

76<sup>th</sup> UNECE workshop: The impact of climate change on the railways: how to protect, adapt and mitigate

# Climate Adaptation Actions of Korea

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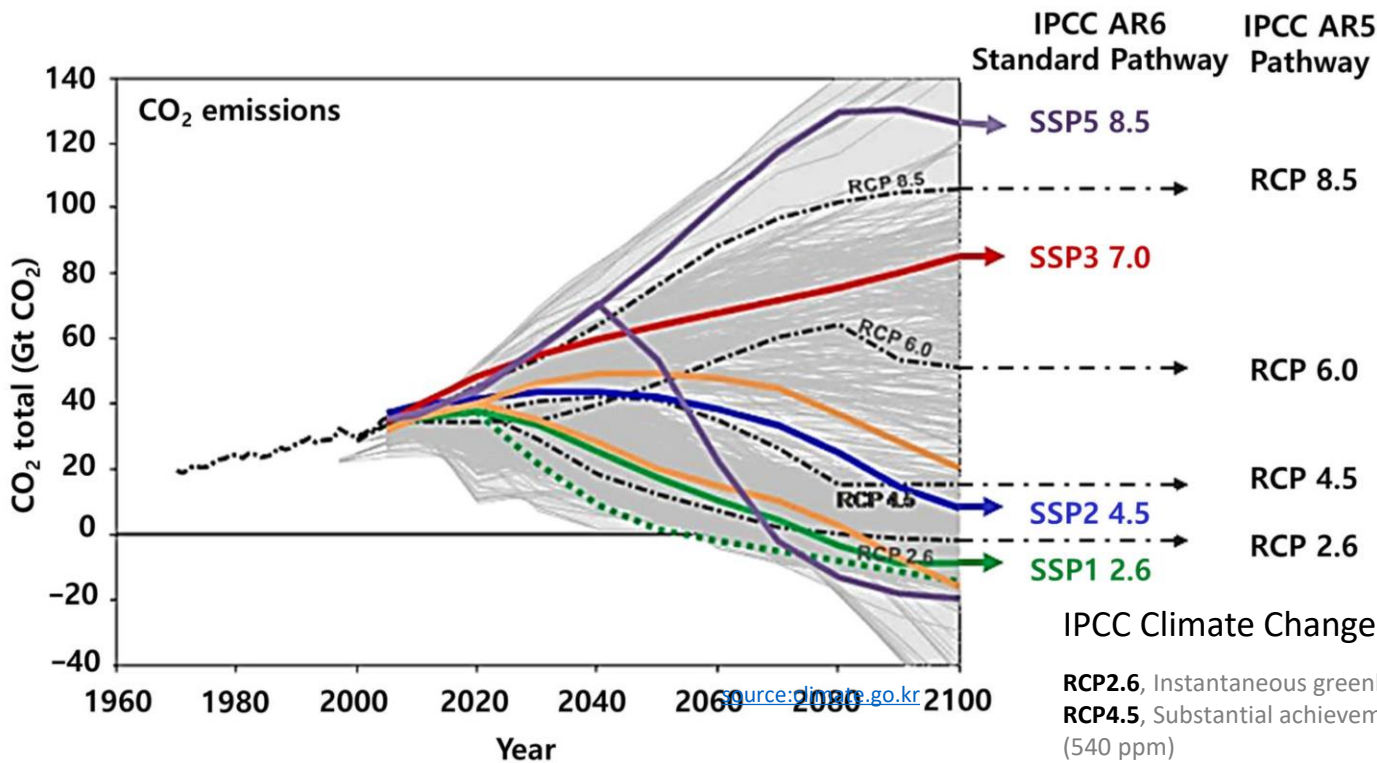
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# 01 Climate Change Expectation

## GLOBAL

- Fig. is well-known IPCC's SSP and RCP scenario. From Fig., different future awaits for us depends on whether there are efforts to turn down the line showing carbon emission is still increasing as things stand at present.
- The number at each pathway means the amount of solar energy additionally absorbed in 2100
- RCP 2.6 and RCP 8.5 will absorb additional energy by 2.6 W/m<sup>2</sup> and 8.5 W/m<sup>2</sup>, respectively.



Effort to curb emissions	Energy generation	New technology	Transport	Temperature 2081-2100 (range in 2020)	Sea level 2081-2100 (range in 2020)	Extreme weather 2081-2100	Adaptation required
Low	Coal-fired power		Cars, trucks	3.7 °C	0.63 m	Large increase	High level at high cost
Medium	Mix		Mix	2.2 °C	0.48 m	Moderate increase	Medium level at medium cost
Medium	Renewable		Mix	1.8 °C	0.47 m	Moderate increase	Medium level at medium cost
High	Renewable	Emissions capture	Bicycles, public transport	1.0 °C	0.4 m	Small increase	Low level at low cost

