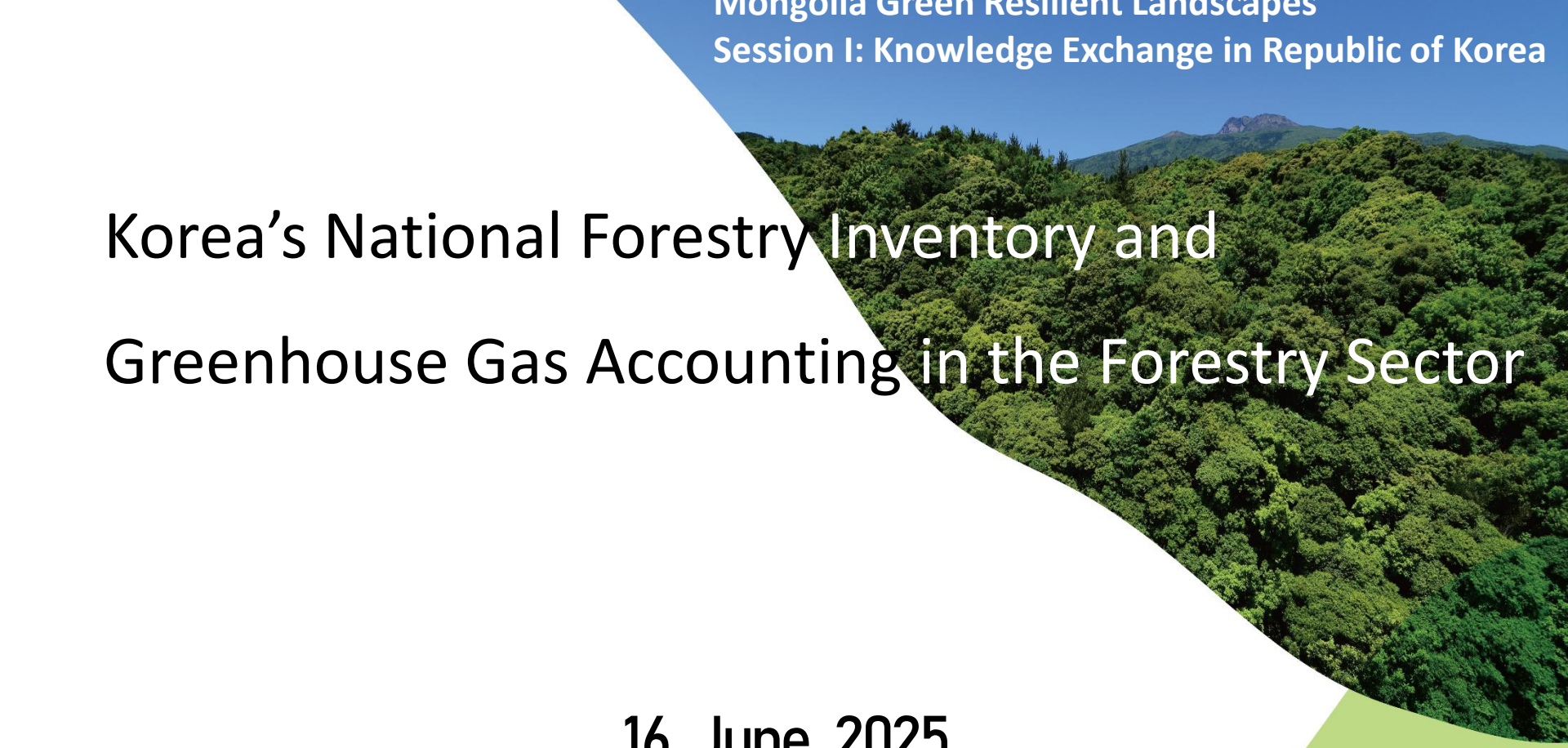

Korea's National Forestry Inventory and Greenhouse Gas Accounting in the Forestry Sector

16. June. 2025

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Republic of Korea

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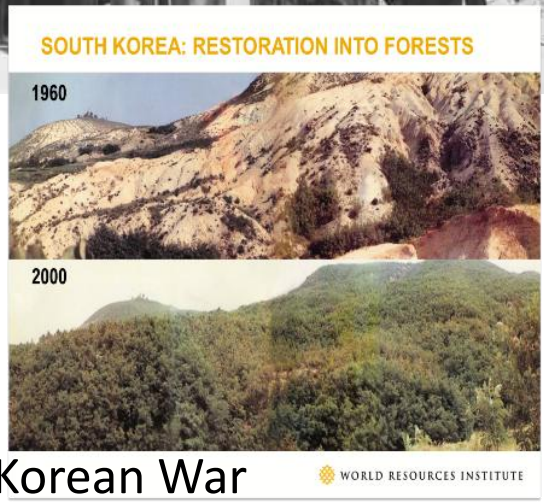
  - 2030 NDC and 2050 carbon neutrality for forestry

Overview of the Korean National Forest Inventory



- A couple of UNDP/FAO projects in 1960s

Forest Resource Inventory Institute in 1969

- Forest Survey Division & Forest Soil Survey Division
- Main Objective: Restoration for degraded forest by the Korean War

Overview of the Korean National Forest Inventory

UNSF/FAO [1960-1964]

Aerial photo + field survey
`60 -` 63 : National forest
`62 - `64 : Private forest

1st NFI [1971-1974]

- Simultaneous inventory
- Random systematic sampling
- Large circle plot (0.1ha)

2nd NFI [1978-1980]

- Simultaneous inventory
- Random systematic sampling
- Large Circle plot (0.1ha)

3rd NFI [1986-1992]

- Rotation inventory (Province/year)
- Stratified systematic sampling
- Cluster plot(0.5ha)

4th NFI [1996-2005]

- Rotation inventory
- 10 years interval

Timber production

8th NFI [2021-2025]

- Annual monitoring inventory
- Permanent plot
- Electronic field form
- Pilot inventory using LiDAR

7th NFI [2016-2020]

- Annual monitoring inventory
- Permanent plot
- FHM inventory items

6th NFI [2011-2015]

NFI + FHM (25%)

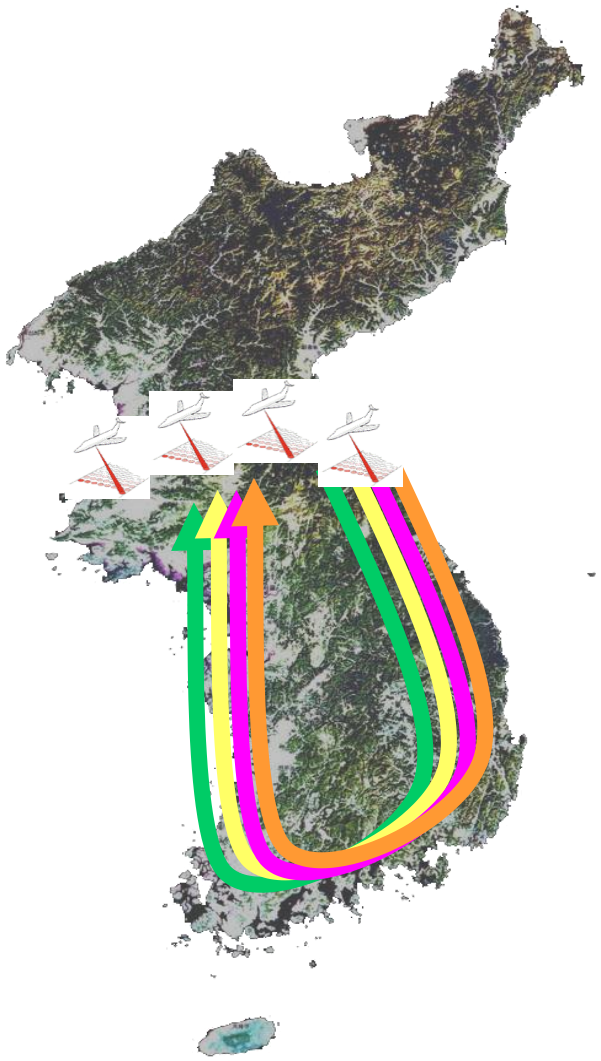
- Annual monitoring inventory
- Permanent plot
- FHM inventory items

5th NFI [2006-2010]

- annual inventory (20%/year)
- Systematic cluster sampling (n= 4,270 clusters in forests)
- Concentric circle plots
- Carbon pools
- Outsourcing (field survey)

Timber production, carbon pool, biodiversity, FHM, etc.

Overview of the Korean National Forest Inventory



The 1st NFI
1972 - 1975 [4 years]

The 2nd NFI
1978 - 1980 [3 years]

The 3rd NFI
1986 - 1992 [7 years]

The 4th NFI
1996 - 2005 [10years]

The 5th NFI
2006 - 2010 [5years]

The 8th NFI
2021 - 2025 [5years]

