AESOP 2025 CONGRESS
Istanbul, 7-11 July
AESOP
YTÜ YILDIZ TEKNİK ÜNİVERSİTESİ

Assessment of Community Resilience to Disaster at the Local Level in Korea

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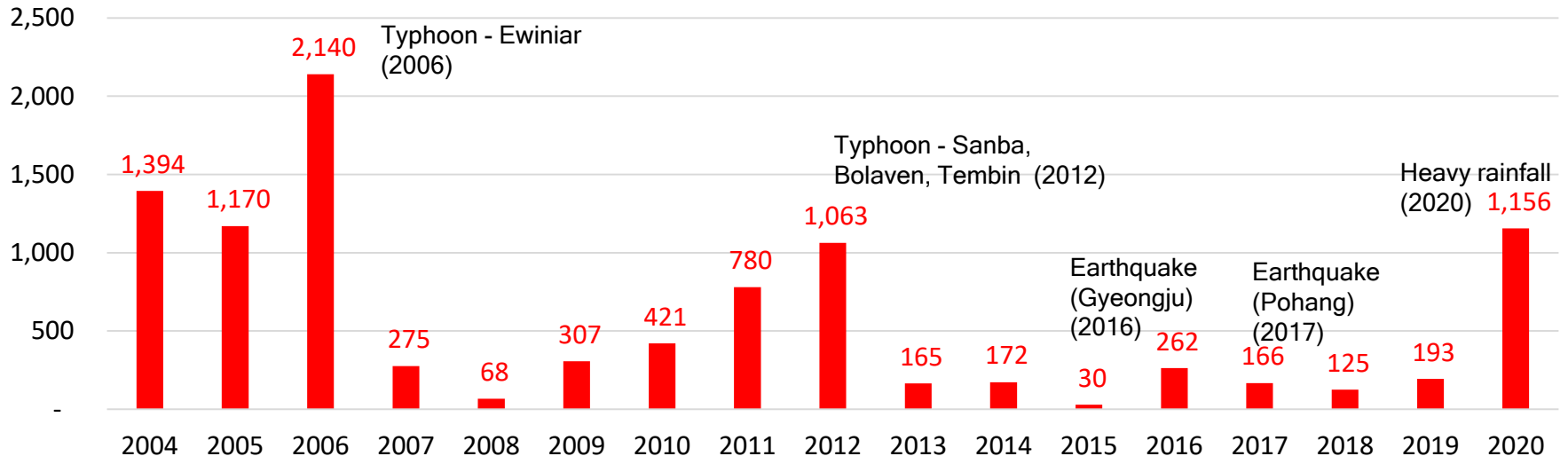
Natural disasters in Korea

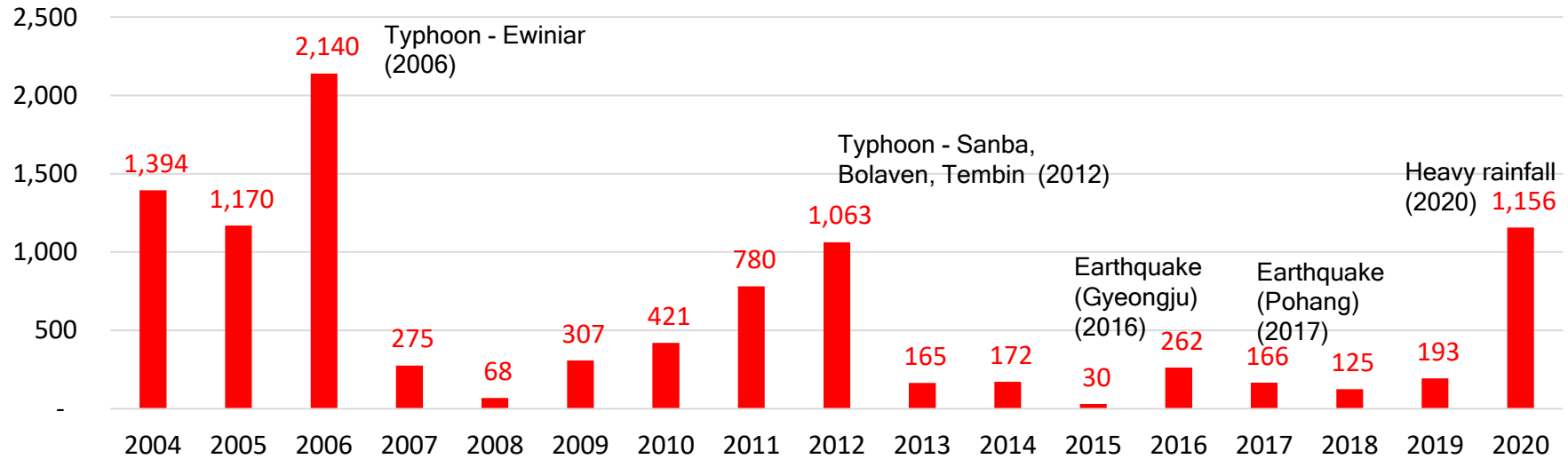
- Over the past 15 years, the average economic losses from natural disasters have been estimated at approximately KRW 582 billion (USD 404.09 million).
- The largest significant damage occurred in 2006 due to Typhoon Ewiniar, reaching KRW 2,140 billion (USD 1,486.41 million).
- Severe damages have continued with events such as Typhoon Sanba, Bolaven and Tembin (2012), Earthquake in Gyeongju (2016) and Pohang (2017) as well as the heavy rainfall over the Korean Peninsula in 2020.



Source: National Emergency Management Agency, Unit: Billion Korean Won

Natural disasters in Korea

- Over the past 15 years, there have been a total of 699 human losses due to natural disasters, averaging approximately 41 losses per year.
- The highest number of casualties occurred in 2011 during heavy rain, with a recorded total of 138 losses that year.

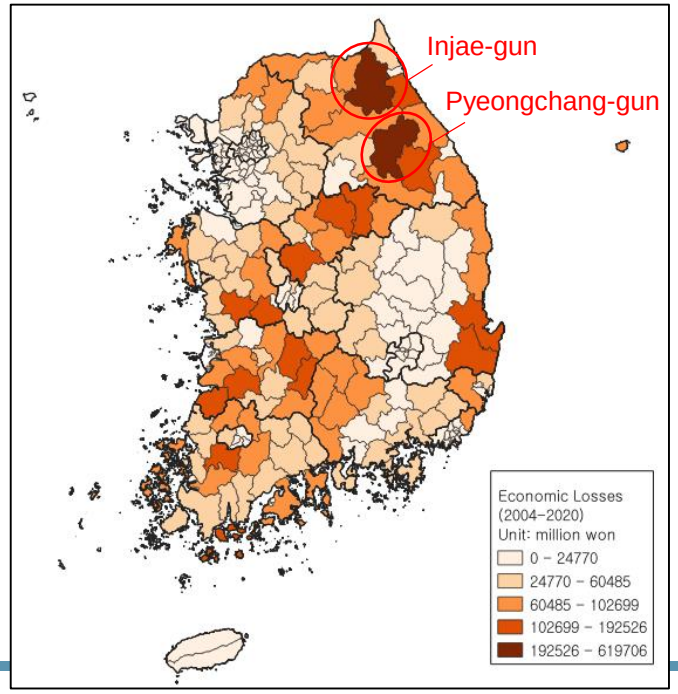


Source: National Emergency Management Agency, Unit: Billion Korean Won

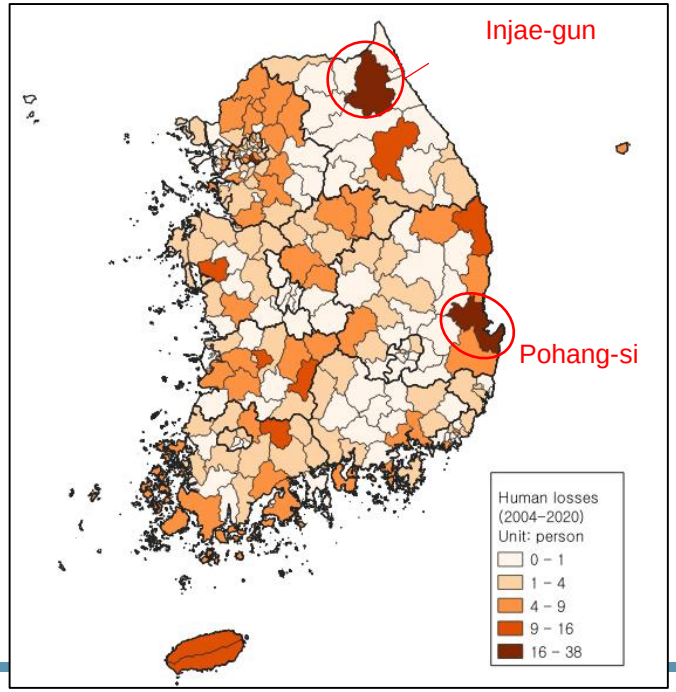
Natural disasters in Korea

- Pyeongchang-gun and Injae-gun in Gangwon province have experienced greater economic losses.
  - Pyeongchang-gun: KRW 619,706 million (USD 452.4 million) / Injae-gun: KRW 511,989 million (USD 373.7 million)
- Pyeongchang-gun in Gangwon province and Pohang-si in Gyeongbuk province have experienced greater human losses Pohang-si: 38 fatalities / Injae-gun: 29 fatalities

[Economic losses from natural disasters (2004-2020)]



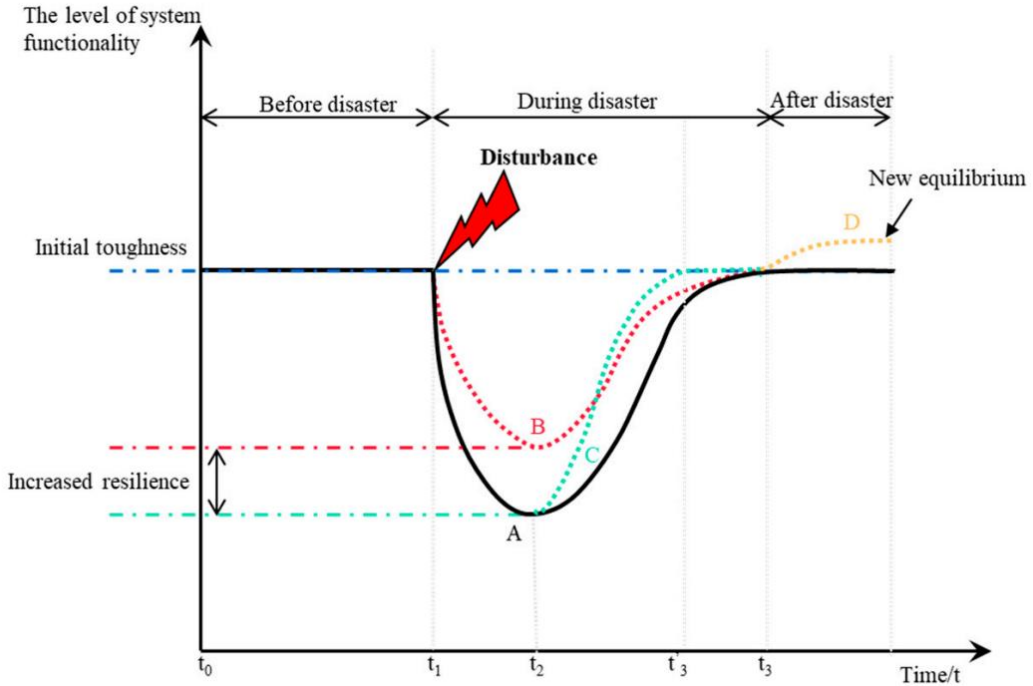
[Human losses from natural disasters (2004-2020)]



Source: National Emergency Management Agency, Unit: Billion Korean Won

Importance of community disaster resilience

- Since it has become increasingly difficult to completely prevent disaster-related damages, building resilience to minimize impacts and accelerate recovery has become more critical than ever.
- Resilient communities enhance their disaster management capacities based on the capacity to minimize damage and recover quickly from the impacts.



