.

Table 1 DRI Indicator by Sector

Indicator by Sector	Recovery Criteria	DRI Weight	
HOUSING		**25.83**	
Type of house wall	Brick	23	5.94
Type of house floor	Not dirt	28	7.23
Toilet Facilities	Private, Shared	26	6.72
Source of drinking water	Improved source of drinking water	23	5.94
		100	25.83
INFRASTRUCTURE		**18.33**	
Road Surface	Asphalt, cement/paving stone, solid/pebble	32	6.17
Public transportation	Access <mean distance	23	4.12

Indicator by Sector	Recovery Criteria	DRI Weight	
Public telephone	Access<mean distance	21	3.75
Traditional market	Access<mean distance	24	4.30
		100	18.33
LIVELIHOODS		**25.83**	
Household income	Increased, same, or decreased<20%	50	12.92
Labor force participation(age 15 - 60)	Keep working or get a job after the tsunami	50	12.92
		100	25.83
SOCIAL		**15.83**	
Health Facility	Access to polyclinic<mean distance	22	3.4826
Health status	Physical and Mental health fair, good, very good	38	6.0154
Education Facility	Access to elementary school<mean distance	28	4.4324
School participation (age 6-15)	Back to /start attending school after the tsunami	12	1.8996
		100	15.83
ENVIRONMENT		**14.18**	
Change in the planting area	Remained the same or increase	100	14.18
All Indicators (18)		**100**	

The housing sector uses type of house wall, type of house floor, toilet facilities, and source of drinking water as its indicators. The housing sector is recovered if the wall is brick, the floor is not dirt, the toilet facilities are private or shared, and water drinking is obtained from an improved source. The improved source of drinking water criteria is bottled water, tap water, pump, protected well/spring, or drinking water from aid. On contrary, the housing sector is not recovered yet if the indicator does not meet the criteria, for example, bamboo wall, dirt floor, public toilet facilities, or the drinking water is obtained from the unprotected well.

Despite categorical criteria i.e. road surface, the infrastructure sector uses distance as recovery criteria measurement. Infrastructure is recovered if access from home to nearest public transportation, public telephone, and the traditional market is below the mean of the distance. Meanwhile, the road is recovered if the surface is asphalt, cement/paving stone, solid/pebble.

In the livelihoods sector, change measurement is used to measure household income and labor force participation. Household income is recovered if it increases, remains the same, or decreases below 20% from the pre-tsunami. As for labor participation, it is recovered if the working-age population aged 15-60 work before and after the tsunami, or they did not work before the tsunami then they get the job and work after the tsunami. The working-age population does not work before and after the tsunami does not meet the recovery criteria.

The social sector consists of four indicators, i.e. health facility, health status, education facility, and school participation. Health and education use the distance as recovery measurement, they are recovered if the distance from home to the nearest polyclinic and elementary school are less than the mean distance. The health status is indicated by both physical and mental health conditions. The health status is given score 1 if the physical and mental condition is fair, good, or very good. School participation uses a similar procedure to labor participation. Recovery is a positive change in school-age participation. It is applied for the school-age children who attended or not attended school yet before the tsunami; subsequently, they attend school after the tsunami. The criteria are not valid for the school-age children do not attend school before and after the tsunami.

The indicator for the environment sector is the change in the planting area. We compare planting areas from before tsunami to aftermath condition. Consistent with the positive change measurement, recovery means remain the same or increase in planting area in the aftermath condition.

Household characteristics

As stated in the previous section, we divide the affected area into three groups based on STAR data classification. Each group shows the degree of damage by the disaster aftermath, which is light, medium, and heavy. In this section, we explore the household condition in the first wave survey according to the group categories. Approximately 57.9 % of all households were in the medium damage area. As for the rest, 21.10% of households were in the light damage area and 20.90 % were in the heavy damage area.

Table 2 illustrates the ownership status of the house. Out of 6.687 households, most survivors (64%) owned their home as private property. Households in light damage area who owned private houses tend to be highest (70.40%) compared with two others, while in the heavy damage area was the lowest (43.70%). Approximately 6.60% of households were still lived in the shelter. Most of them were from heavy damage area, 22.80% of total households in heavy damage area lived in the shelter. Meanwhile, in two other affected areas, 2.90% of households in a medium damage area and 0.60% of households in the light damage area still lived in the shelter at the time of the survey.