### IPCC Climate Change Scenario (IPCC 5<sup>th</sup>)

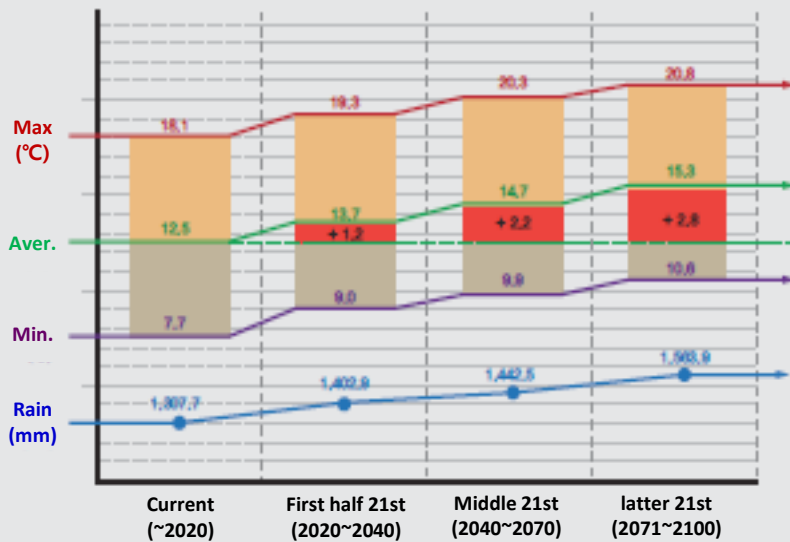
- RCP2.6**, Instantaneous greenhouse gas reduction (420 ppm)
- RCP4.5**, Substantial achievement of greenhouse gas reduction policy (540 ppm)
- RCP6.0**, Fair achievement of greenhouse gas reduction policy (670 ppm)
- RCP8.5**, Greenhouse gas emission as current trend ((940 ppm)

# 01 Climate Change Expectation

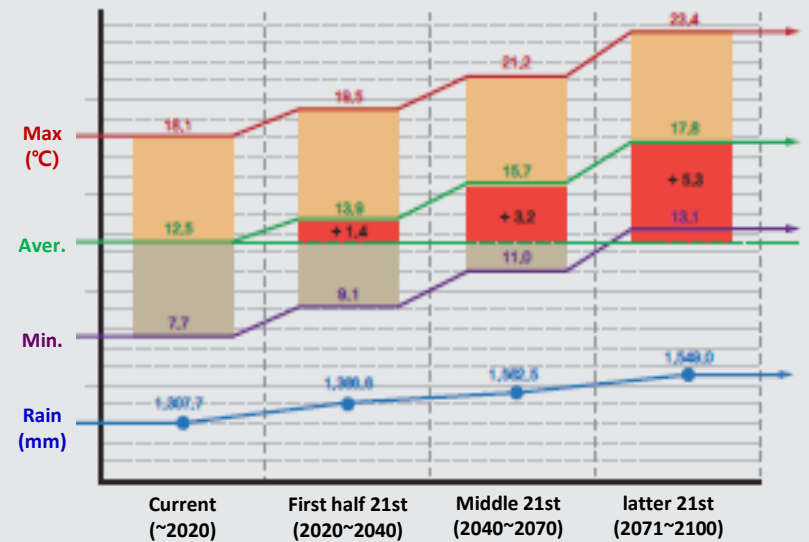
## SOUTH KOREA

- Climate change expectation results with RCP 4.5 and TCP 8.5
- South Korea same trend which has been on the rise.
- Average annual temperature: *has steadily increased*
- Average annual rainfall: *has dramatically increased by the mid-21<sup>st</sup> century and then remained*
- Average annual windspeed: *foresees similar with current weather*