Source: Evaluation Model of Urban Resilience in the Face of Public Health Emergencies: A Case Study of Xi'an (Liu et al., 2023)

Definition of community disaster resilience

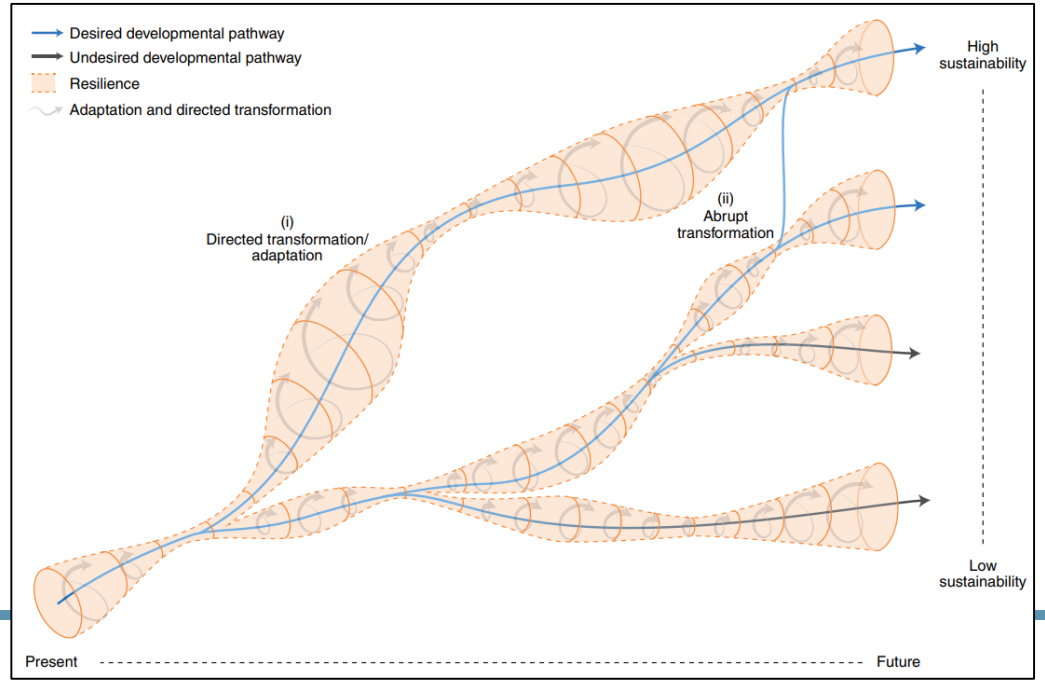
- The term resilience means “bouncing back,” derived from the Latin word resiliere (“to jump back”) (Klein et al., 2003)
- Holling (1973) first applied resilience to ecosystems, describing their ability to absorb and persist despite external changes or threats
- “Measure of the persistence of systems and their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables.” (Holling, 1973)
- “The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner” (UNDRR)
- “The ability to prepare and plan for, absorb, recover from, or more successfully adapt to actual or potential adverse events” (National Research Council, 2012)

Community disaster resilience

- Community disaster resilience helps reduce economic losses and human injuries by lowering vulnerability to disasters (Berke & Campanella, 2006)
- It involves both minimizing disaster impacts and recovering with minimal social disruption (Buckle et al., 2000; Manyena, 2006).
- Community resilience includes post-disaster recovery and adaptation processes (Cutter et al., 2008; Koebele et al., 2019).
- Resilient communities suffer fewer losses, while less resilient ones face greater disruptions.
- Such communities are better prepared to cope with and adaptively manage disaster risks (Paton & Johnston, 2017; Koebele et al., 2019).

Transformative resilience

- Resilience is not inherently good or bad, but a flexible attribute, which can become desirable or undesirable on how it is managed through planning (Elmqvist et al., 2019).
- Although community resilience is often treated as static, it is dynamic, shaped by evolving capacities across sectors.
- Tracking these changes helps assess resilience trends and understand how communities sustain it through shifting subcomponents (Derakhshan et al., 2025).



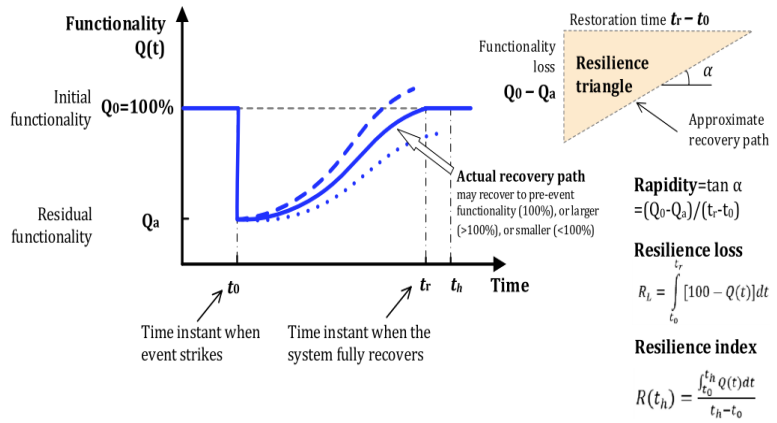
Source: Sustainability and resilience for transformation in the urban century (Elmqvist et al., 2019)

Measurement of Community disaster resilience

Methodologies for measuring resilience can be categorized into two main approaches

- Mathematical resilience measurement based on resilience curves and index-based measurement.
- Mathematical resilience measurement assesses resilience by quantifying values including slope (declining or recovery) and area under the resilience curve, which reflects changes in the community's performance (or function).
- Index-based resilience measurement conceptually evaluates resilience using indicators to assess sub-components of resilience.

Mathematical resilience measurement



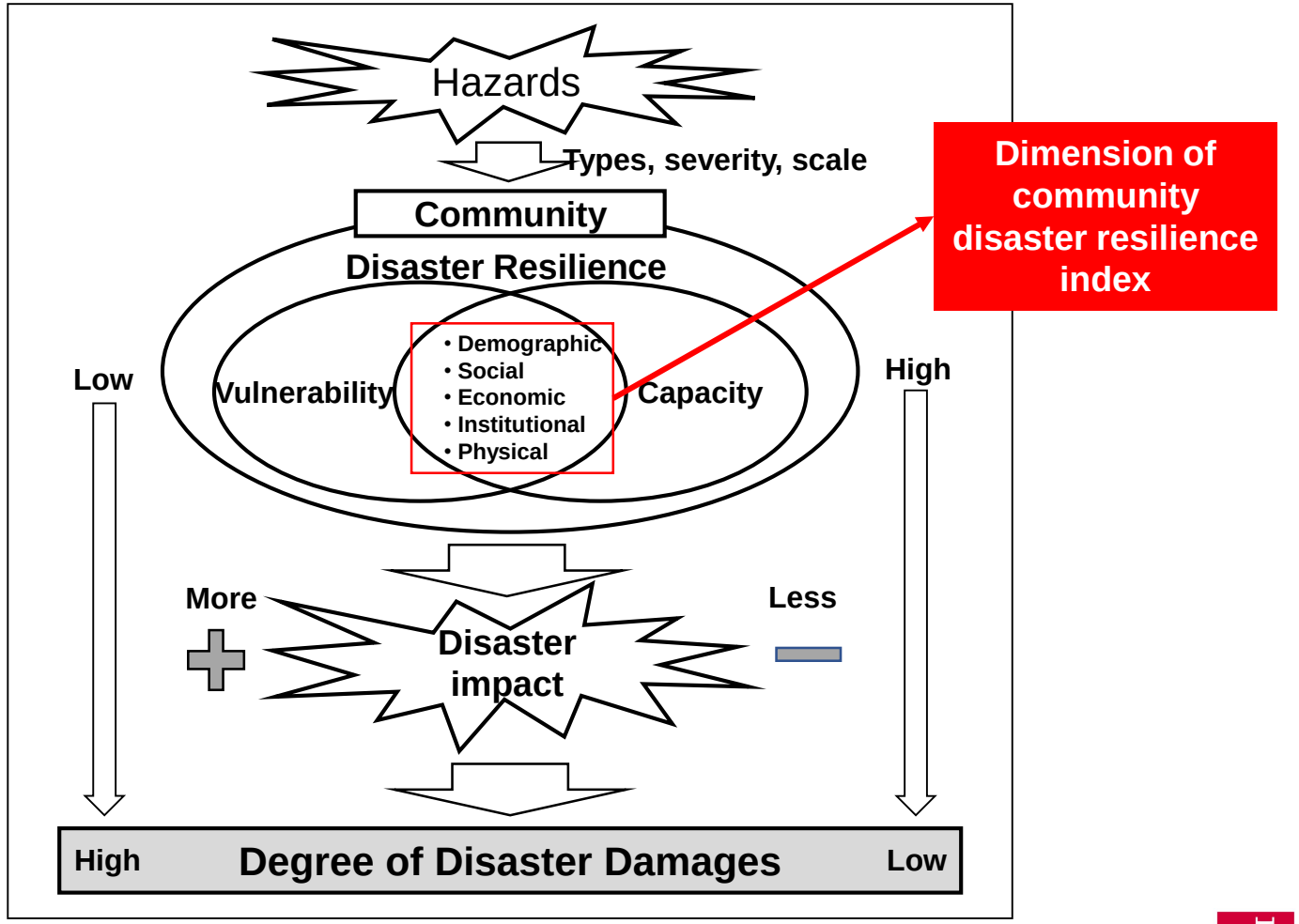
Resilience triangle (Sun et al., 2018)