Table 2 Ownership status of the house

%household	Degree of Damage			
	Light	**Medium**	**Heavy**	**Total**
Private-own property	70.40	67.10	43.70	62.90
Lease/rent	9.30	9.30	10.80	9.60
Occupying	15.50	16.40	15.70	16.10
Shelter	0.60	2.90	22.80	6.60
Official/Employer house/Dormitory	4.20	4.20	6.90	4.80
Other	0.00	0.20	0.20	0.10
n-sample	1,417	3,873	1,397	6,687

More than 50% of households in all areas had access to improved water sources either from protected well/spring, bottled water, tap water, pump, or drinking water from aid. Meanwhile, dependence on the unsustainable source of drinking water like bottled water or drinking water from aid in the heavy damage area tends to be higher than the light or medium area.

Table 3 Source of drinking water

%household	Degree of Damage			
	Light	**Medium**	**Heavy**	**Total**
Bottled water	2.60	3.20	8.30	4.20
Tap water	9.50	20.50	19.90	18.00
Pump	2.10	2.00	2.90	2.20
Protected well/spring	52.60	37.60	23.60	37.80
Unprotected well/spring	27.50	27.40	18.80	25.60
Drinking water from the aid	1.00	1.90	24.30	6.40
Other	4.70	7.40	2.30	5.70
n-sample	1,417	3,873	1,397	6,687

The surprising fact is the heavy damage area had safer final disposal of sewage than two other affected areas in percentage. Approximately 64.90% of households in heavy damage area used the septic tank to dispose of the sewage. Meanwhile, only 34.20% in the medium damaged and 38.40% in the light damaged used a septic tank. The reason for the fact possibly related to the high proportion of households in the heavy damage which still lived in the shelter. Sanitation system including final disposal of sewage in the shelter was more standardized than the normal house. It confirms that most of the house was built without a proper sewage system. In order to support the "Build Back Better" concept, the housing reconstruction must be integrated with the sewage system.

Table 4 Final disposal of sewage

%household	**Degree of Damage**			
	Light	**Medium**	**Heavy**	**Total**

Septic tank	38.40	34.20	64.90	41.50
Pond/rice field	2.30	2.20	1.40	2.00
River/lake/ocean	36.30	30.80	14.00	28.50
Hole	17.80	22.60	13.70	19.70
Shore/open field	5.10	10.00	5.90	8.10
Other	0.20	0.10	0.10	0.10
n-sample	1,417	3,872	1,397	6,686

Results

The recovery level at first wave STAR data survey is presented in figure 2. For all samples, the recovery progress reaches 62.24% from the disaster condition. The light damage area becomes the fastest to recover with recovery level 66.83 %, followed by medium (61.87%) and heavy (62.24%) damage area affected by the tsunami.

Figure 2 Composite DRI by Degree of Damage

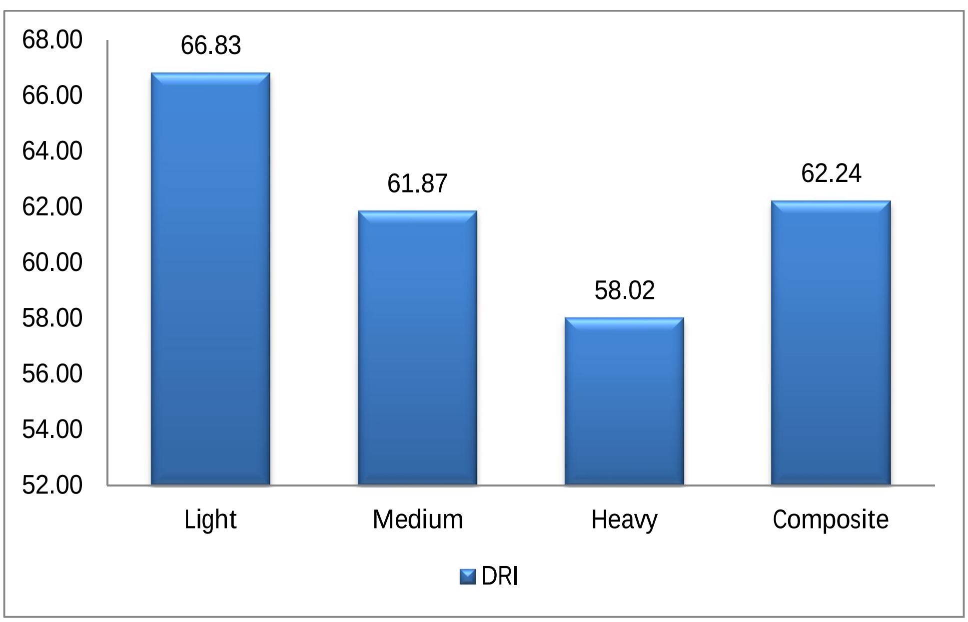


Table 6 illustrates the progress of recovery in three categories-affected areas by sector. Recovery trends were similar in the three categories areas, except in the social sector. The recovery level in the light damage area was the fastest followed by medium damage than the heavy damage area. Meanwhile, for the social sector recovery progress tend to be the slowest one in medium damage area than two other areas.