RCP 4.5



RCP 8.5

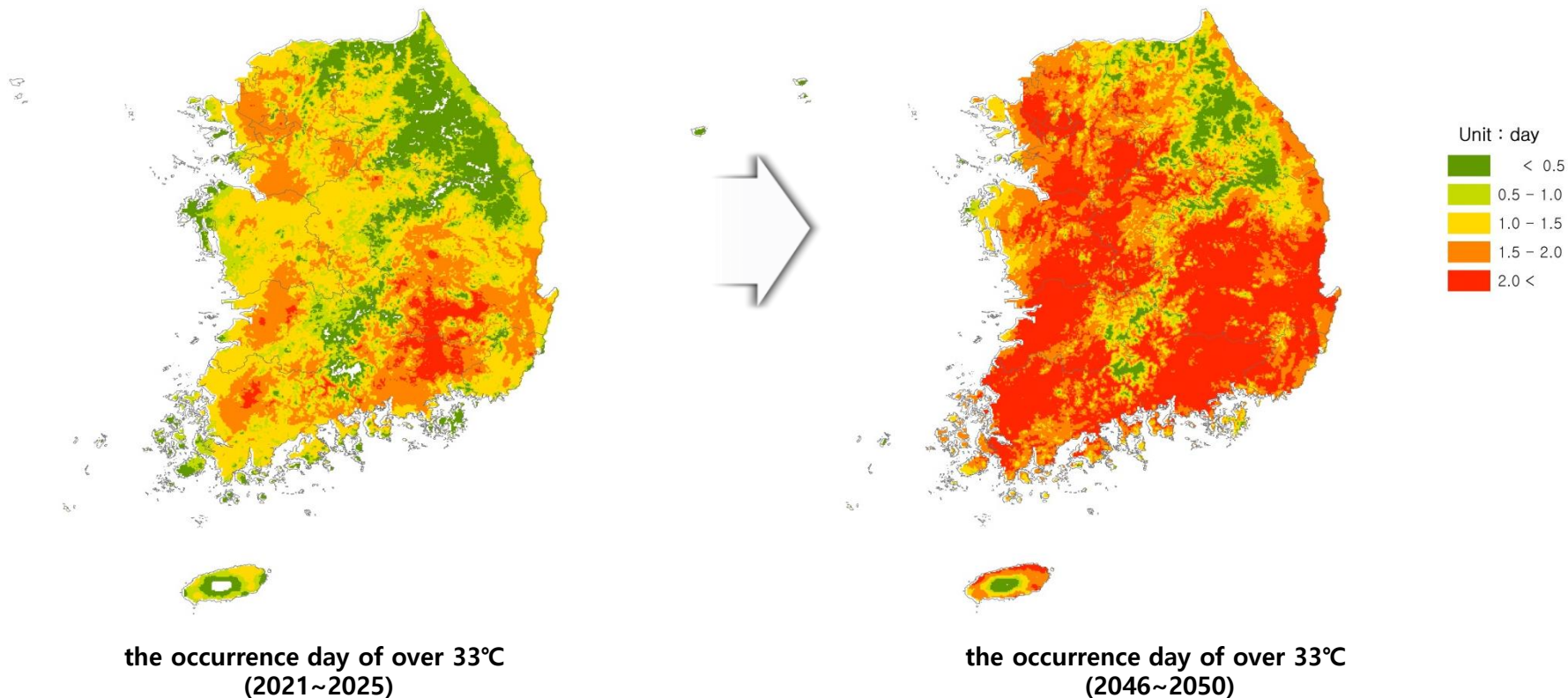




# 01 Climate Change Expectation

## TEMPERATURE SIMULATION (NUMBER OF DAYS OVER 33°C)

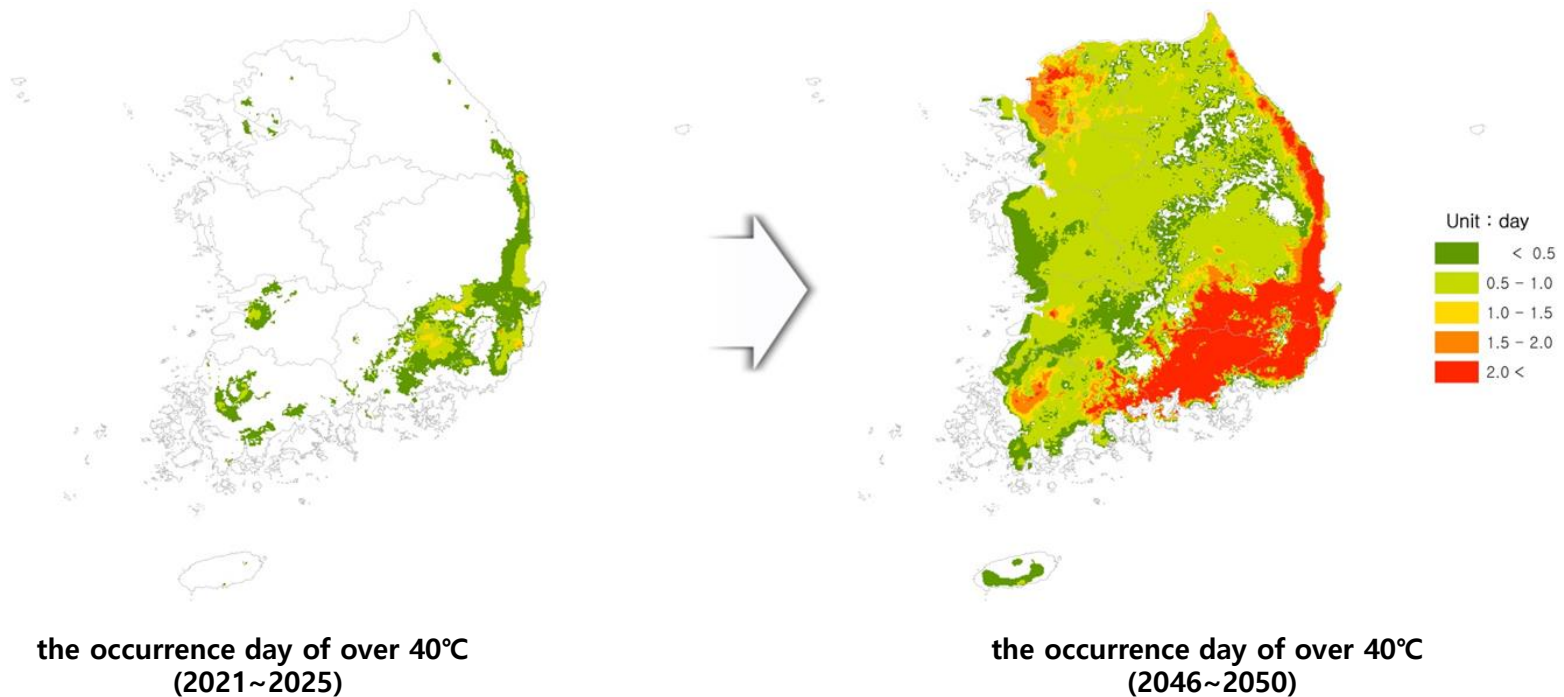
- From the simulation (occurrence days of over 33°C) like fig. using the RCP 8.5 scenario
  - Right fig. shows above 33°C will be sustained for more than 2 days at most region in Korea
  - At present, some places at south east region have had this temperature



# 01 Climate Change Expectation

## TEMPERATURE SIMULATION (NUMBER OF DAYS OVER 40°C)

- From the simulation (occurrence day of over 40°C) like fig. using the RCP 8.5 scenario
  - Temperature of some places at the south east region will be above 40°C for more than 2 day
  - Currently, it is rare to find this phenomenon



# 01 Climate Change Expectation

## HEAVY RAIN CONCENTRATED AT THE CENTRAL PART IN THIS SUMMER

Some underground metro station were waterlogged.