Index-based resilience measurement

Resilience concept	Variable description	Justification	Dataset
Social resilience			
Educational attainment equality	Negative absolute difference between % population with college education and % population with less than high school education	Morrow (2008) and Sherrieb et al. (2010)	9
Pre-retirement age	% Population below 65 years of age	Morrow (2008) and Peek (2010)	4
Transportation	% Households with at least one vehicle	Peacock et al. (2010) and Tierney (2009)	9
Communication capacity	% Households with telephone service available	Burger et al. (2013) and Strawderman et al. (2012)	9
English language competency	% Population proficient English speakers	Messias et al. (2012) and Senkbeil et al. (2013)	9
Non-special needs	% Population without sensory, physical, or mental disability	Davis and Phillips (2009) and Matherly and Mobley (2012)	8
Health insurance	% Population under age 65 with health insurance	Chandra et al. (2011) and Plough et al. (2013)	4, 5
Mental health support	Psychosocial support facilities per 10,000 persons	Pietrzak et al. (2012) and Springgate et al. (2011)	4, 30
Food provisioning capacity	Food security rate	Pingali et al. (2005) and Tobin and Whiteford (2012)	28
Physician access	Physicians per 10,000 persons	Chandra et al. (2011) and Norris et al. (2008)	9
Economic resilience			
Homeownership	% Owner-occupied housing units	Haveman and Wolff (2005) and Pendall et al. (2012)	9
Employment rate	% Labor force employed	Rose and Krausmann (2013) and Sherrieb et al. (2010)	9
Race/ethnicity income equality	Negative Gini coefficient	Norris et al. (2008) and Sherrieb et al. (2010)	9
Non-dependence on primary/tourism sectors	% Employees not in farming, fishing, forestry, extractive industry, or tourism	Rose and Krausmann (2013) and Sherrieb et al. (2010)	9
Gender income equality	Negative absolute difference between male and female median income	Enarson (2012) and Sherrieb et al. (2010)	9

Indicators of BRIC (Cutter et al., 2014)

Conceptual model of Community Disaster Resilience Index (CDRI)



Measurement of community disaster resilience index, 2010, 2015, 2020

Community disaster resilience index, 2010, 2015, 2020

- Unit : 229 si-gun-gu (local municipalities)
- Indicator : vulnerability + capacity = demographic, social, economic, institutional, physical dimensions

Selection of variables for CDRI

- Normalization, Cronbach's alpha test
- 22 variables in 5 dimensions for 2010, 2015, 2020

Quantification of community disaster resilience based on CDRI

- Normalization: min-max normalization (0 ~ 1)
- Weigt: Entropy – Critic weight methodology

Analysis of geographical distribution of CDRI

Analysis of change in community disaster resilience over ten years(2010-2020)

Exploring drivers influencing change in community disaster resilience

Community disaster resilience indicators

Dimension	Code	Indicator	Vulnerability (V) / Capacity(C)	Cronbach's alpha
Demographic	D1	Proportion of population over 65 years	V	
(5)	D2	Proportion of population with high school diploma and higher	C	
	D3	Proportion of population receiving basic livelihood security benefits	V	0.951
	D4	Proportion of population with diagnosed diseases	V	
	D5	Proportion of working-age population	C	
Social	S1	Proportion of single-person households	V	
(4)	S2	Net inflow rate of population	C	0.538
	S3	Proportion of marriage migrants in the population	V	
	S4	Proportion of population covered by health insurance	C	
Economic	E1	Per capita local tax revenue	C	
(5)	E2	Financial independence ratio	C	
	E3	Per capita GRDP (Gross Regional Domestic Product)	C	0.772
	E4	Proportion of high value-added industries	C	
	E5	Proportion of budget allocation to community-led disaster management	C	
Institutional	I1	Number of public officers per 10,000 population	C	
(4)	I2	Number of police stations per 10,000 population	C	0.709
	I3	Number of fire stations per 10,000 population	C	
	I4	Number of social welfare facilities per 10,000 population	C	
Physical	P1	Proportion of aged buildings	V	
(5)	P2	Percentage of retention basin area	C	
	P3	Pavement rate of roads	C	0.605
	P4	Sewerage coverage rate	C	
	P5	Number of building construction permits	C	

Community Disaster Resilience Index (CDRI) - 2010 vs. 2015 vs. 2020

Average total CDRI in 2020 decreased by 1.40% compared to 2010.

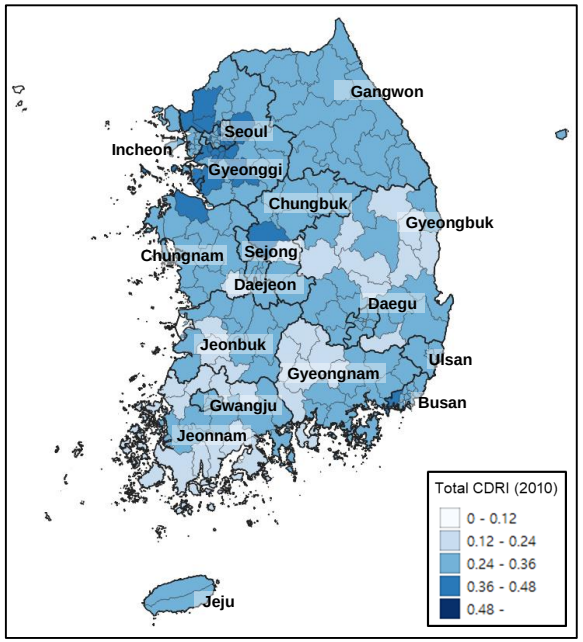
Average total CDRI in 2015 increased by 1.90% compared to 2010, whereas it decreased by 3.24% in 2020 relative to 2015.

-(2010) average (0.293) - max (0.487) - min (0.146)

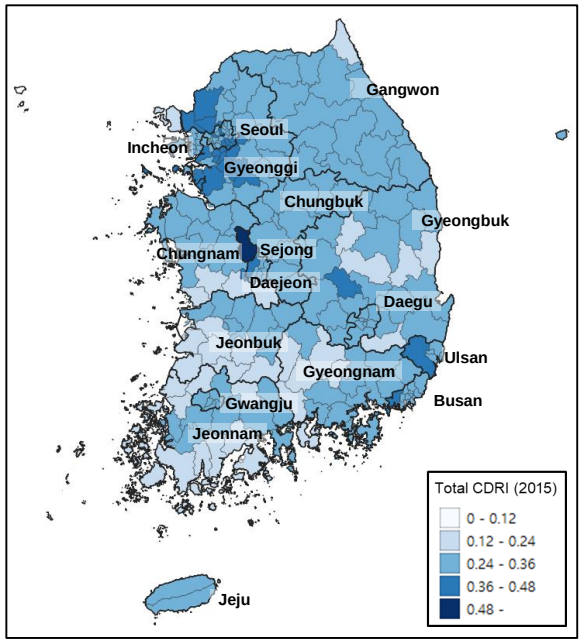
-(2015) average (0.299) - max (0.497) - min (0.175)

-(2020) average (0.289) - max (0.478) - min (0.169)

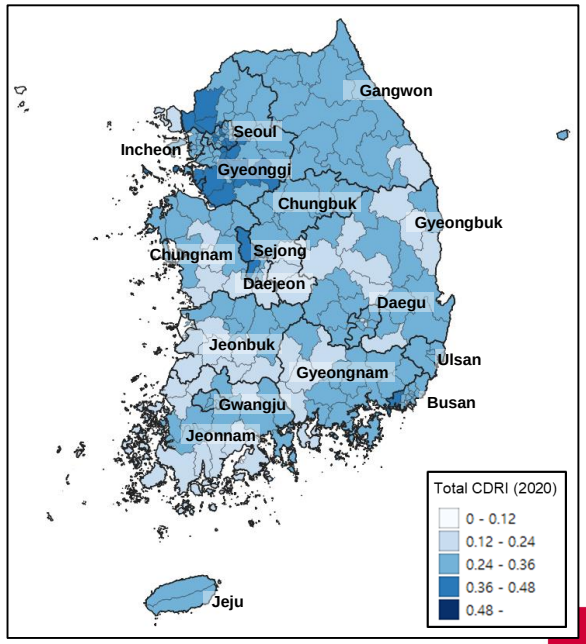
[Total CDRI (2010)]



[Total CDRI (2015)]



[Total CDRI (2020)]



Community Disaster Resilience Index (CDRI) - 2010 vs. 2015 vs. 2020

- (2010-2015) Some dimensions of resilience increased, others decreased.

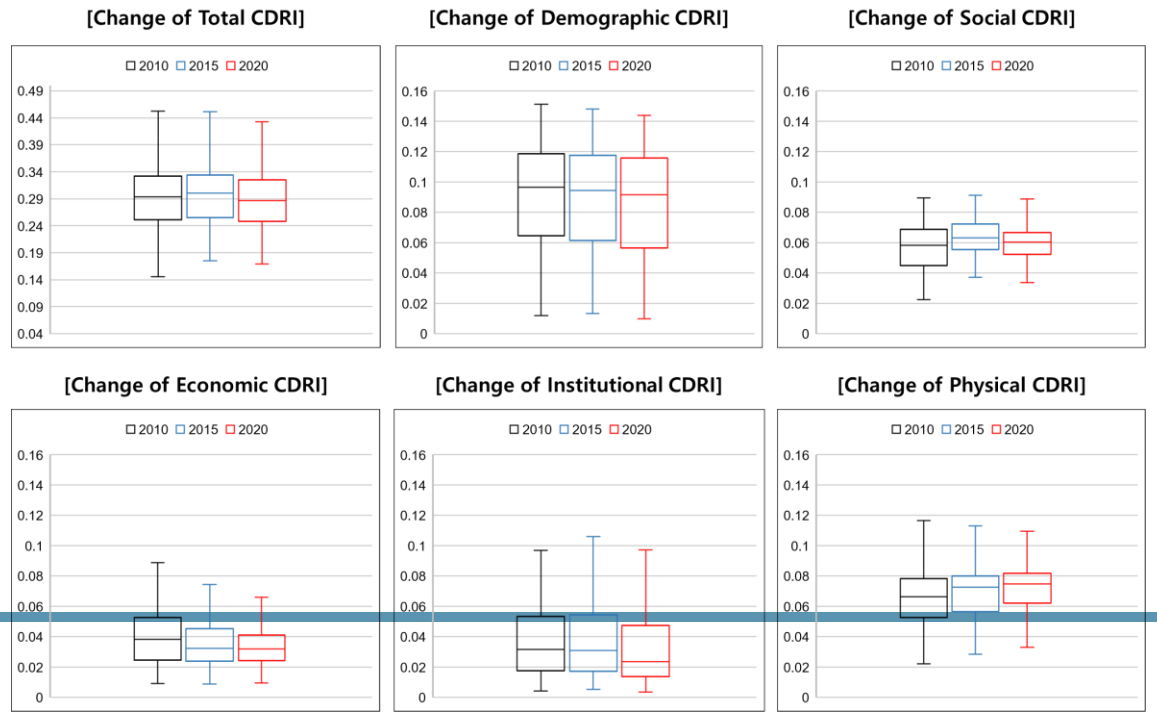
-Notable increases in social dimension (+10.79%) and decreases in economic dimension (-9.51%).