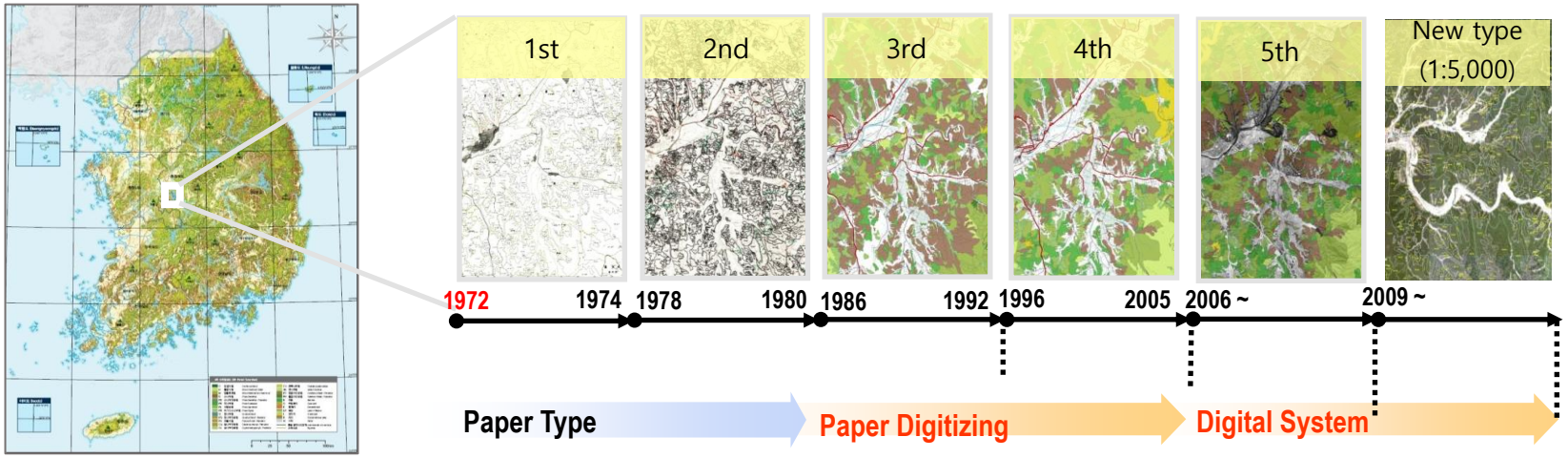
Overview of the Korean National Forest Inventory

- *History of Korean NFI (forest cover map)*
  - 1st : Drawing only forest types on BW color paper
  - 2st : topographic map base for readability increase
  - 3rd : standard production method absence
  - 4th : standard production method establish & conjugation
  - 5th : digital mapping system based on aerial-photo data
  - 1:5,000 map : upscale resolution & data index increase

1:25,000 (Analog)

1:25,000 (Digital)

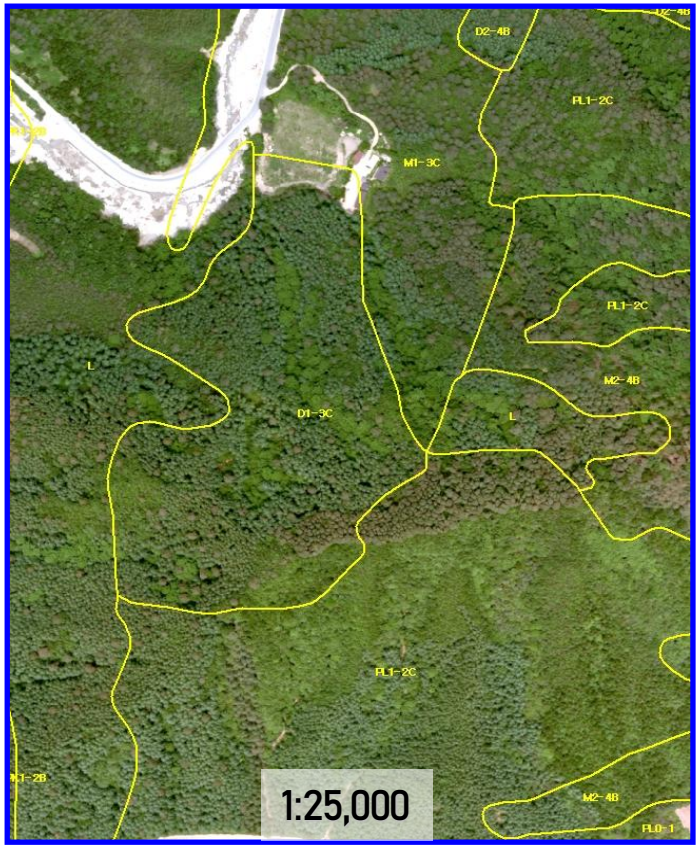
1:5,000 (Digital)

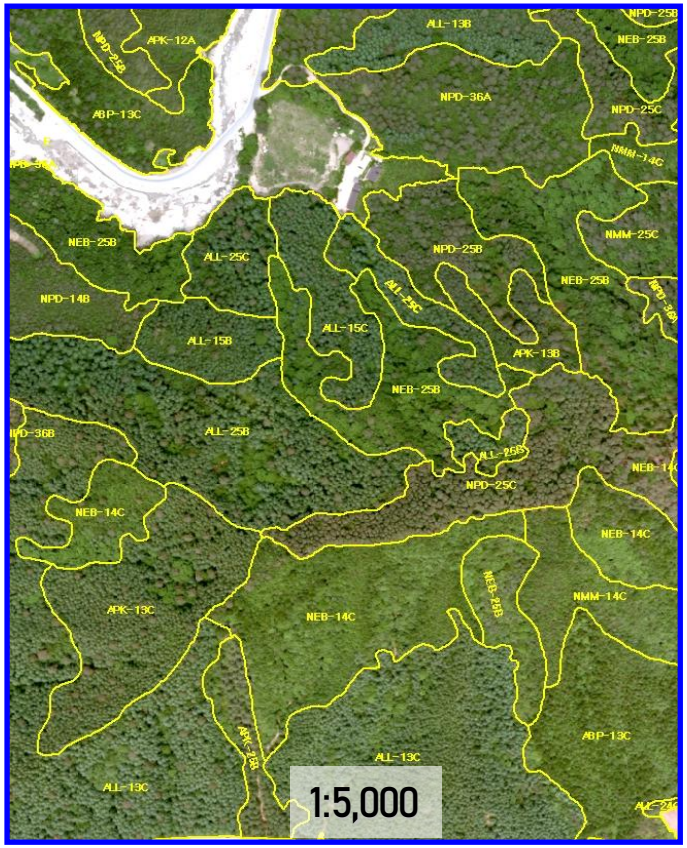


Overview of the Korean National Forest Inventory

- *History of Korean NFI (forest cover map)*

  Attributes: Forest/Non-Forest, Forest cover type, Dominant tree species, Age class, DBH class, Crown density





Reorganization of the 5th NFI(`06~`10)

- *Backgrounds and Objective*
  - Supporting for Sustainable forest management and GHG inventory & biodiversity etc.
- *Core changes of NFI5*
  - Five-year inventory cycle with annual panel system
  - Sampling design : Pre-Stratified sampling (with Forest cover map)→ Systematic sampling
  - New systematic layout of ca. 4,000 permanent cluster plots(4 x 4km)
  - Field plot design - a cluster plot consisted of 4 subplots.
  - Re-measurements of ground plots every 5 years
  - New measurement variables including biodiversity, forest health, carbon stock, etc.
  - Interagency collaboration : Korea Forest Service(KFS),

    Forestry Promotion Institute(KoFPI), National Forest Cooperatives Federation(NFCF)

Reorganization of the 5th NFI(`06~`10)

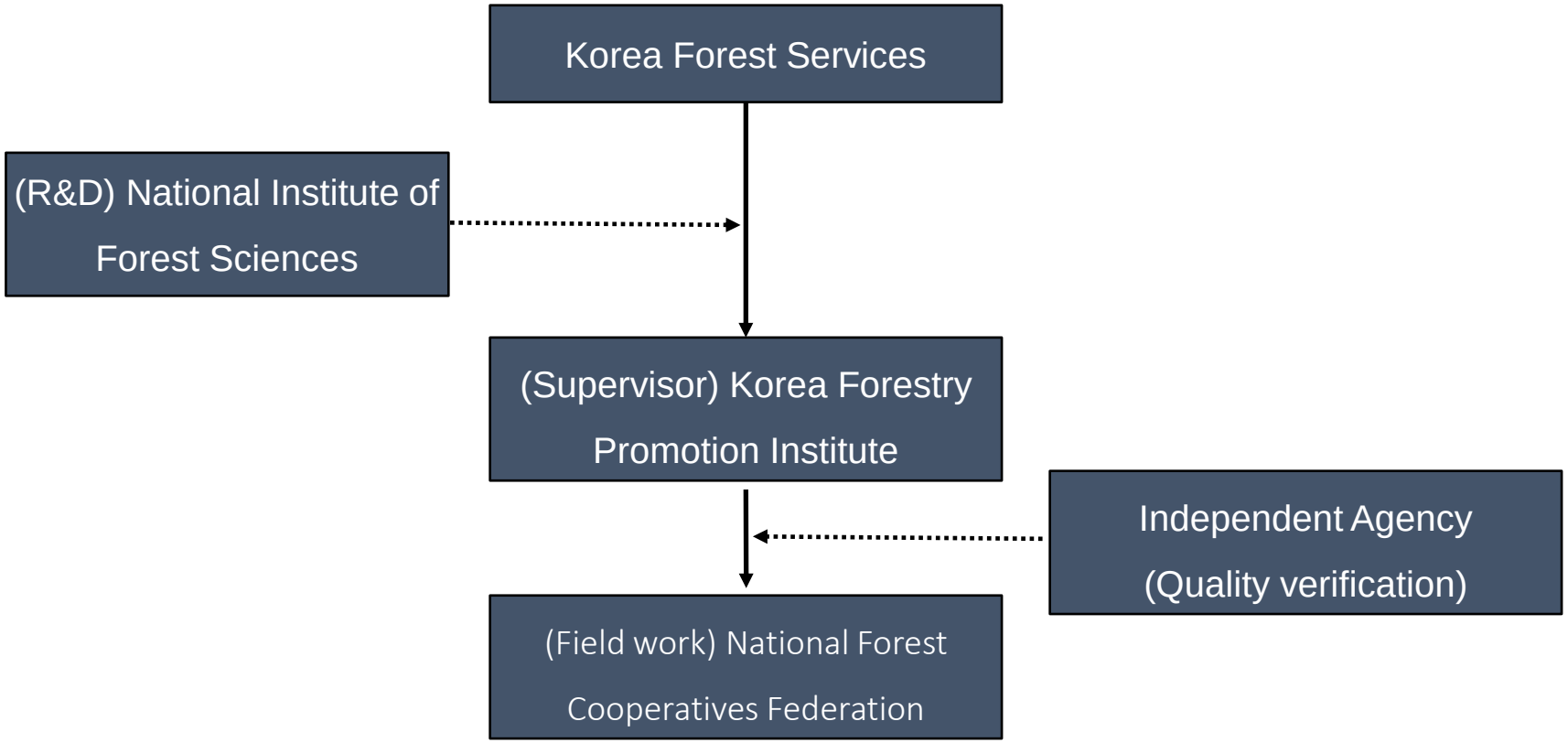
- *Established related Law*

NFI	FHM (Forest Health Monitoring)
CREATION AND MANAGEMENT OF FOREST RESOURCES ACT	FOREST PROTECTION ACT
(Article 32 : Survey of forest resources) (1) The Administrator of the KFS and a Mayor/Do Governor shall survey forest resources on a regular basis, as prescribed by Ordinance of the MFAFF and the Mayor/Do Governor shall report the results thereof to the Administrator of the KFS. <Amended by Act No. 8852, Feb. 29, 2008>	(Article 19 : levels of health and vitality of forest) (1) The Minister of the KFS may examine and assess levels of the health and diversity maintained in each forest ecosystem (hereinafter referred to as "levels of health and vitality of forest") in order to enhance functions of forest. <Amended by Act No. 10000, Feb. 4, 2010>