Average annual precipitation of Korea: 1,200 mm

- This summer (2022) precipitation: 380 mm/day, 140 mm/hr in Seoul

- Highest precipitation recorded in Summer from Typhoon: 870mm/day in 2002



# 02 Climate Change and Railway

## KOREA RAILWAY NETWORK (HIGH SPEED AND REGIONAL)

Total length of the railway : 4,274 km (as of 2019)

- 26 % increased in last 15 years
- 1.5 billion passengers used (2019)
- Passenger share : 15 %

Electrification: 72.9 % (3,116 km)

	(Km,%)		
-	'10	'15	'19
Total Length	3,557.3	3,951.8	4,274.2
Electrification (%)	2,147.0(60.4)	2,805.4(71.0)	3,116.2(72.9)

Coastal Railway lines are also vulnerable from abnormal weather



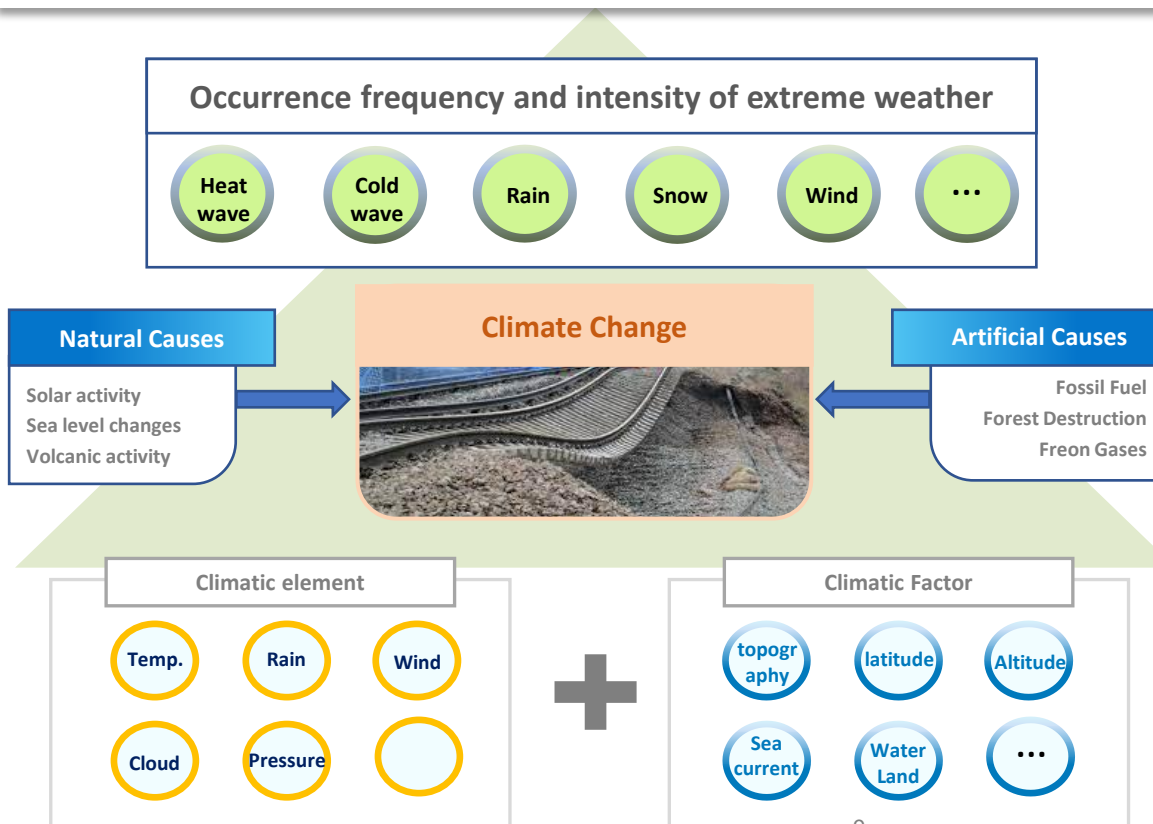


# 02 Climate Change and Railway

## CLIMATE CHANGE AND 2 IMPACTS TO RAILWAY

- ◉ Extreme weather happens with 2 causes: natural and artificial
- climate change results 2 impacts to railway: **direct and indirect**
- Needs prevention efforts by each climate elements: Temp. Rain...