- (2015-2020) Most CDRI components showed decline.

-Notable decrease in institutional dimension (-15.58%).

- (2010-2020) Some dimensions of resilience increased, others decreased.

-Notable increases in physical dimension (+11.01%) and decreases in institutional dimension (-13.84%).



CDRI		2010	2015	2020
Total	Max	0.487	0.497	0.478
(sum)	Min	0.146	0.175	0.169
	Average	**0.293**	**0.299**	**0.289**
Demographic	Max	0.151	0.148	0.144
	Min	0.012	0.013	0.010
	Average	**0.090**	**0.089**	**0.086**
Social	Max	0.090	0.091	0.103
	Min	0.023	0.037	0.034
	Average	**0.057**	**0.063**	**0.061**
Economic	Max	0.160	0.165	0.163
	Min	0.009	0.009	0.009
	Average	**0.041**	**0.037**	**0.036**
Institutional	Max	0.187	0.180	0.138
	Min	0.004	0.005	0.003
	Average	**0.039**	**0.039**	**0.033**
Physical	Max	0.154	0.151	0.154
	Min	0.022	0.020	0.032
	Average	**0.066**	**0.070**	**0.074**

CDRI – demographic

Average CDRI of demographic dimension in 2020 decreased by 5.14% compared to 2010.

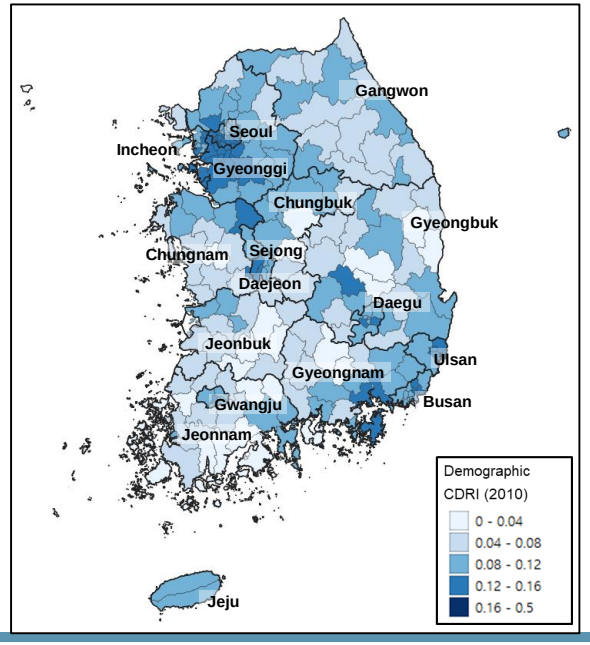
Average CDRI of demographic dimension in 2015 decreased by 1.66% compared to 2010 and decreased by 3.54% in 2020 relative to 2015.

-(2010) average (0.090) - max (0.151) – min (0.012)

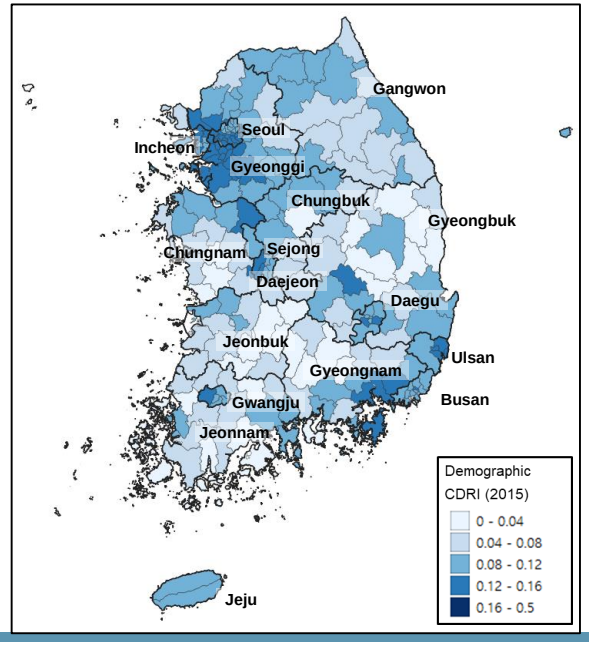
-(2015) average (0.089) - max (0.148) – min (0.013)

-(2020) average (0.086) - max (0.144) – min (0.010)

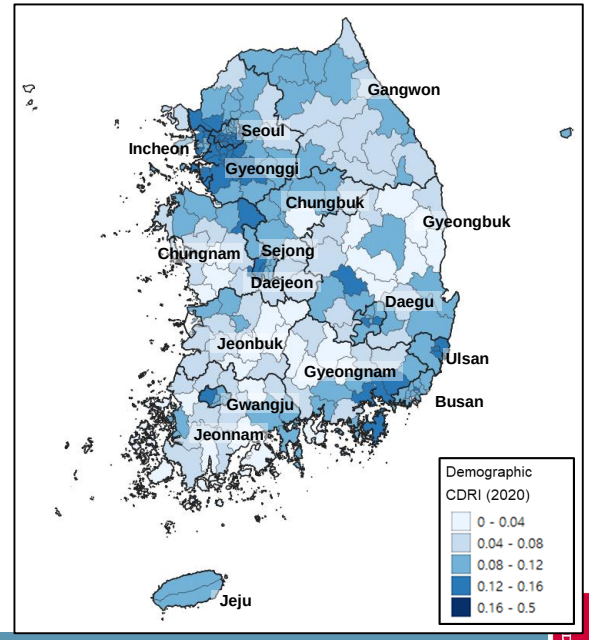
[Demographic CDRI (2010)]



[Demographic CDRI (2015)]



[Demographic CDRI (2020)]



CDRI – social

Average CDRI of social dimension in 2020 increased by 5.70% compared to 2010.

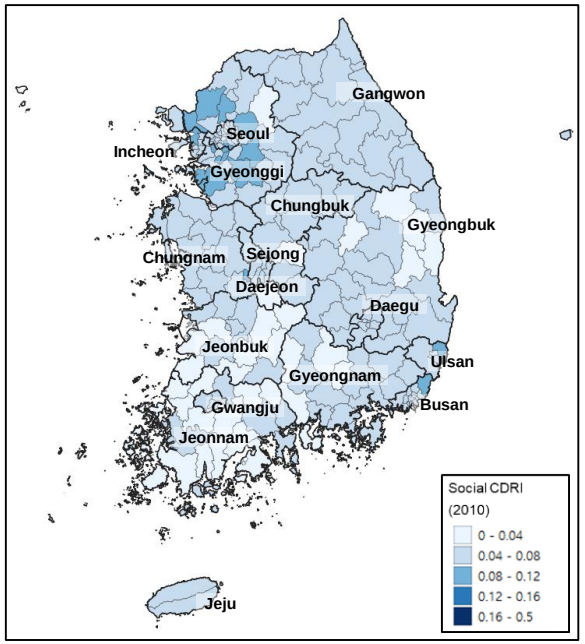
Average CDRI of social dimension in 2015 increased by 10.79% compared to 2010, whereas it decreased by 4.59% in 2020 relative to 2015.

-(2010) average (0.057) - max (0.090) – min (0.023)

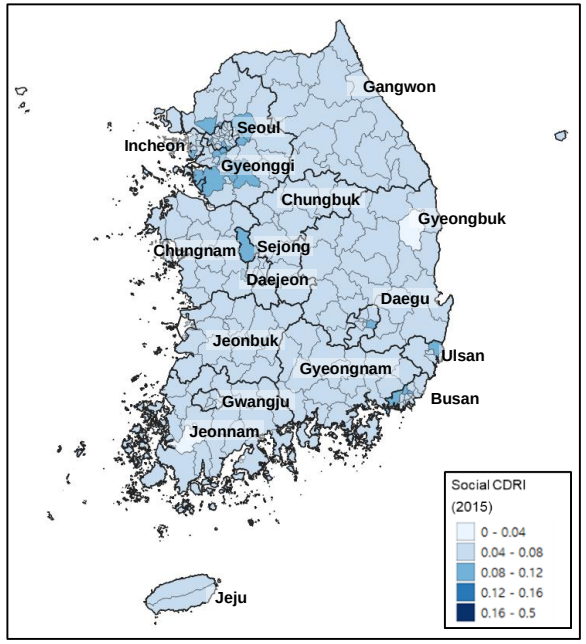
-(2015) average (0.063) - max (0.091) – min (0.037)

-(2020) average (0.061) - max (0.103) – min (0.034)

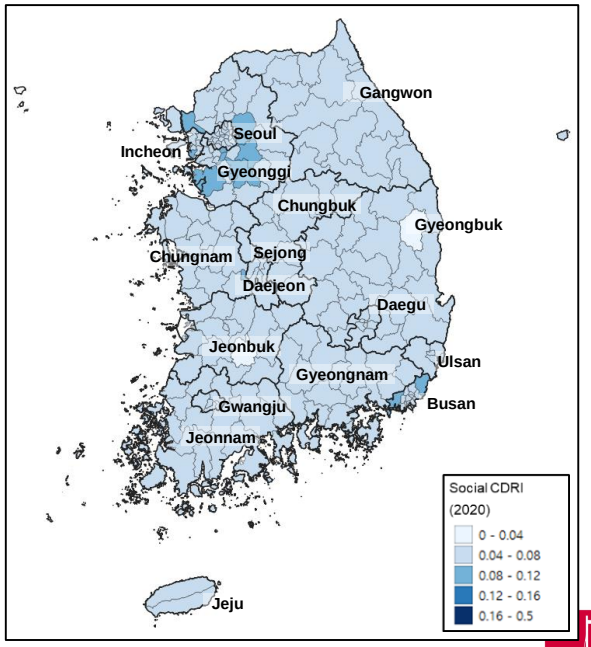
[Social CDRI (2010)]



[Social CDRI (2015)]



[Social CDRI (2020)]



CDRI – economic

Average CDRI of economic dimension in 2020 decreased by 11.54% compared to 2010.