Reorganization of the 5th NFI(`06~`10)

	NFI1~4	NFI5 ~
Agency	KFS, NiFoS (Forest cover map, Field survey, Data management & Analysis, Reporting)	KFS : General agency NiFos : RND, International Reporting KoFPI : Project Management, Analysis, Reporting NFCF : Field survey, data input
Sampling Method	Pre-Stratified sampling with forest cover map	Systematic sampling
Person	50 → 30 → 10	KFS (1), NiFoS(2), Kofpi(3), NFCF(30)
Fund		$ 2 M per year

Reorganization of the 5th NFI(`06~`10)



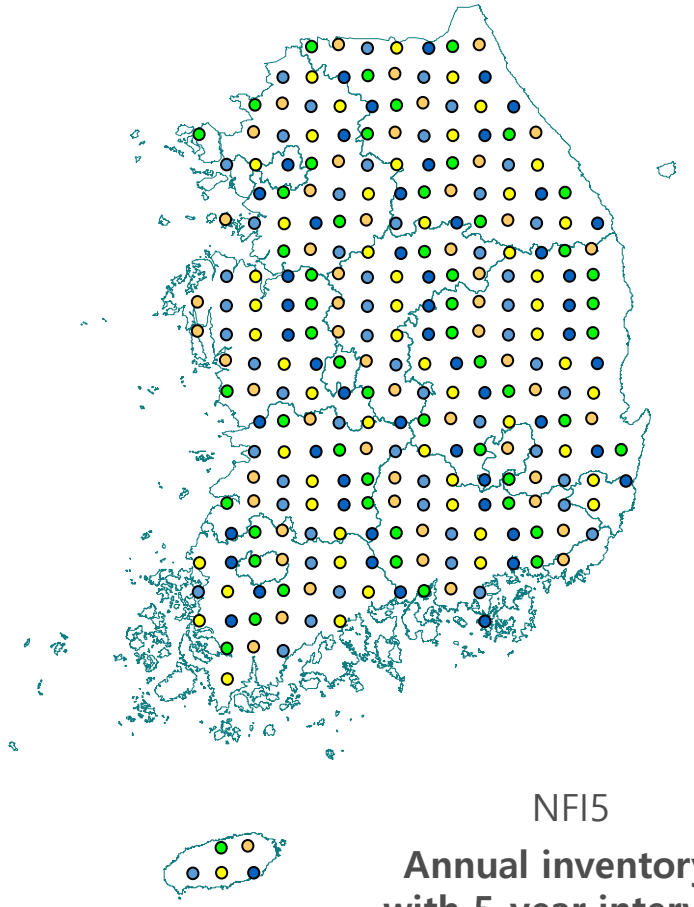
< Cooperation System for the new NFI >

Reorganization of the 5th NFI(`06~`10)

- Sample points across total land: 6,264 (4km X 4km)
- Samples in forests: 4,065 clusters
- Sampling intensity : 1plot/1,600ha (0.01%)

$$n \geq \frac{t^2 c^2 A}{e^2 A + t^2 a c^2} \approx \left(\frac{tc}{e}\right)^2$$

Variable	Value
CV	130%
t (95% 신뢰수준)	2
e(허용오차)	±5%
n	2,704

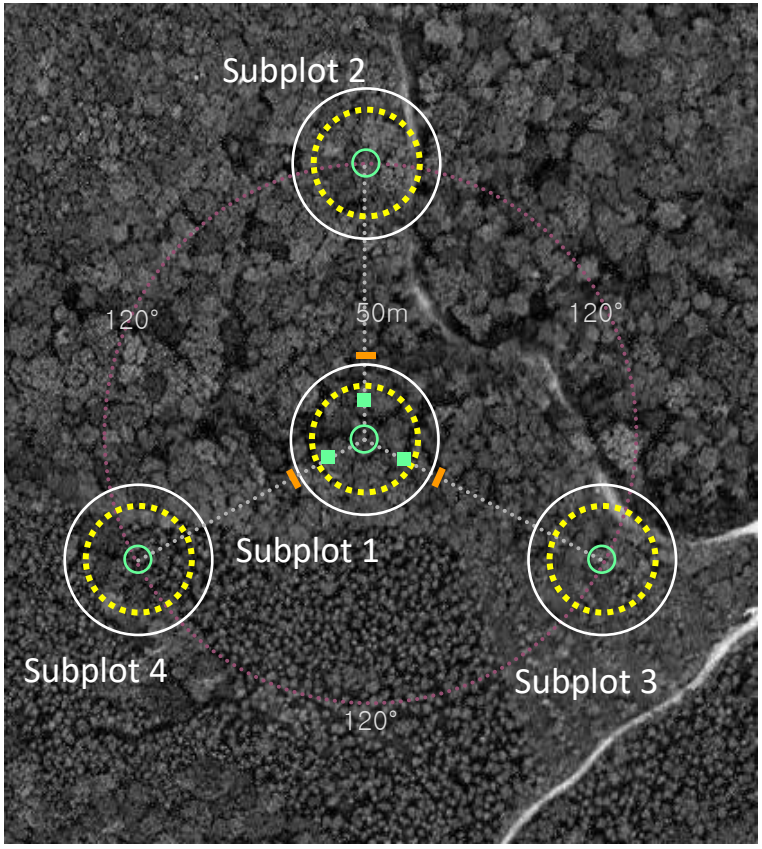


NFI5

Annual inventory with 5-year interval

Reorganization of the 5th NFI(`06~`10)

- *Sampling and Plot design*



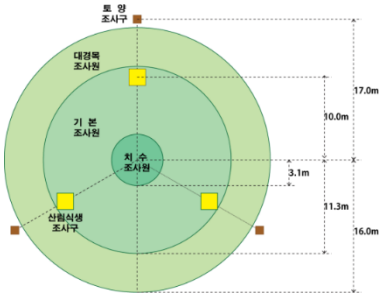
Permanent Sample Plot

- A cluster plot consists of 4 subplots.
- Subplot design is a tri-areal plot.
  . Large tree plot(16m, 0.08ha)
  . Core tree plot(11.3m, 0.04ha)
  . Seeding tree plot(3m, 0.003ha)
- Subsampling 25% of ground plots
  . Vegetation plot(2m x 2m)
  . Soil plot(0.3m x 0.3m)

☞ only in subplot 1(center subplot)

Reorganization of the 5th NFI(`06~`10)