### Disaster Probability Increase from extreme weather



### Direct impacts

1. Loss of life
2. Loss of asset
3. Service discontinuity
4. Recovery Cost
5. Compensation

### Indirect impacts

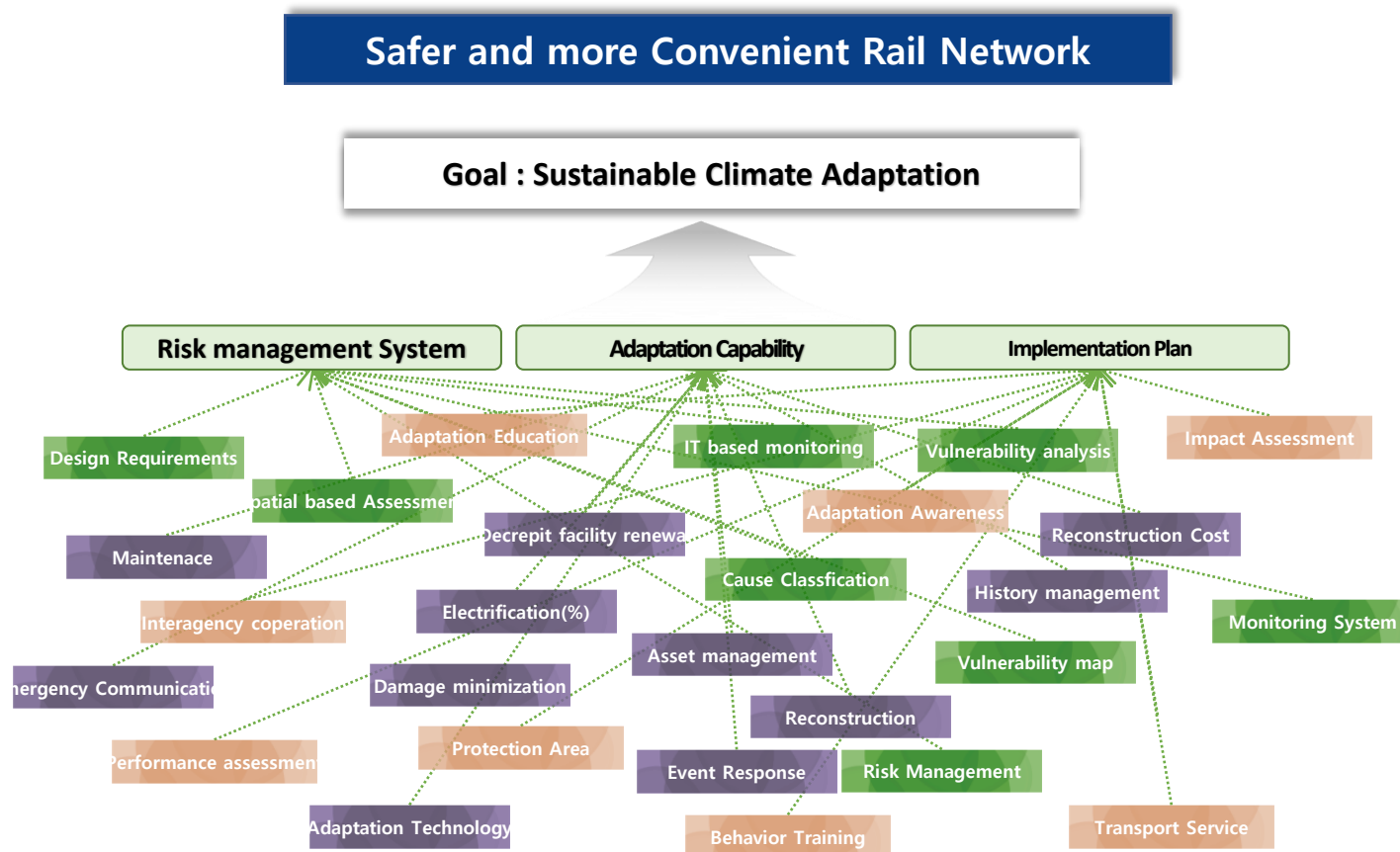
Negative effect to

1. Transport discontinuity
2. Life quality
3. Competitiveness

# 02 Climate Change and Railway

## FOR CONSTANT RAIL SERVICE UNDER ANY ABNORMAL CLIMATE

- Korea Railway and Infrastructure Manager has built up Adaptation Strategy:
  - Climate Risk Management, Adaptation Capability and Implement Plan
  - Each strategies have detailed adaptation actions



# 02 Climate Change and Railway

## ADAPTATION ACTIONS (3 STEPS)

- Korea railway actions with 3 steps: Current Status Analysis–Risk Assessment–Adaptation actions
  - With Vulnerability assessment by climate elements, Adaptation actions are implemented
  - Vulnerability assessment with impact assessment by climate elements of temp., rain etc.

### Analysis

#### Current Status

- KNR general situation
- Risk(disaster) management system
- Business sector characteristics
- ...

#### Data analysis

- Related Regulations
- Related Policies
- Case(Media, Literature) Studies
- Statistics and internal documents
- Research Studies
- ...

### Risk assessment

#### Climate Change Scenarios

- Korea Climate Change Report Analysis
- Regional unit Report Analysis
- Applied Scenario Analysis