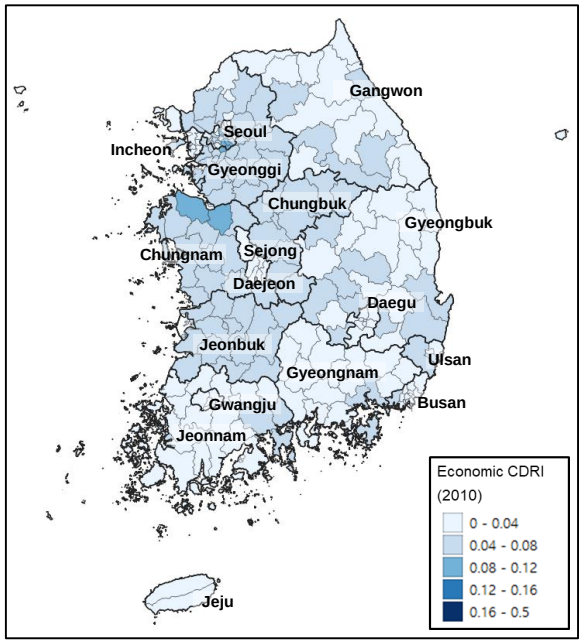
Average CDRI of economic dimension in 2015 decreased by 9.51% compared to 2010 and decreased by 2.25% in 2020 relative to 2015.

-(2010) average (0.041) - max (0.160) – min (0.009)

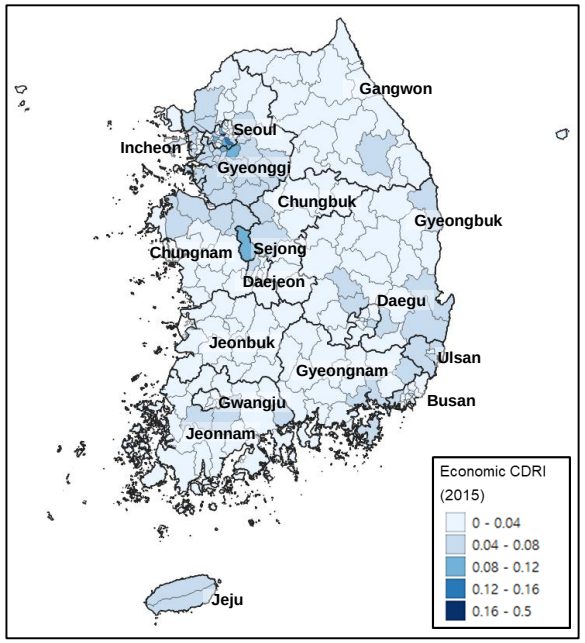
-(2015) average (0.037) - max (0.165) – min (0.009)

-(2020) average (0.036) - max (0.163) – min (0.009)

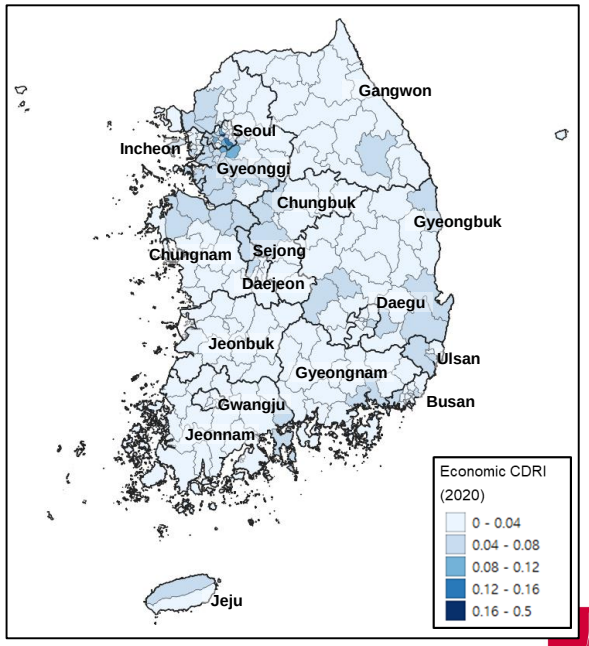
[Economic CDRI (2010)]



[Economic CDRI (2015)]



[Economic CDRI (2020)]



CDRI – institutional

Average CDRI of institutional dimension in 2020 decreased by 13.84% compared to 2010.

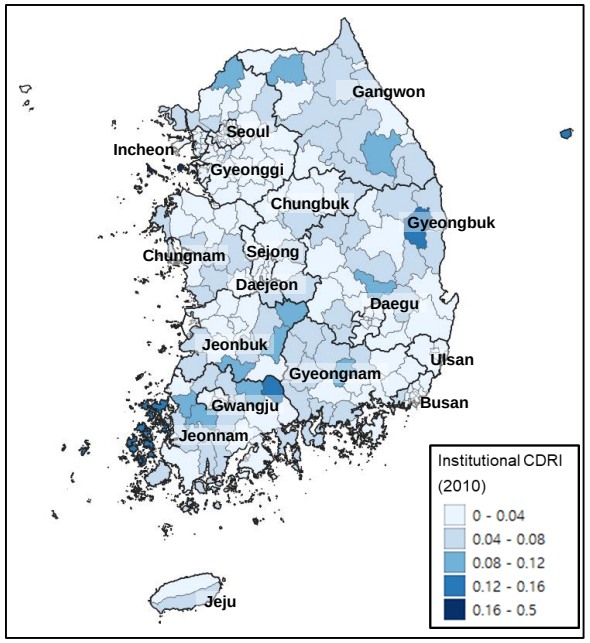
Average CDRI of institutional dimension in 2015 increased by 2.06% compared to 2010 and decreased by 15.58% in 2020 relative to 2015.

-(2010) max (0.187) – min (0.004) – average (0.039)

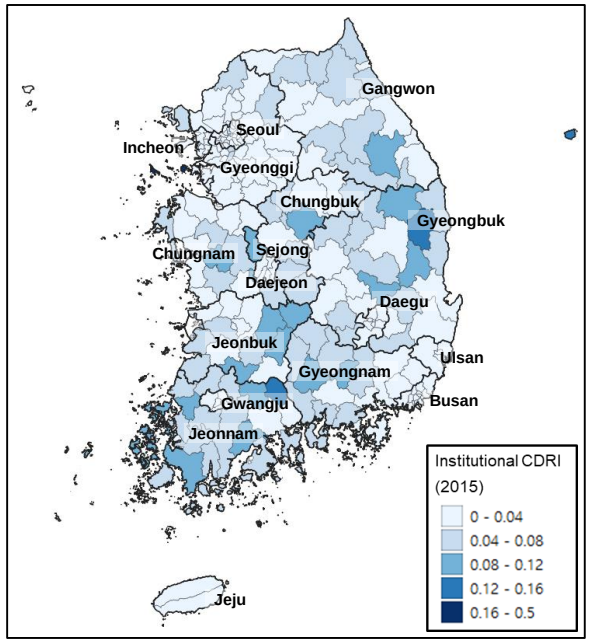
-(2015) max (0.180) – min (0.005) – average (0.039)

-(2020) max (0.138) – min (0.003) – average (0.033)

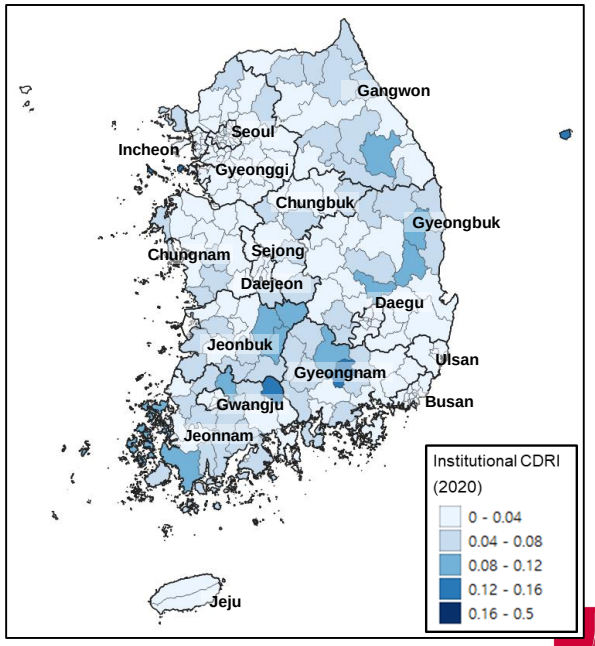
[Institutional CDRI (2010)]



[Institutional CDRI (2015)]



[Institutional CDRI (2020)]



CDRI – physical

Average CDRI of physical dimension in 2020 increased by 11.01% compared to 2010.

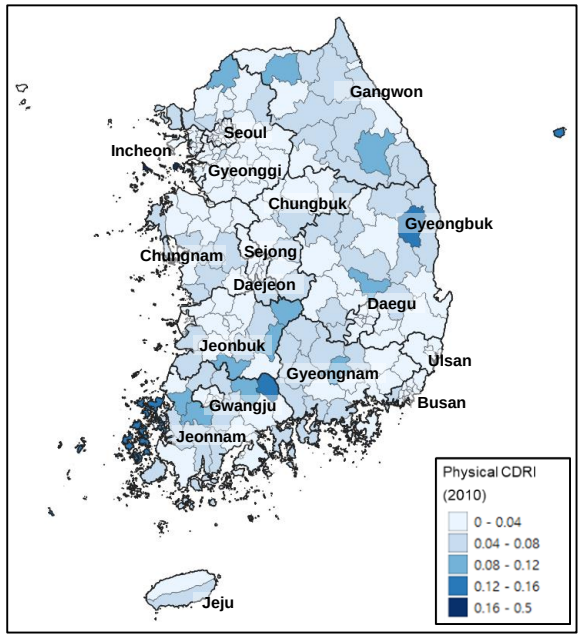
Average CDRI of physical dimension in 2015 increased by 5.95% compared to 2010, and increased by 4.77% in 2020 relative to 2015.