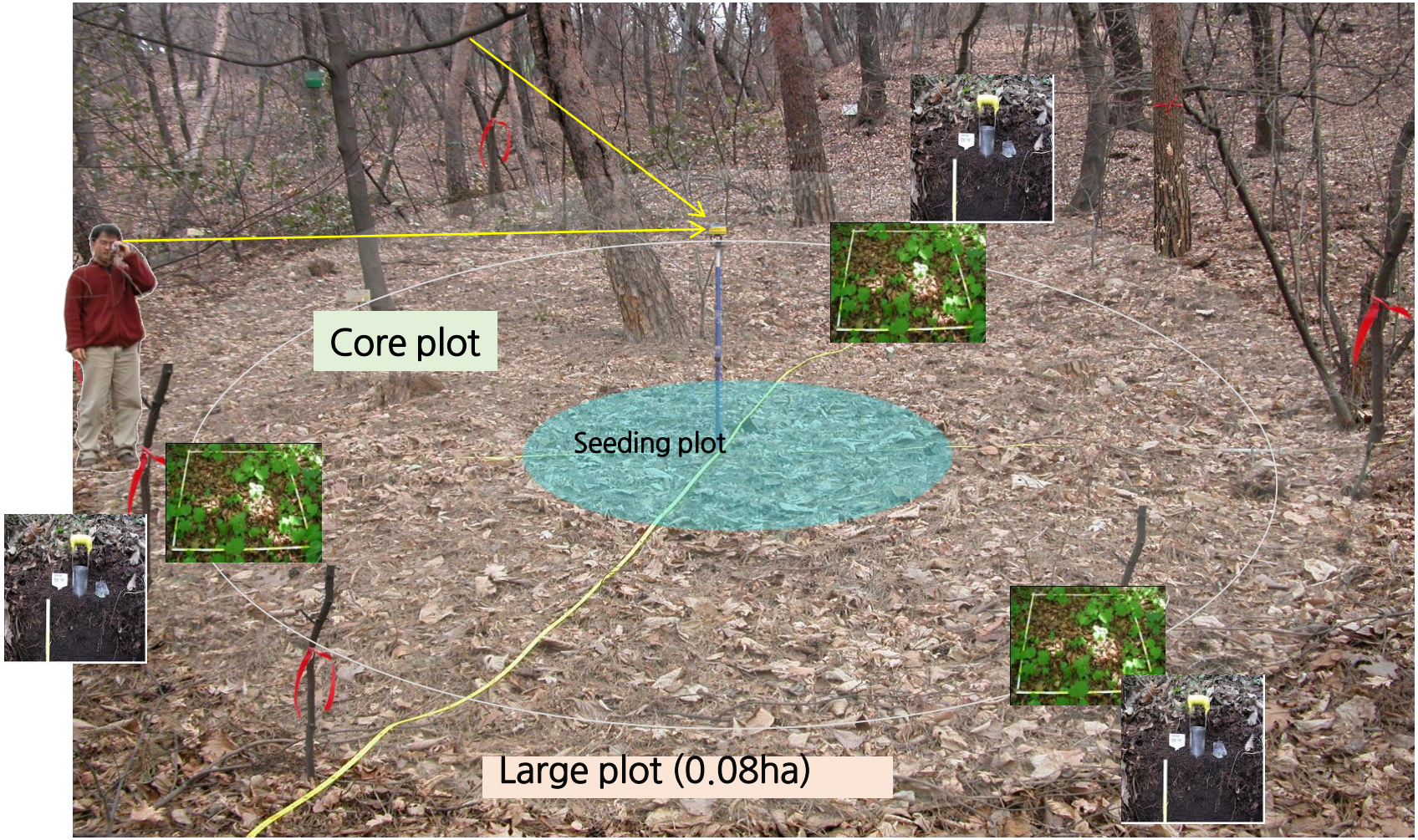
- *Sampling and Plot design*



Classification	Plot size (ha)	Inventory Items
Large plot	0.08	Scope: Large tree(>DBH 30cm)
Core plot	0.04	Scope : All trees(≥ DBH 6cm), deadwood, stump
Small plot	0.003	Scope : seeding and young trees (< DBH 6cm)
Vegetation plot	0.0004	Species, root radius
Litter	30cm X 30cm	Organic sample collection
Soil plot		Soil sample collection by 10cm, soil depth, etc.

Reorganization of the 5th NFI(`06~`10)

- *Overview in a center subplot*



Reorganization of the 5th NFI(`06~`10)

- *Core difference in inventory cycle*

Support to carbon inventory		1~4th NFI	5th NFI ~
Carbon Pool	Living Biomass	O	O
	Deadwood	X	O
	Litter	X	O
	Soil	X	O
Uncertainty		X	O
Sample plot		Temporary plot	Permanent plot





Estimator for forest growing stocks

- Annual statistics : Estimator from Post-stratified sampling
- Combining of annual statistics : weighted moving average method (USDA, 2005)
- Forest basic statistics : published every five years (including every local level)

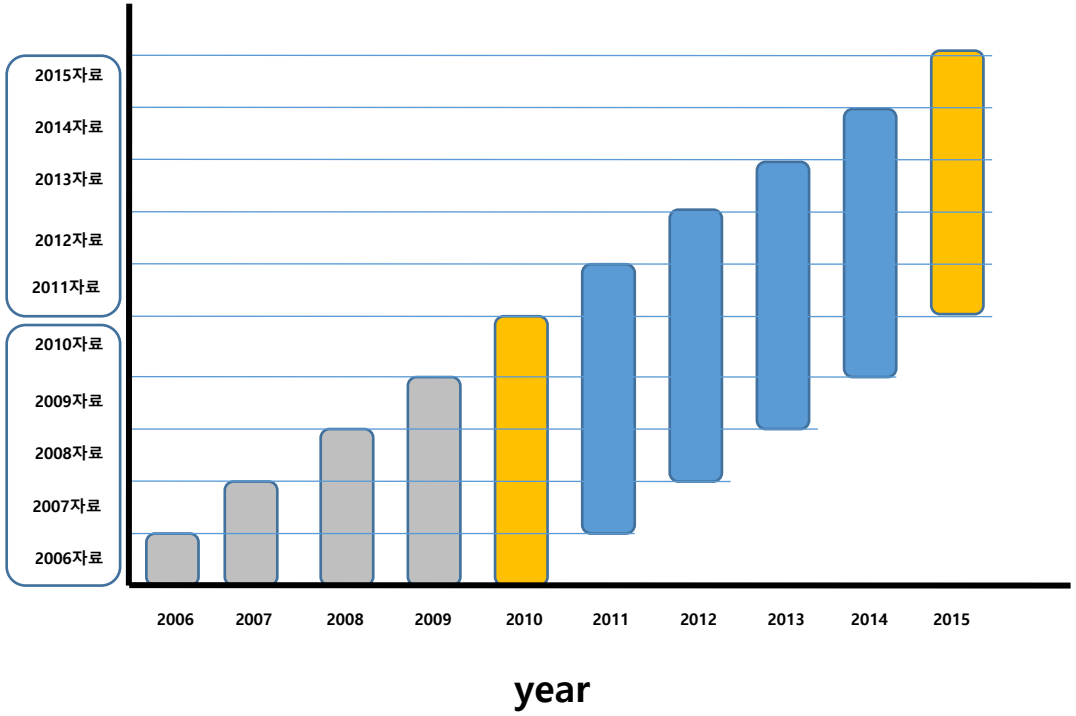
→ An annual inventory system can produce forest growing stock estimates every year

$$\bar{y}_{wma} = \sum_{l=1}^{5} w_l \times \bar{y}_l$$

w_l : weight for surveyed year (l) $(w_l = \frac{n_l'}{n'})$

n_l' : number of subplots at a surveyed year (l)

n : total number of subplots $(n = \sum_{l=1}^{5} n_l')$



Comparison of National Forest Inventories

Classification	Korea	Mongolia
New system	Since 2006 (NFI5)	Since 2014 (NFI1)
Current period	NFI8(`2020-2025)	NFI1(2014-2017)
Objectives	SFM, UNFCCC, CBD, *etc*.	SFM, REDD+
Forest area	Administrative statistics + Forest cover map	Point sampling + arial photo
Sampling design	Systematic sampling	Systematic / Random sampling
Plot design	Cluster plot with 4 subplot	Cluster plot with 3 subplot
	nested circle plot	nested circle plot
Interval	5-years (Permanent plot)	Not yet (Permanent + temporary plot)

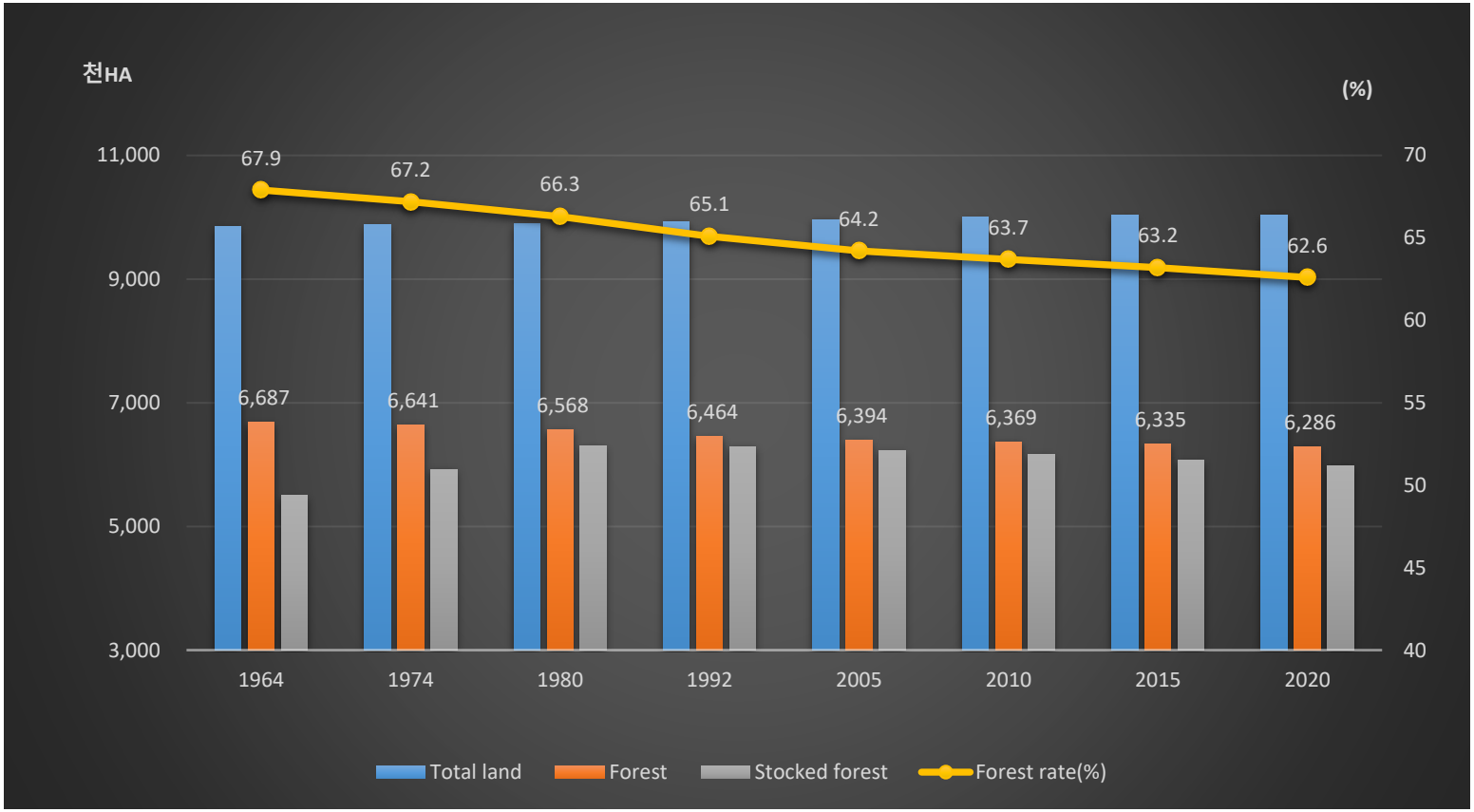
Source : (ROK) The National forest inventories (Springer, 2009)

(Mongolia) Dan Altrell (2019) Multipurpose National Forest Inventory in Mongolia, 2014-2017. GES 12(3): 167-183.