#### Impact Assessment

- Impact Assessment by Climate element
- Vulnerable Facility Selection

### Adaptation actions

#### Risk Analysis

- Risk assessment analysis
- List Risk Priority
- by Climate Elements

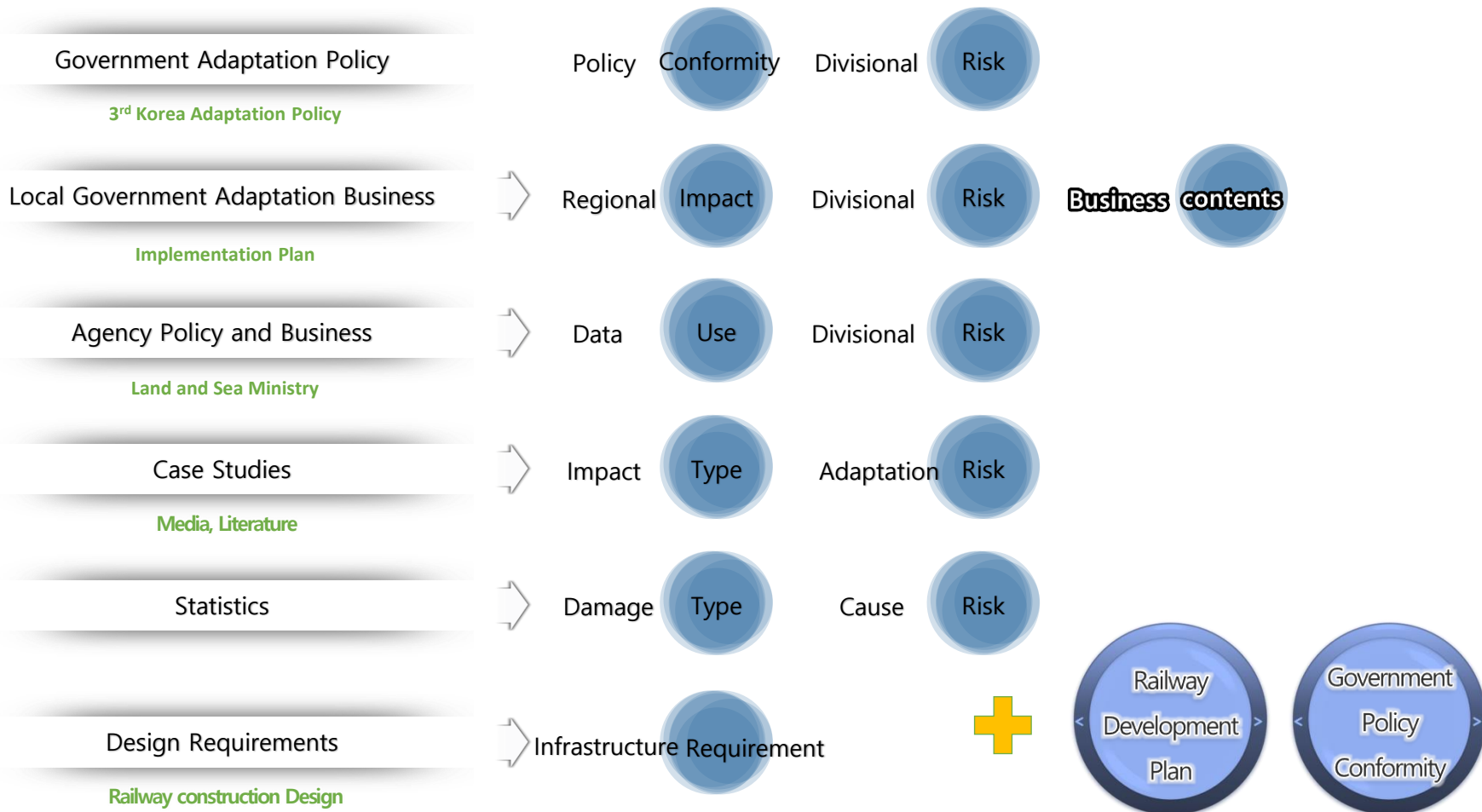
#### Actions

- Adaptation Goal Establishment
- Designate responsible department
- Cost Analysis
- Implementation and Management

# 03 Climate Change and Railway (Risk Assessment)

## RAILWAY IS NATIONAL WIDE INFRASTRUCTURE

- RISK ASSESSMENT TAKES INTO ACCOUNT OF CENTRAL, LOCAL GOVERNMENT AND MINISTRY
- TO COVER ALL RELATED RISKS EXPECTED FROM BY REGION WITH CLIMATE ADAPTATION



# 03 Climate Change and Railway (Risk Assessment)

## RISK ASSESSMENT 5 STEPS

CASE STUDY



1 ST

CLIMATE RISK IDENTIFICATION AND INVESTIGATION

- CLIMATE IMPACT ELEMENTS CLASSIFICATION



2 ND

CLIMATE RISK CURRENT RESPONSE ANALYSIS

- CURRENT RESPONSE LEVEL INVESTIGATION

with checklist for current response level



3 RD

IMPACT ASSESSMENT BY CLIMATE ELEMENTS

- IMPACT TARGET : FACILITY, EQUIPMENT, FIELD WORKER



4 TH

RISK ASSESSMENT

- USING PAST WEATHER INFORMATION



5 TH

RESPONSE PLAN ESTABLISHMENT

WITH RESPONSE PRIORITY



<Flooding>



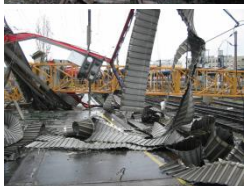
<Snowslide>



<Soilloss>



<RockSlide>



<Strong Wind>



# 03 Climate Change and Railway (Risk Assessment)

## RISK IDENTIFICATION BY CLIMATE ELEMENTS

◦ DIFFERENT POTENTIAL RISKS BY EACH CLIMATE ELEMENTS



- TEMP. CHANGE Durability
- UV IRRADIATION deterioration
- HEATWAVE Tract distortion
- DROUGHT Weak Ground
- FIRE Human, Asset loss
- COLDWAVE Isolation
- FREEZING facility trouble



- DROUGHT Support Reduction
- HEAVY RAIN crack
  - FOUNDATION WEAKENING Rollover
  - LAND SLIDE accessibility
  - FLOODING Service delay
- HEAVY SNOW Load
  - AVALANCHE accessibility



- LIGHTNING FREQUENC
- OUTBREAK OF FIRE Degradation
- Deconstruction



- WIND VELOCITY Wind Load
- ELONGATION Degradation
- VIBRATION Short Catenary



- SHORE EROSION Support Reduction
- TSUNAMI Electrical short
- SALINITY DAMAGE Degradation



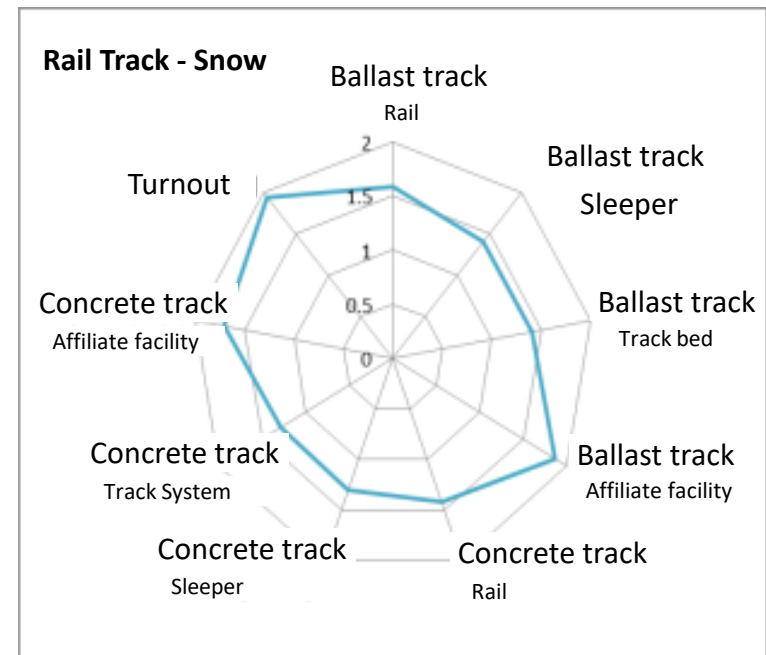
- SPECIES VARIETY accessibility
- PLANT GROWTH Degradation