Table 5 DRI by Sector and Degree of Damage

Sector	Degree of Damage		
	Light	Medium	Heavy
HOUSING	67.67	63.49	58.76
INFRASTRUCTURE	51.80	49.63	47.34
LIVELIHOODS	86.92	79.73	78.30
SOCIAL	69.11	68.54	69.77
ENVIRONMENT	45.59	34.75	20.39
Composite DRI by the degree of damage	66.83	61.87	58.02
Composite DRI		62.24	

The comparative results of the sectors are also presented in table 6. In all affected areas, the livelihood sector achieved the best recovery progress indicated by the highest DRI among sectors. The livelihood recovery was supported by a large amount of aid, especially in cash transfer form. Cash transfer directly affected the household income and flexible in allocation compared with the in-kind transfer. Cash transfer assistance was provided in the various programs during the early recovery period. However, the most popular and played a vital role in income-generating and increase labor participation was Cash for Work (CFW). These programs provided cash to affected people in return for their work on various recovery projects such as debris removal and the repair or reconstruction of damaged infrastructure (Nagamatsu, 2015). CFW programs in Aceh were initiated within two weeks of the tsunami, reached their peak intensity during the first three to four months of 2005, and had ceased by the end of 2005 (Thorburn, 2009). A further challenge in livelihood sector recovery was the transition from the short-term recovery phase to a long-term recovery phase in order to revitalize in a more sustainable way.

On the other hand, the environment sectors were the slowest in recovery compared to the other sector in three affected areas. The tsunami destroyed approximately 61,816 ha of agricultural land. It was caused by deposits of salt and marine mud, the spreading of waste and building rubble, and by the breaking of irrigation and drainage systems, with impacts on the areas farmed and agricultural production (UNEP, 2007). Soil fertility was affected in many areas, so the planting area decreased in almost affected areas compared to the pre-tsunami condition. Technology and supporting infrastructure to recover land productivity was an important priority in the next recovery phase.

The slower recovery than the expectation in the housing sector was caused by a number of obstacles (Azmeri, Mutiawati, Al-Huda, & Mufiaty, 2017; BRR and World Bank, 2005; Masyrafah & Mckeon, 2008; Steinberg, 2007) i.e. land tenure and ownership, environmental problem, construction specification and materials, selection of beneficiaries, etc. The other problem was implementing community participation in housing and infrastructure recovery action. The community structure had destroyed by the three-decade conflict and the tsunami. As a result, effective community participation took time and needed continuous facilitation (Steinberg, 2007).

In light and heavy damage area, social sector recovery had a similar achievement, are about 69%. Nevertheless, in the medium area, the recovery level was 68.54%, which was slower compared with the two other areas. More than half of the survivors (57.9 %) lived in the medium area, while the remaining was distributed in two other areas in almost the same proportion. So it is reasonable that recovering the education and health of the more survivors in the medium area was harder than two other areas. The bad access to education and health in the pre-tsunami condition due to the conflict is also potentially affecting the slow progress.

Conclusions

This research finds that overall recovery was still only reached 62.84% in the first wave of the STAR data survey which was conducted several months after the disaster. That is an interesting finding in post-tsunami recovery monitoring since we can measure the progress.

The fastest recovery in Aceh post-tsunami recovery was reached by livelihood sectors across the three damage areas. Cash for work programs played a significant role both in generating income and unemployment reduction in the short-term reconstruction and recovery phase. Consequently, livelihood recovery still needs more sustainable programs. The environment sector became the slowest to recover caused by the heavy damage in agricultural land. In order to recover land productivity, the needs of technology and supporting infrastructure is an important priority. The housing, infrastructure, and social sector recovery need the community support to accelerate the progress, so building the community structure has to be the most priority in the post-disaster recovery.

DRI provides alternative measurements in post-disaster recovery progress. The index is useful to monitor the progress, to evaluate the implemented programs, to design the effective recovery programs based on remaining recovery needs, and to be lesson learned for better post-disaster recovery policymaking.

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