2020 Forest Resources in Korea

◈ Forest area

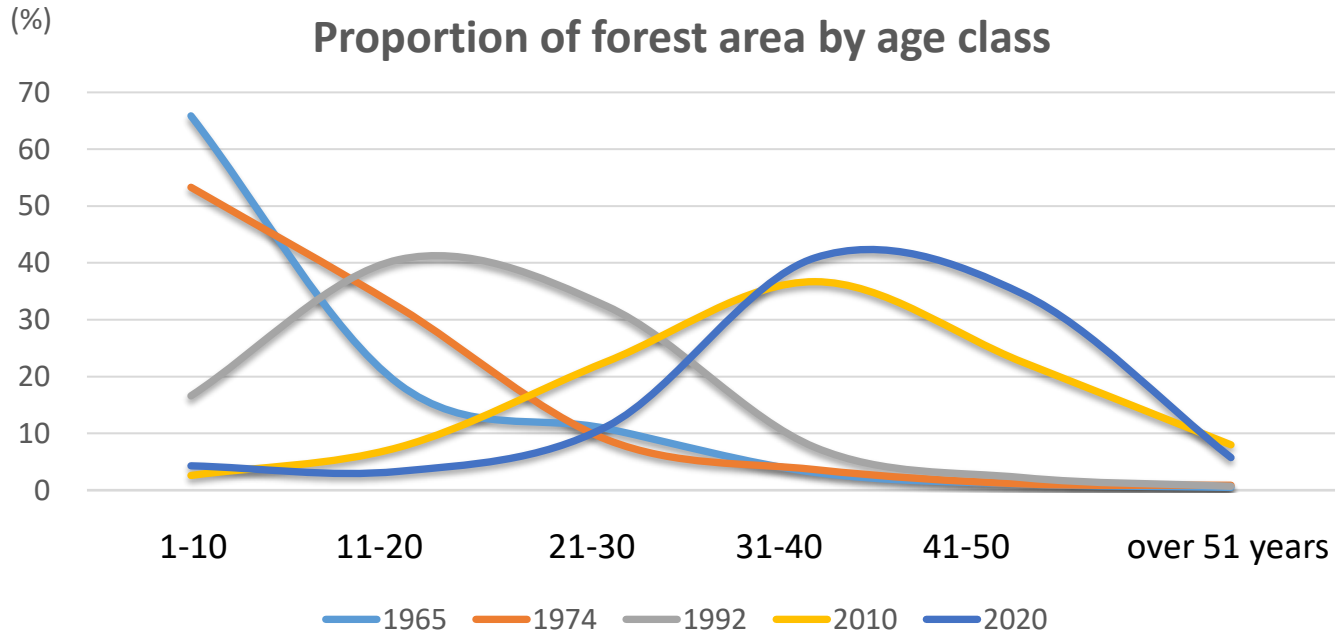
➢ Forest area: (`74) 6,641→ (`92) 6,464 → (`10) 6,369 → (`20) 6,298 kha



2020 Forest Resources in Korea

➢ Forest area by age class

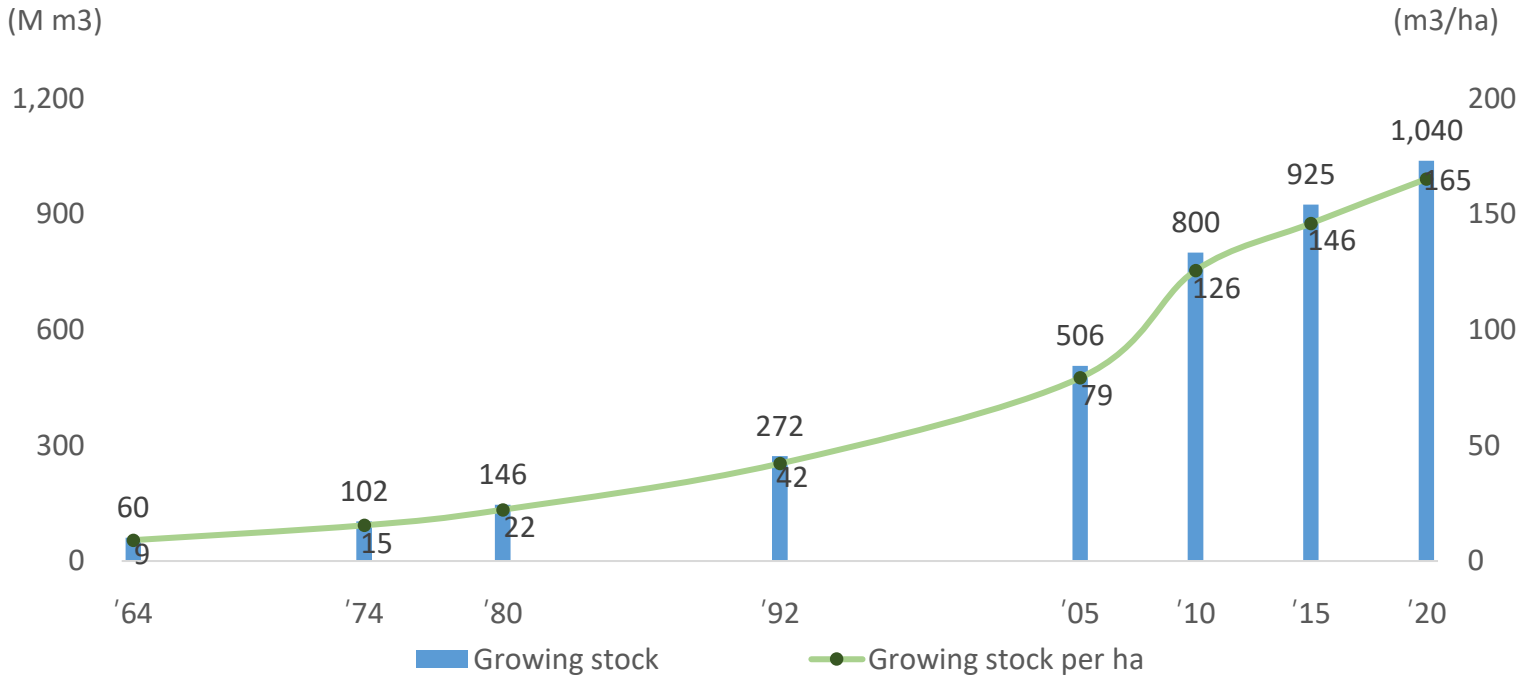
- Over 31 years: (`65) 5% → (`74) 7% → (`92) 67% → (`10) 67% → (`20) 81%
- Under 20 years: (`65) 85% → (`74) 85% → (`92) 57% → (`10) 10% → (`20) 8%
- Young trees were distributed widely due to large-scale restoration of forests that were degraded in the 1970s-1980s and over time, most of them are over 31 years old



2020 Forest Resources in Korea

➢ Forest growing stock volumes

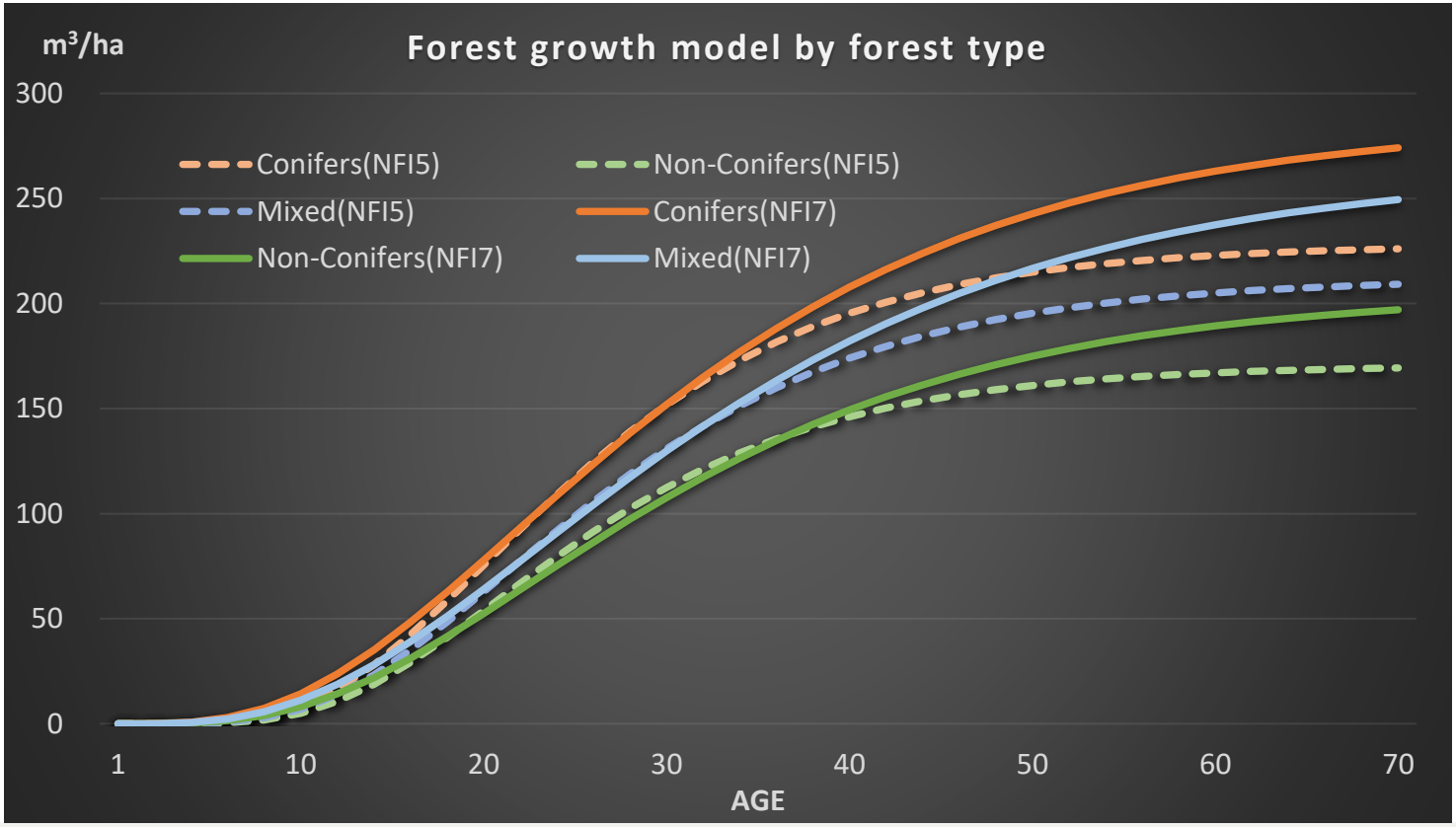
- Total GSVs : 1,040 M m^3 (165 m^3/ha)
- Trend of mean GSVs : (`64) 9 → (`80) 22 → (`92) 42 → (`10) 126 → (`20) 165 m^3/ha
- Stocked forest : 174 ± 1.4 m^3/ha (Relative Sampling Error : 0.4%)
- The total GSVs in 2010 gradually increase due to reorganization of NFI5 (→Recalculation)



2020 Forest Resources in Korea

➢ Changes in Forest growth by inventory cycle ?