-(2010) max (0.154) – min (0.022) – average (0.066)

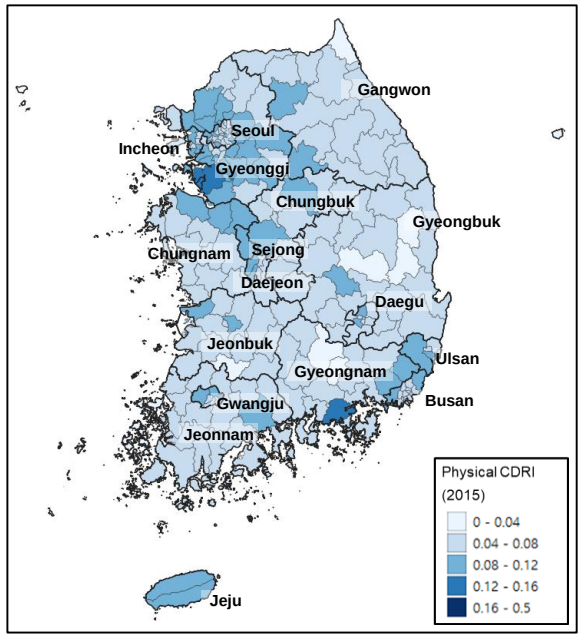
-(2015) max (0.151) – min (0.020) – average (0.070)

-(2020) max (0.154) – min (0.032) – average (0.074)

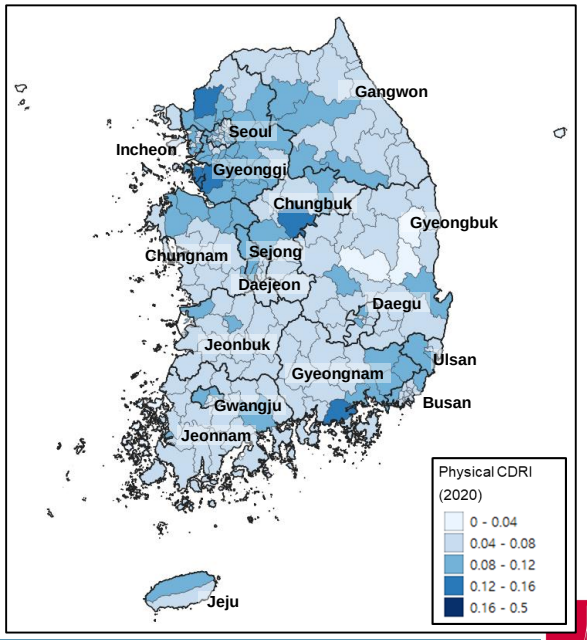
[Physical CDRI (2010)]



[Physical CDRI (2010)]



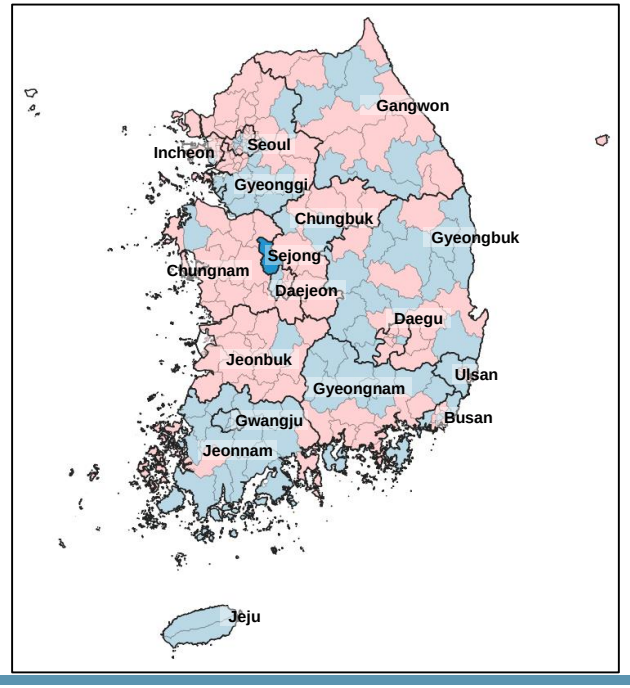
[Physical CDRI (2010)]



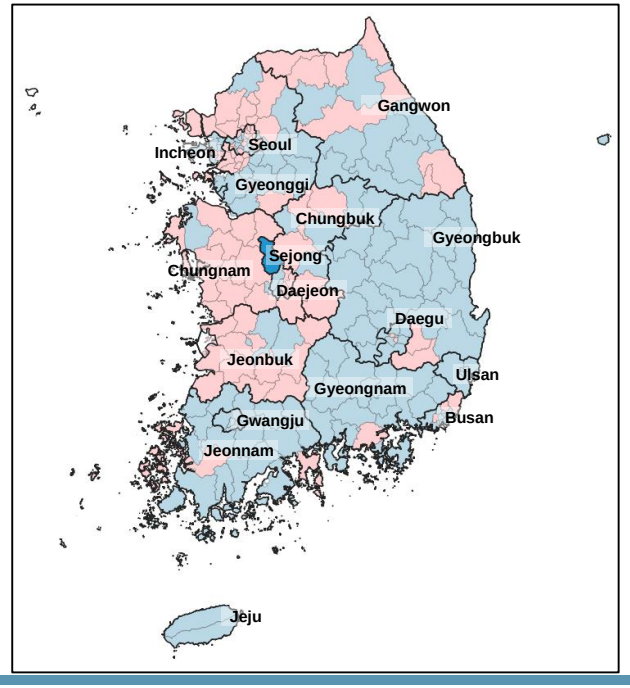
Change of Total CDRI

- (2010⇒2020) 40.6% of municipalities showed improvement of total CDRI
- (2010⇒2015) 59.4% of municipalities showed improvement of total CDRI.
- (2015⇒2020) 23.6% of municipalities improved, with most experiencing a decline.

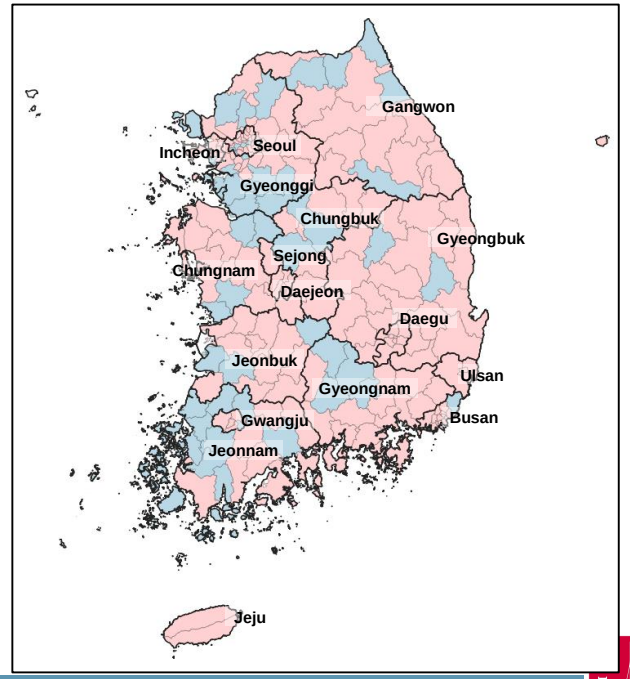
[Change of Total CDRI (2010-2020)]



[Change of Total CDRI (2010-2015)]



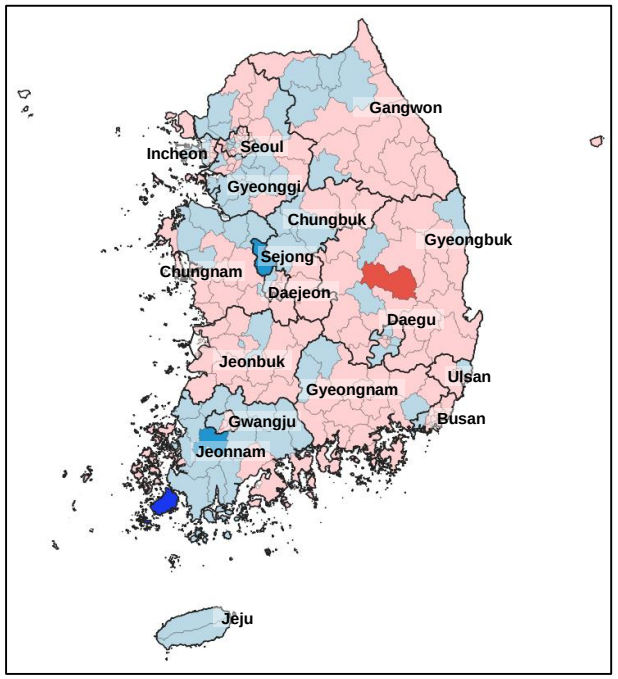
[Change of Total CDRI(2015-2020)]



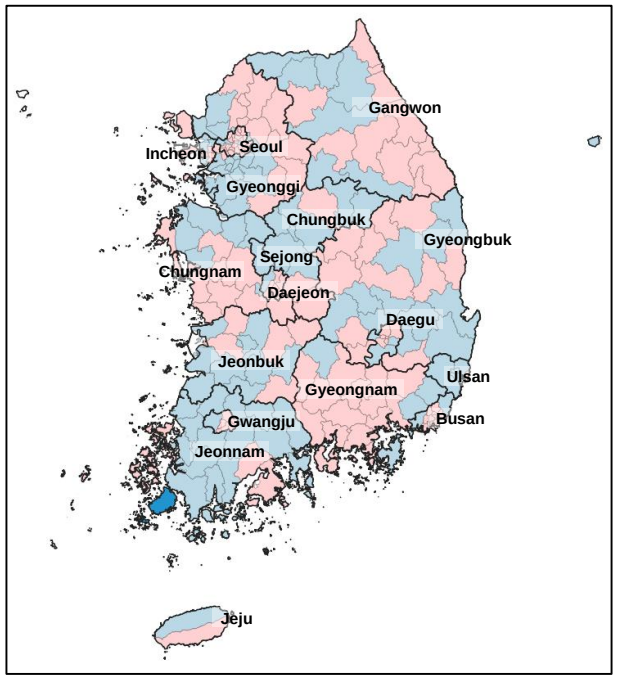
Change of CDRI – demographic

- (2010⇒2020) 32.3% of communities improved, with most experiencing a decline.
- (2010⇒2015) 44.1% of communities showed improvement of CDRI of demographic dimension.
- (2015⇒2020) 31.0% of communities improved.

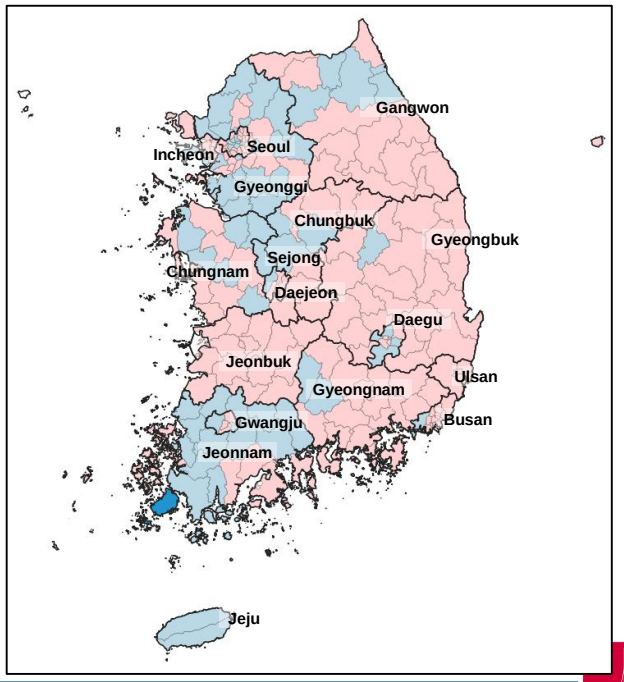
[Change of CDRI (demographic) (2010-2020)]



[Change of CDRI (demographic) (2010-2015)]