# 03 Climate Change and Railway (Risk Assessment)

## IMPACT ASSESSMENT

- done by each climate elements for each categories of railway infrastructure
  - for example, in case heavy snow at track system, turnout system will be the most affected
  - done by survey with experts of each parts of infrastructure

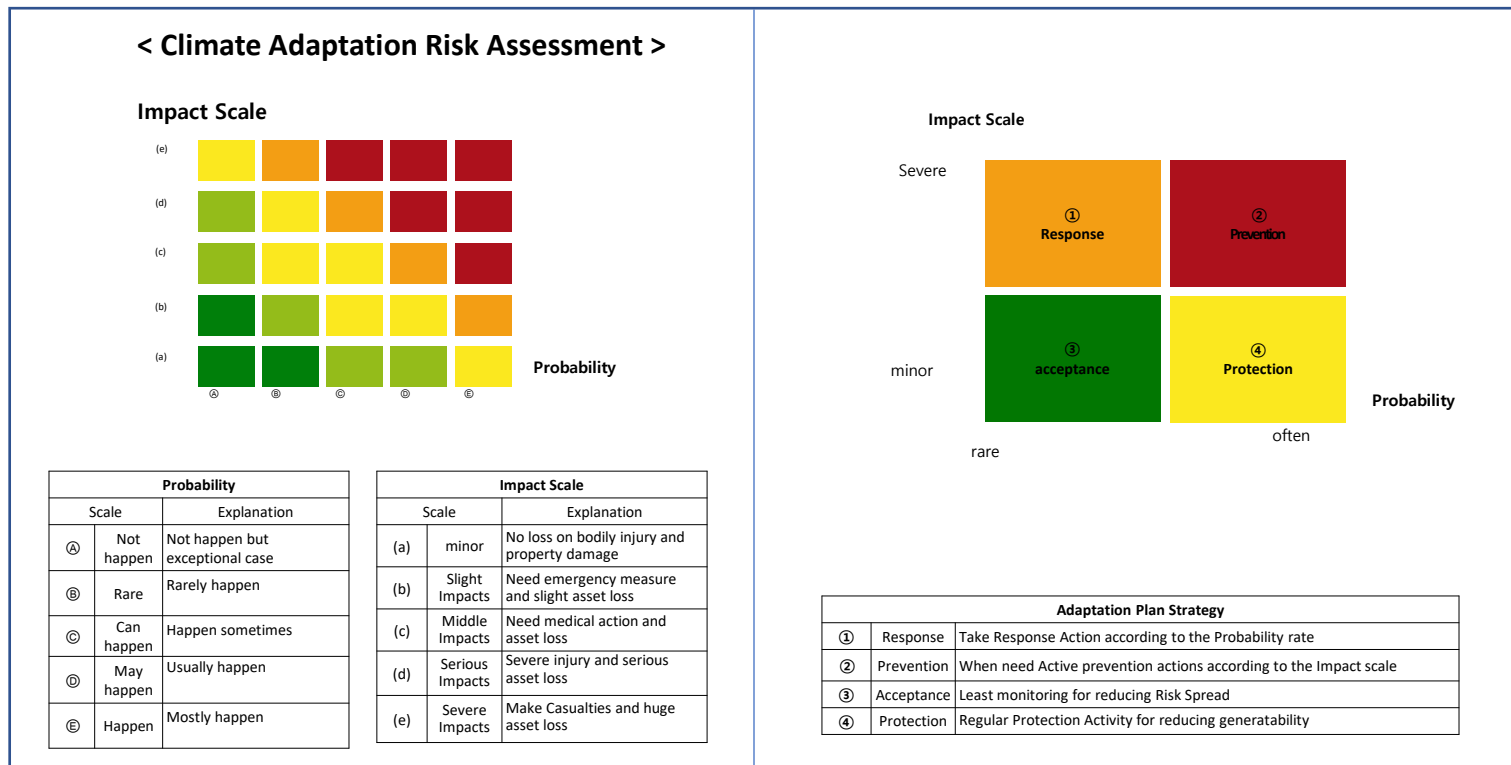
		Level		Total	Average		
1st	2nd	3rd	Risk Types				
Civil Engineering	Structure	Soil Structure	@humidity	106	1.54	2.18	1.58
			ⓑFoundation Weakening	177	2.57		
			ⓒLandslide	172	2.49		
			ⓓFlooding	147	2.13		
		Intersection Structure	@humidity	77	1.12	1.54	
			ⓑFoundation Weakening	115	1.67		
			ⓒLandslide	117	1.70		
			ⓓFlooding	115	1.67		
		Drainage Structure	@humidity	73	1.06	1.61	
			ⓑFoundation Weakening	108	1.57		
			ⓒLandslide	126	1.83		
			ⓓFlooding	136	1.97		
	Affiliate Facility	@humidity	83	1.20	1.69		
		ⓑFoundation Weakening	119	1.72			
		ⓒLandslide	132	1.91			
ⓓFlooding		132	1.91				