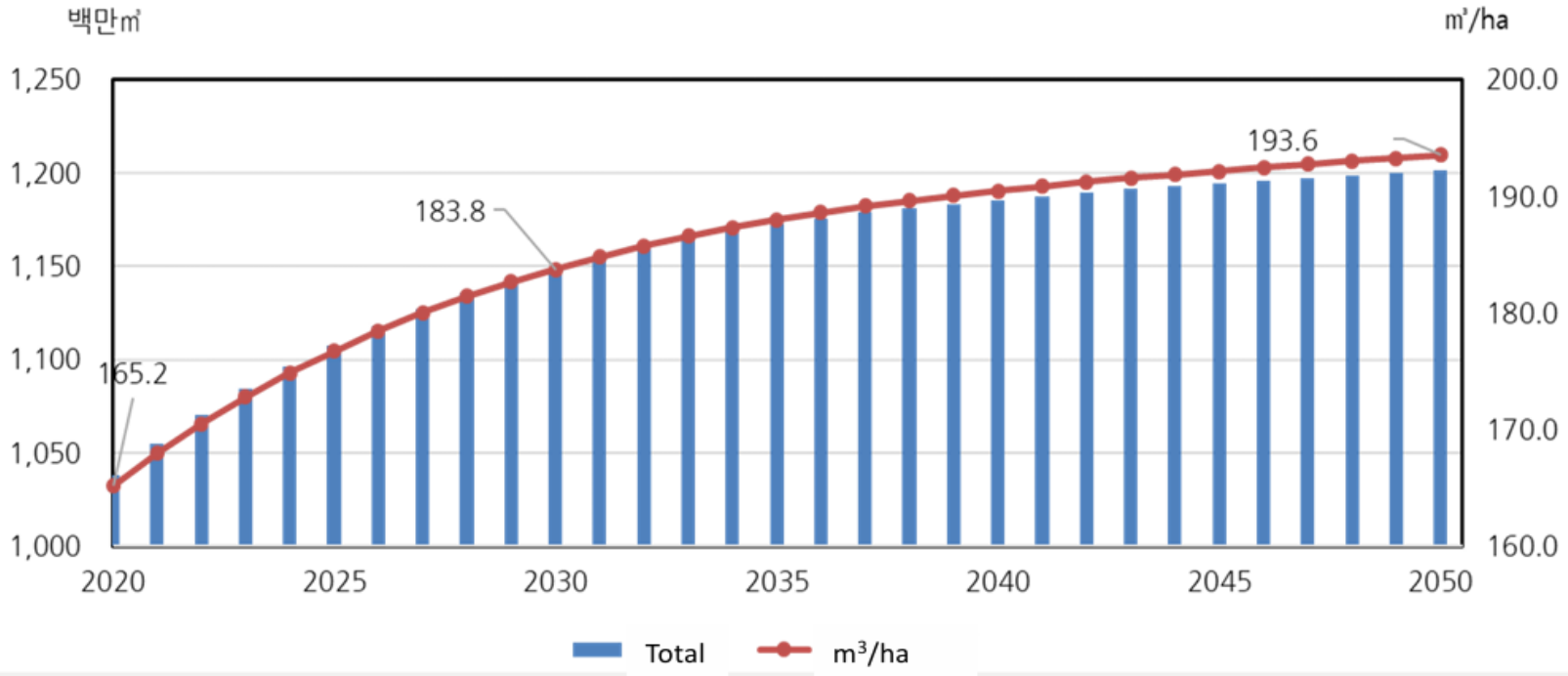
- ✓ Applied Model: Chapman-Richards
- ✓ Forest growing stocks(m^3/ha) by age increase in NFI7(`16-`20) compared to NFI5(`06-`10)



2020 Forest Resources in Korea

➢ Projection for forest growth

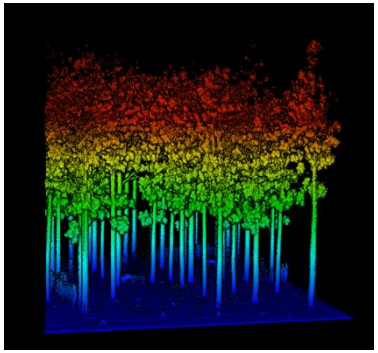
- ✓ Reference data : NFI 5 (`06-`10)
- ✓ Mean forest growing stock : (`20) 165 → (`30) 184 → (`40) 191 → (`50) 194 ㎥/ha
- ✓ **Decreasing in annual forest growth rate** leads **to reduce GHG removals**



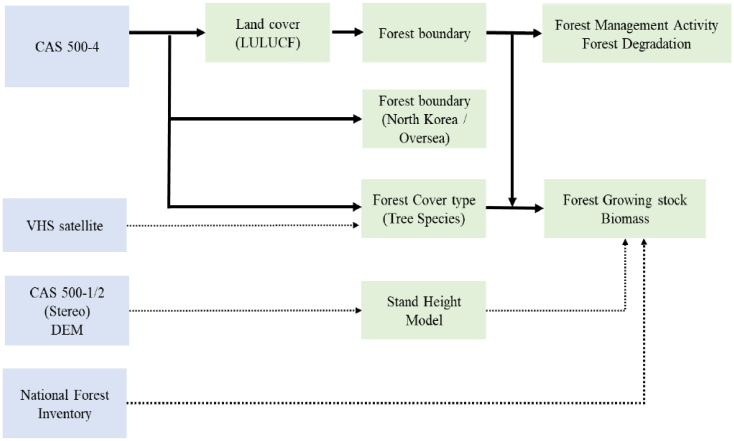
Application of New technologies

◈ Electronic Pad

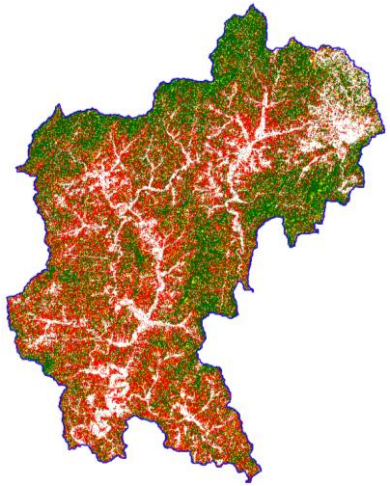
◈ LiDAR



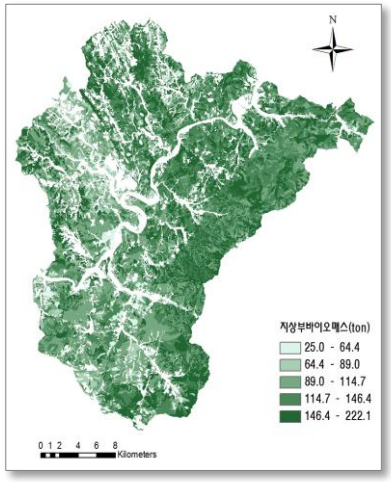
◈ Forest resource thematic maps (NFI+ Satellite data)



Korean satellite (CAS-500) scheduled to launch in 2026



Forest cover type map



Forest AGB map

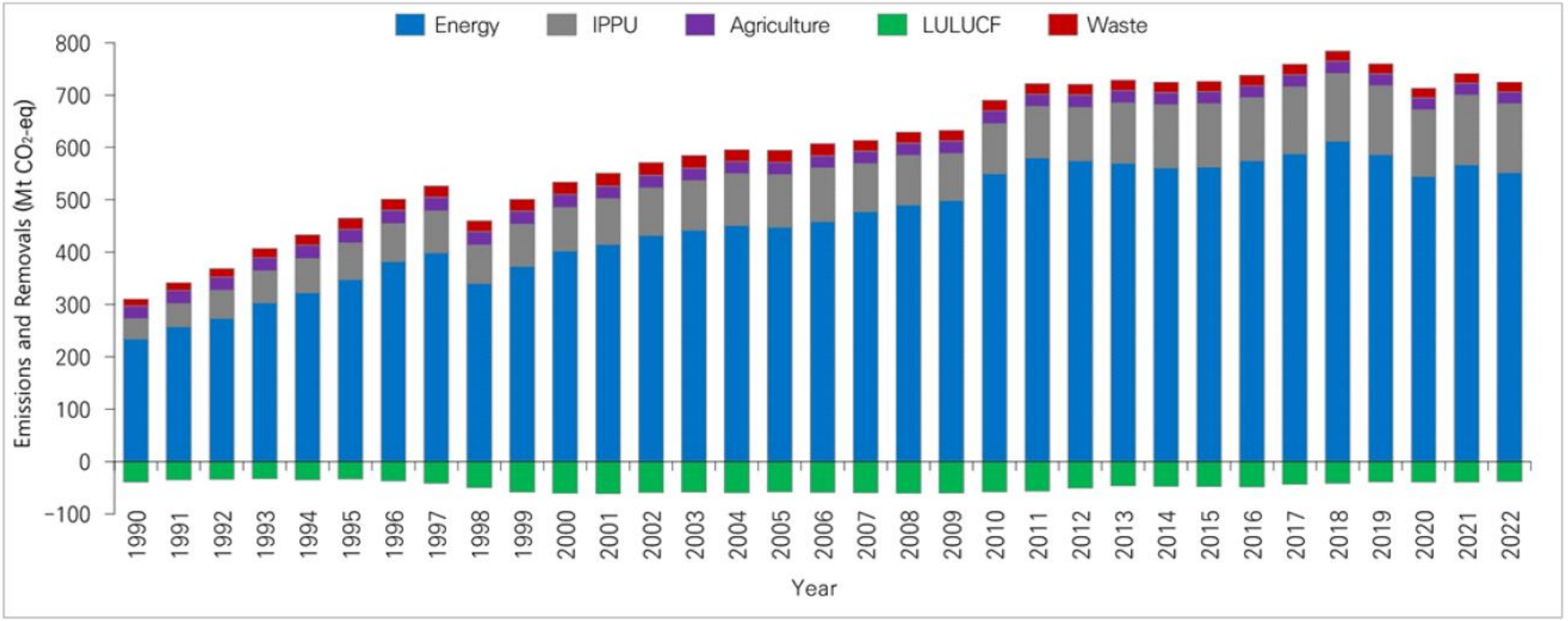
National GHG Accounting in the Forestry Sector