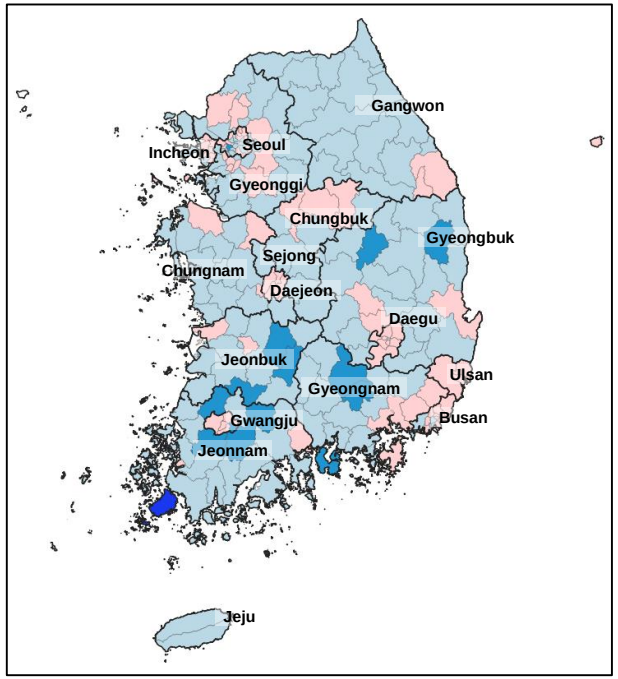
[Change of CDRI (demographic) (2015-2020)]



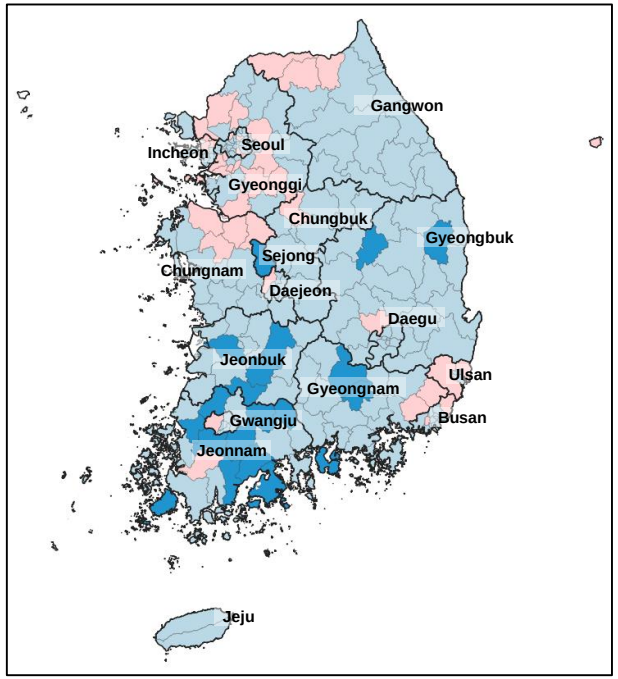
Change of CDRI – social

- (2010⇒2020) 64.2% of communities improved.
- (2010⇒2015) 82.5% of communities showed improvement of CDRI of social dimension.
- (2015⇒2020) 23.6% of communities improved, with most experiencing a decline.

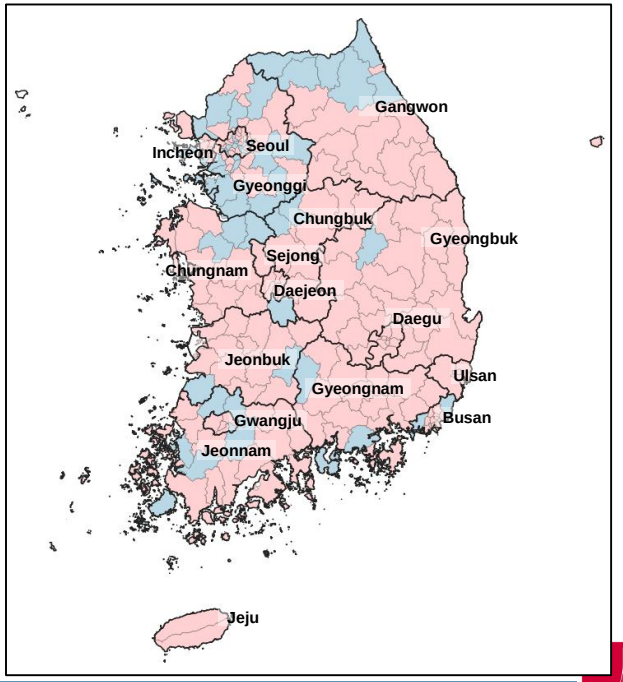
[Change of CDRI (social) (2010-2020)]



[Change of CDRI (social) (2010-2015)]



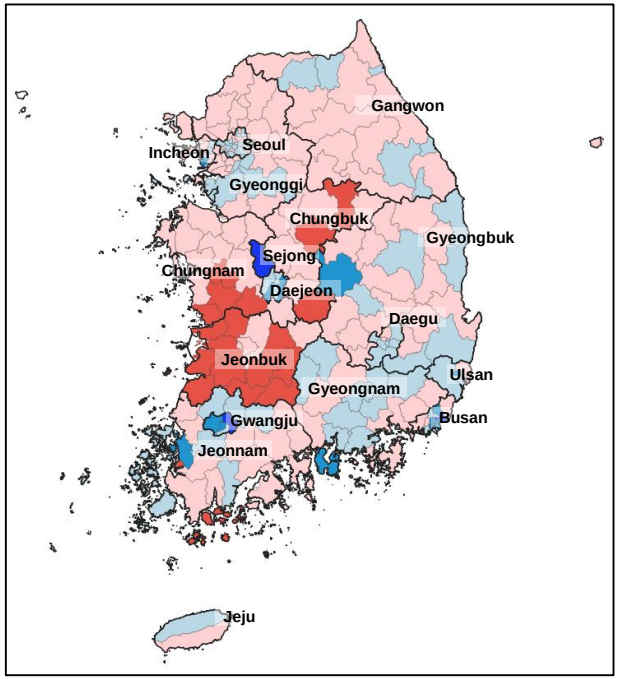
[Change of CDRI (social) (2015-2020)]



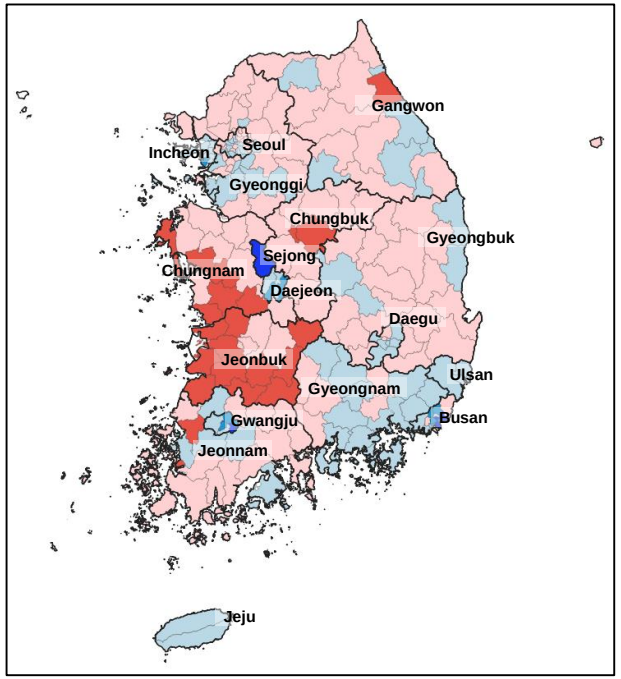
Change of CDRI – economic

- (2010⇒2020) 40.2% of communities improved.
- (2010⇒2015) 41.0% of communities showed improvement of CDRI of economic dimension.
- (2015⇒2020) 46.7% of communities improved.

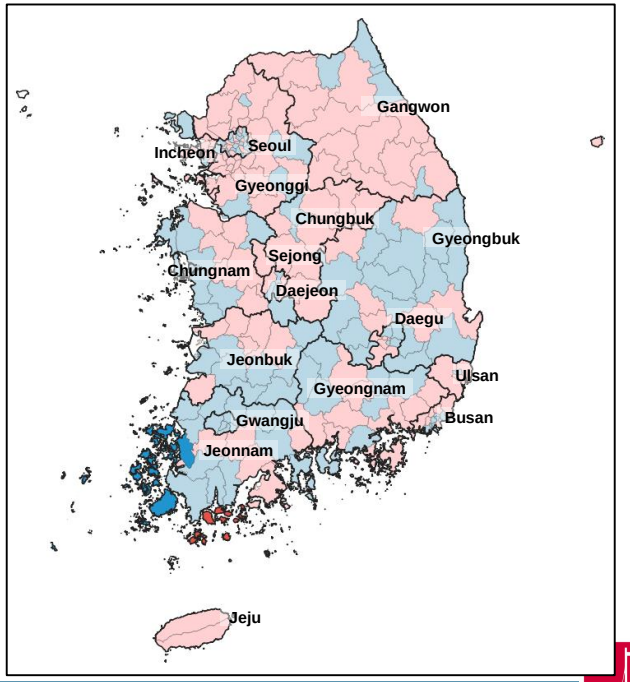
[Change of CDRI (economic) (2010-2020)]



[Change of CDRI (economic) (2010-2015)]



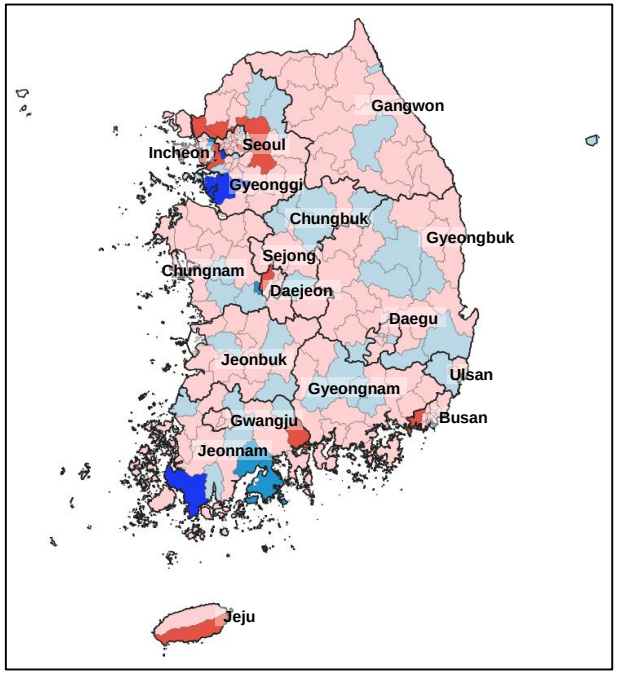
[Change of CDRI (economic) (2015-2020)]



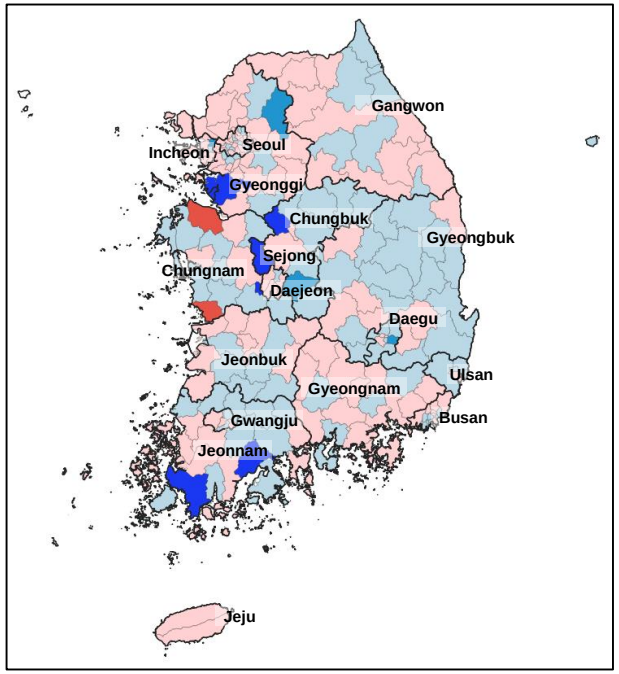
Change of CDRI – institutional

- (2010⇒2020) 21.0% of communities improved.
- (2010⇒2015) 45.4% of communities showed improvement of CDRI of institutional dimension.
- (2015⇒2020) 8.3% of communities improved, most communities' CDRI decreased.