# 03 Climate Change and Railway (Risk Assessment)

## RESPONSE PRIORITY

- When making Response Priority,
  - 2 factors considered: Probability and Impact scale
  - These factors are acquired and quantified throughout survey from workers
  - And, by multiplying two factors, response priority is determined



# 04 Adaptation Action

## INFRASTRUCTURE MANAGER

- As adaptation action,
  - Need to match Classification Hierarchy of infrastructure components to manage
  - Develop history management system using GIS technology for maintenance
  - And operate smart safety system to monitor vulnerable fields



# 04 Adaptation Action

## INFRASTRUCTURE MANAGER

- Also take into consideration of [government railway network construction plan](#) with
  - Buildup the safety standard to prevent from abnormal lighting (occurrence frequency and intensity) as Electrification Increased
  - Analysis causes of damages at vulnerable area
  - Renewal of old facilities

### Electrification Rate (%)

78 % in 2030

Electrification Increase



Build up safety criteria of Eclectic facility

Prevention from lighting

### Analysis Vulnerable Area

Integrated Classification

as natural disaster

Technical, human factor analysis



Damage cause Analysis

### Renewal obsolete facilities

Safe Rail Service

Decrepit Facility / Vulnerable Facility



Long term investment



# 04 Adaptation Action

## INFRASTRUCTURE MANAGER

- Higher Design Requirements of infrastructure
  - For the safety measurements against any abnormal climate
  - Take the most severe climate elements in the last 40 years into Design consideration
  - with extending application of monitoring system for soundness maintenance

### Case Analysis

#### Impacts from Rain, Snow

Landslide, Soil Loss – Heavy Rain

Malfunction at Door, traction line etc– Heavy Snow



Damage Minimization

### Design Requirements

#### Severe Climate Elements

Highest and Lowest Value in the last 40 years



Tightening Design Requirements

### Abnormal Temperature

#### Rail Service Disruption

From rail temperature rise



Rail Temperature Sensor

# 04 Adaptation Action

## CURRENT RESPONSE ACTION

- ◉ With the results of risk assessment, response actions of Korea railway are like follows
  - Different response action are applied to each infrastructure facility by climate elements
  - For example, for the heat wave case,
    - 1) temperature sensing system buildup is key response action for track
    - 2) however, for signal system, maintenance improvement is more appropriate

Climate Element	Facility	Major Risk	Response	
Heat Wave	Civil Engineering	• Need to renew Response Plan due to over Design requirements	Prevention And Response	<ul style="list-style-type: none"> <li>• Revision Design Requirements</li> <li>• Temperature Monitoring system buildup</li> <li>• High Durable parts application</li> </ul>
	Track	• Need to renew Response Plan due to over Design requirements	Prevention	<ul style="list-style-type: none"> <li>• Monitoring system buildup</li> <li>• Maintenance system improvement</li> <li>• Control the operation as temperature variation</li> </ul>
	Architect	• Need to renew Response Plan due to over Design requirements	Prevention	<ul style="list-style-type: none"> <li>• Cooling and heating system improvement</li> <li>• Isolation buildup</li> </ul>
	Electricity	• Need to renew Response Plan due to over Design requirements	Prevention	<ul style="list-style-type: none"> <li>• Revision Design Requirements</li> <li>• Insulation at connection</li> <li>• Cooling and heating system improvement</li> </ul>
	Signal	• Need a plan for minimizing hazard	Prevention And Response	<ul style="list-style-type: none"> <li>• Maintenance system improvement</li> <li>• Anti-Disaster Drill buildup</li> </ul>
	Communication	• Need a plan for minimizing hazard	Prevention	<ul style="list-style-type: none"> <li>• Monitoring system buildup</li> <li>• High Durable parts application</li> <li>• Decrepit renewal</li> </ul>

# 05 Climate Adaptation Projects

Goal	Detailed Goal	Detailed Projects	
1. Climate Risk Management System	1-1. Efficient Asset Management	1-1-1. construction of event & damage cause classification	In Process
		1-1-2. Adaptation response database	New
	1-2. Integrated IT system	1-2-1. History management system	In Process
	1-3. Monitoring System	1-3-1. IT connected safety management	In Process
		1-3-2. Sensoring-based monitoring system	In Process
		1-3-3. Spatial information based impact assessment	New
	1-4. Assessment System	1-4-1. Adaptation project	New
		1-4-2. Implementation monitoring system	New
2. Buildup Climate Adaptation Capability	2-1. Buildup Design Requirement	2-1-1. Review of design requirements of each facility	In Process
		2-1-2. Review of construction requirements	In Process
	2-2. Buildup Response Capability	2-2-1. Emergency management monitoring system	In Process
		2-2-2. Event Response Scenario and manual	In Process
		2-2-3. Event Response Drill	In Process
	2-3. Prevention System	2-3-1. Decrepit facility Renewal	In Process
		2-3-2. Vulnerable Area designation and management	In Process
	2-4. Experts Training	2-4-1. Adaptation technology development	In Process
3. Implementatio n Platform	3-1. Reeducation	3-1-1. Adaptation Experts and management department	New
		3-1-2. Adaptation Department	New
	3-2. Awareness	3-2-1. Participation of regional the people and the government consultative group	In Process
	3-3. Impact Assessment	3-3-1. Adaptation impact assessment	New
	3-4. Connected Response	3-4-1. Emergency communication system	In Process

# Appreciate for your attention

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