- Overview National GHG accounting of Korea
- National GHG inventory in the forestry sector in Korea
- 2030 NDC and 2050 carbon neutrality for forestry

Overview of the Korean GHG Inventory

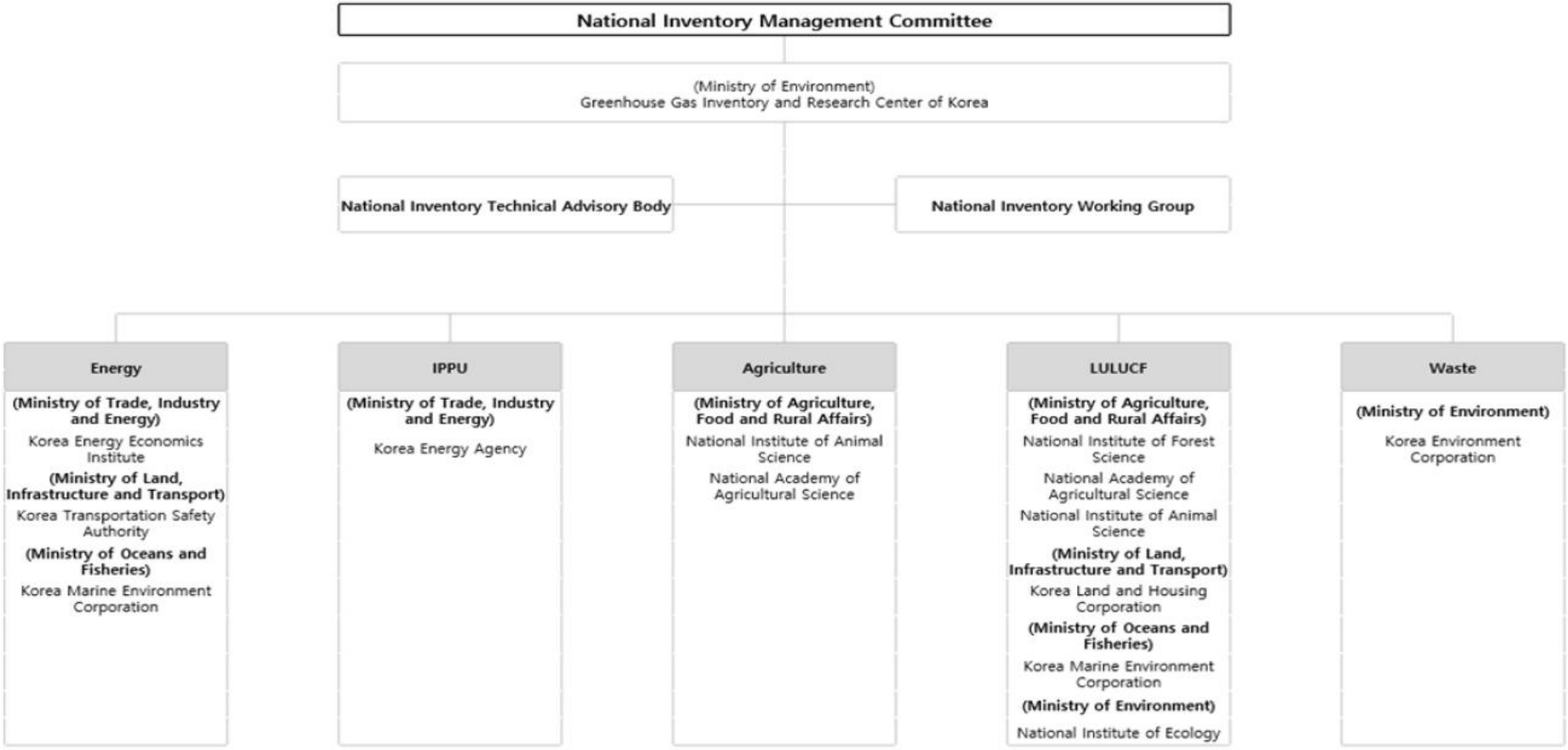
➢ Net GHG Emissions

- 2022(Inventory year) : **686.5 Mt**CO_2eq. (⇩ 8.4% compared to 2018)
- Energy (76.2%) > IPPU(18.2%) > Agri.(3.2%) > Waste(2.5%) * LULUCF (-37.8Mt)



Overview of the Korean GHG Inventory

➢ National GHG Inventory Preparation Framework



Overview of the Korean GHG Inventory

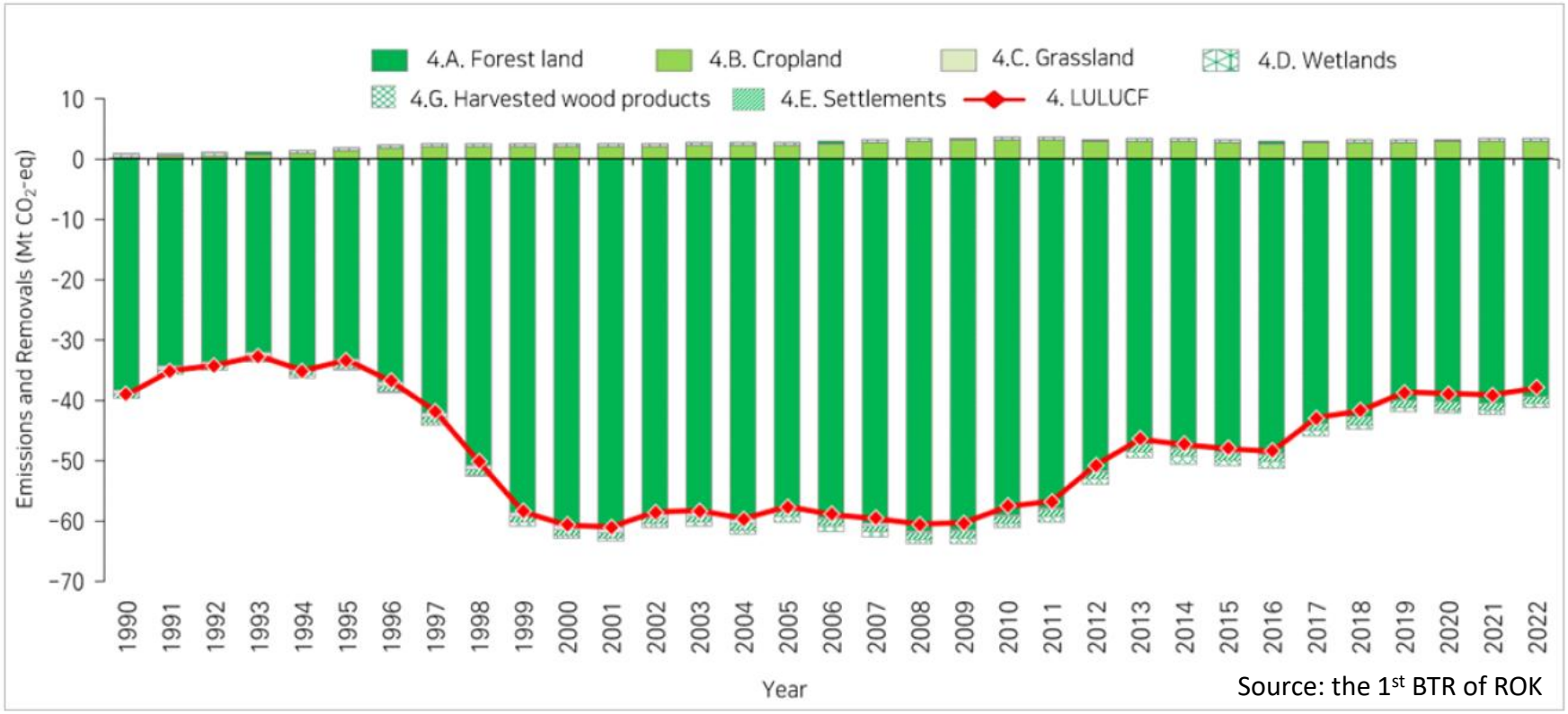
➢ National GHG Inventory Preparation Framework

Sector and category		Competent Authority	Designated Agency
LULUCF	Forest Land, Harvested Wood Products	Ministry of Agriculture, Food, and Rural Affairs (MAFRA)	National Institute of Forest Science (NIFOS)
	Cropland		National Academy of Agricultural Science (NAAS)
	Grassland		National Institute of Animal Science (NIAS)
	Wetlands-Inland	Ministry of Environment (ME)	National Institute of Ecology (NIE)
	Wetlands-Coastal	Ministry of Oceans and Fisheries (MOF)	Korea Marine Environment Corporation (KOEM)
	Settlements, Other Land	Ministry of Land, Infrastructure and Transport (MOLIT)	Korea Land and Housing Corporation (KLHC)