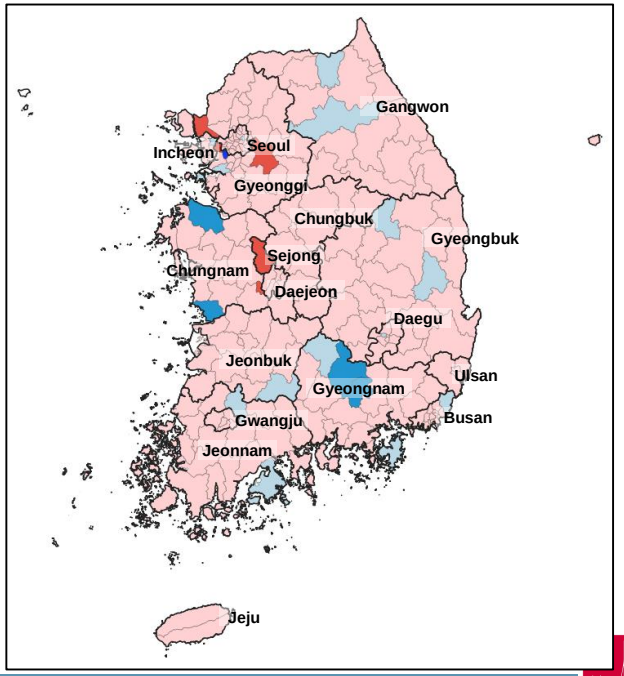
[Change of CDRI (institutional) (2010-2020)]



[Change of CDRI (institutional) (2010-2015)]



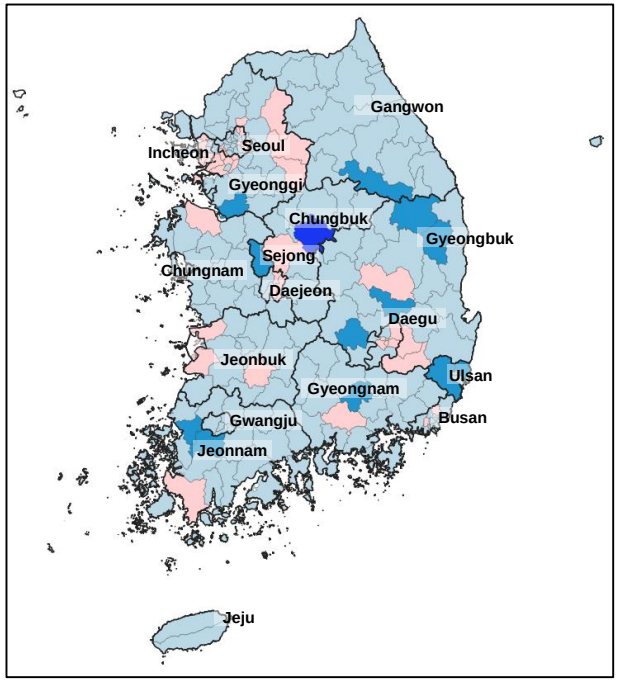
[Change of CDRI (institutional) (2015-2020)]



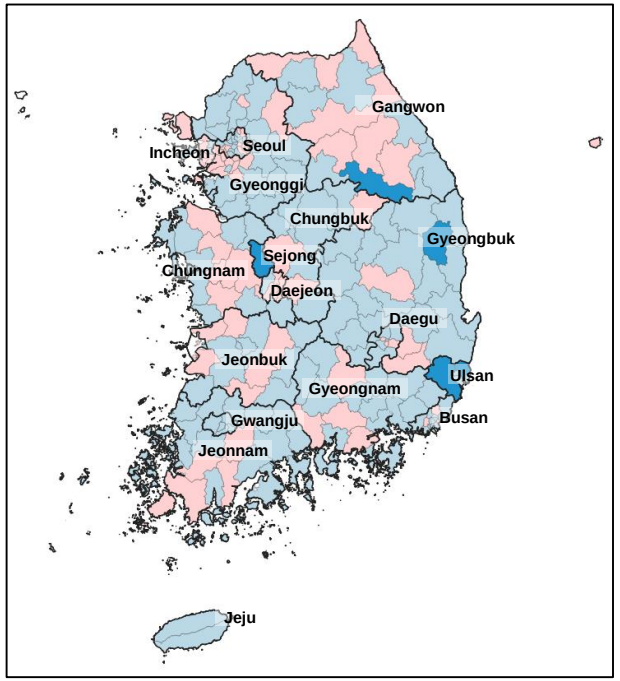
Change of CDRI –physical

- (2010⇒2020) 80.8% of communities improved.
- (2010⇒2015) 67.7% of communities showed improvement of CDRI of physical dimension.
- (2015⇒2020) 73.8% of communities improved, with most experiencing a decline.

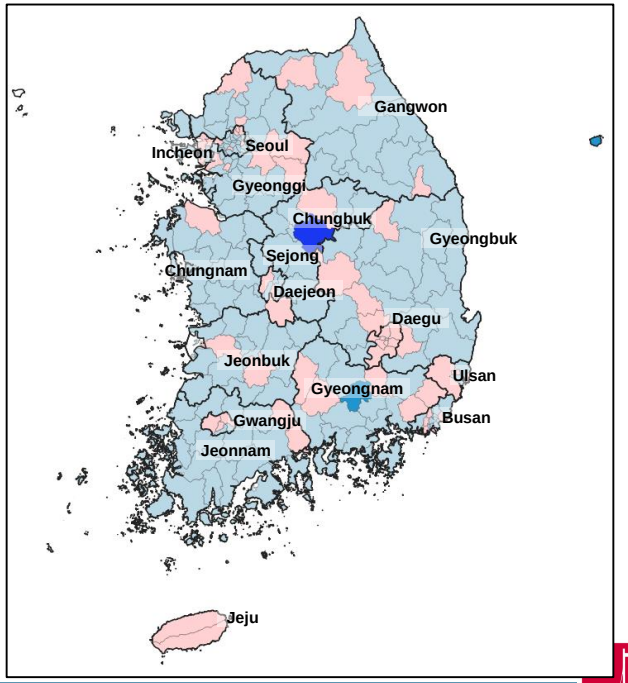
[Change of CDRI (physical) (2010-2020)]



[Change of CDRI (physical) (2010-2015)]



[Change of CDRI (physical) (2015-2020)]



Correlation analysis b/w community Characteristic and changes in CDRI

- Total CDRI and most dimensions showed greater improvement in rural communities than in urban communities.
- From 2010 to 2020, the social dimension of CDRI increased more significantly in rural communities.
- Economic dimension of CDRI showed more improvement in urban communities.

Variables	2010-2015	2015-2020	2010-2020
	Urban(1) / Rural(0)	Urban(1) / Rural(0)	Urban(1) / Rural(0)
Change in demographic dimension of CDRI	-.026	.048	-.008
Change in social dimension of CDRI	-.485***	-.139**	-.515***
Change in economic dimension of CDRI	.384***	-.235***	.280***
Change in institutional dimension of CDRI	-.068	-.275***	-.262***
Change in physical dimension of CDRI	-.043	-.308***	-.239***
Change in total CDRI	-.064	-.217***	-.185***

Relationship b/w CDRI & Damages

- Disaster resilient communities should suffer from lower levels of human losses due to natural disaster than less disaster resilient communities.
- The validity of the CDRI was assessed by conducting OLS Regression between total CDRI and human losses

Model	Model 1			Model 2			Model 3			Model 4		
Dependent variable	Human losses by year (2010-2020)			Average human losses (2011-2015)			Average human losses (2016-2020)			Human losses (2021)		
Independent variable	Total CDRI by year (2010-2020)			Total CDRI in 2010			Total CDRI in 2015			Total CDRI in 2020		
	B	Std. Err.	Sig.	B	Std. Err.	Sig.	B	Std. Err.	Sig.	B	Std. Err.	Sig.
Constant	.083	.014	.000	.071	.017	.000	.122	.028	.000	.023	.012	.050
Total CDRI	**-.222**	**.047**	**.000**	**-.193**	**.056**	**.001**	**-.324**	**.092**	**.000**	-.049	.039	.214
R Square	.009			.051			.052			.007		
F	22.399			12.129			12.493			1.551		
Sig.	.001			.001			.001			.214		
N	2,519			229			229			229		

Conclusion

- Between 2010 and 2020, total CDRI declined by 1.40% overall, indicating a decrease in community disaster resilience in South Korea.
- Over the past decade (2010–2020), demographic, economic, and institutional dimensions of CDRI declined across most municipalities, with especially sharp drops in institutional dimension of CDRI between 2015 and 2020.
  - Social dimension of CDRI increased (+10.79%) from 2010 to 2015, but decreased after 2015 (-4.59%).
  - Economic dimension of CDRI consistently declined except in parts of the Seoul metropolitan area, while most rural provinces (e.g., Jeonbuk, Chungnam) saw marked decreases.
  - Physical dimension of CDRI was the only dimension that steadily improved, with over 70% of municipalities showing improvement—particularly Goesan-gun and Sejong-si with notable increases.
  - Municipalities with a high total CDRI tend to experience relatively fewer human losses from natural disasters.

Thank you!

AESOP 2025
CONGRESS

Istanbul, 7-11 July

AESOP

YTÜ YILDIZ TEKNİK ÜNİVERSİTESİ