Overview of the Korean GHG Inventory

➢ Net GHG Emissions and Removals for the LULUCF Sector

- 2022(Inventory year) : **- 37.8 Mt**CO_2eq. (⇩ 2.9% compared to 1990)
- FL (-39.3) > Settlements (-1.2) > HWP(-0.5) > CL (2.9) > WL (0.4) > GL

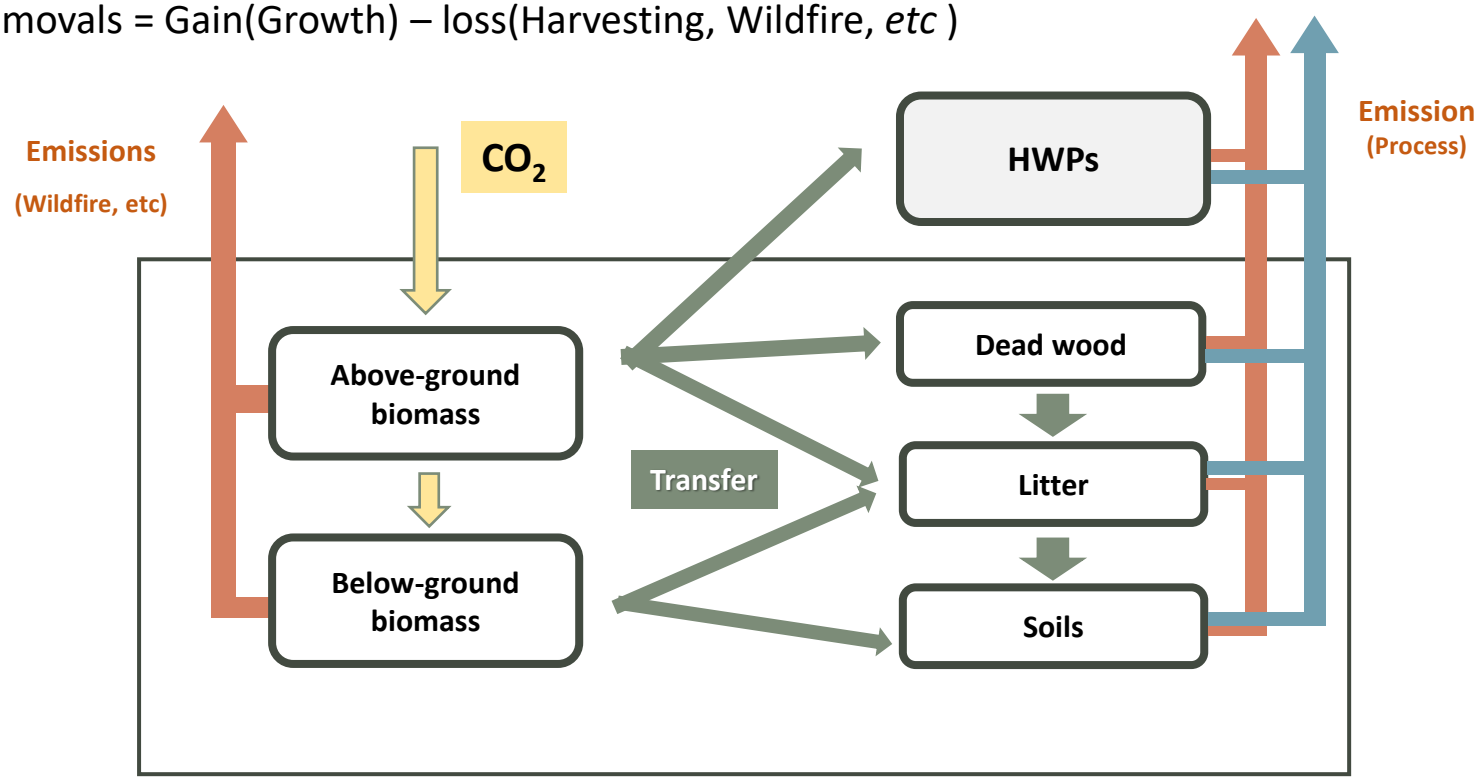


Source: the 1st BTR of ROK

National GHG inventory for Forestry sector

➢ Characteristics of forestry sector

- (**Mitigation**) GHG sources / sink + (Adaption) Ecosystem conservation / Biodiversity
- Carbon Pools: Biomass, Dead Organic Matter, Soil Organic Matter, HWPs
- Net Removals = Gain(Growth) – loss(Harvesting, Wildfire, *etc*)



Source: 2006 IPCC GL

National GHG inventory for Forestry sector

➢ GHG and Notation keys for forestry sector

CRT	Sources	Gas	Notation key
4A (Forest Land)			
4A1	Forest Land remaining Forest Land	CO_2	E, NE
4A2	Land converted to Forest Land		IE(4A1), NE
4(Ⅰ)A	Direct N2O emissions from N fertilization	N_2O	NO
4(Ⅱ)A	Non-CO2 emissions from drainage of soils	CH_4, N_2O	NO
4(Ⅲ)A	N_2O emissions from converted to Forest Land	N_2O	NE
4(Ⅳ)A	Biomass Burning	CO_2, CH_4, N_2O	E
4G1	Harvested Wood Products	CO_2	E

E: Estimated ; IE: Included Elsewhere ; NE: Not Estimated ; NO: Not Occurring; NA: Not Applicable

National GHG inventory for Forestry sector

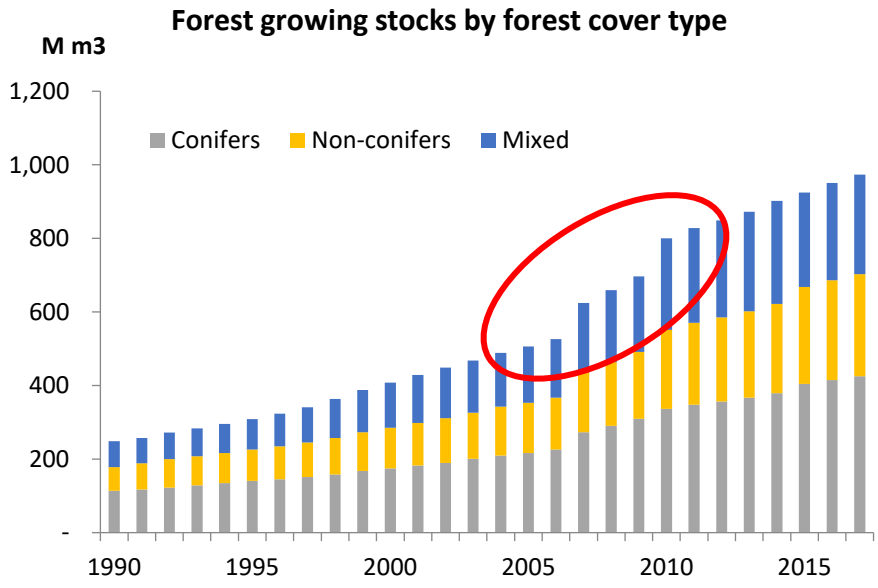
➢ Overview of GHG inventory for forestry sector

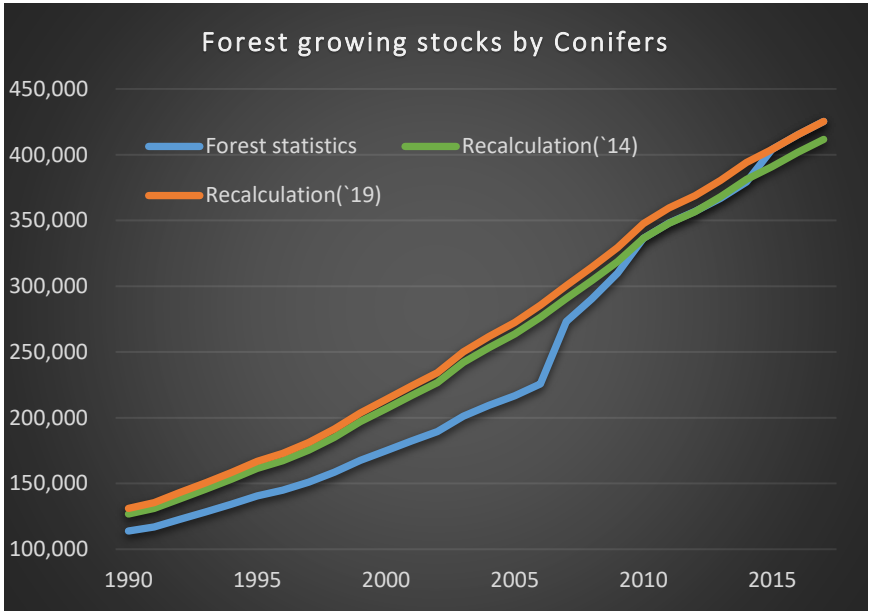
- ✓ Report year: 1990 ~
- ✓ Carbon pool: Above/below ground biomass, HWP, Wildfire, DOM, SOM
- ✓ **Activity data**: Biomass(forest growing stocks by forest cover type),
  HWP (productions by wood materials), Wildfire(damaged volumes by forest cover type)
- ✓ **Emission Factor** (Biomass) Country-Specific EF (wood basic density/BEF, root ratio)
  IPCC default(carbon fraction: **conifers 0.51**, **non-conifers 0.48**)
  (Wildfire) IPCC default(combustion factor, *etc*) → Developing CSEF (Tier 2)
  (HWP) 2019 IPCC default(decay constants by wood materials)
- ✓ Inventory year: t-2 (**3-year moving average**; t-4, t-3, t-2)
- ✓ Method: **Stock-difference method**(Biomass, HWP)
- ✓ Reporting date: up 31. March (NiFOS → KFS/MAFRA → GIR)
- ✓ **Recalculations**: Reorganization of NFI system, Forest cover map(1:25k → 1:5k scale)

National GHG inventory for Forestry sector

➢ Recalculations

- Background : Reorganization of NFI(`14) / Scale change of Forest cover map(`19)
- Method: **Overlap approach** between forest statistics and updated forest statistics



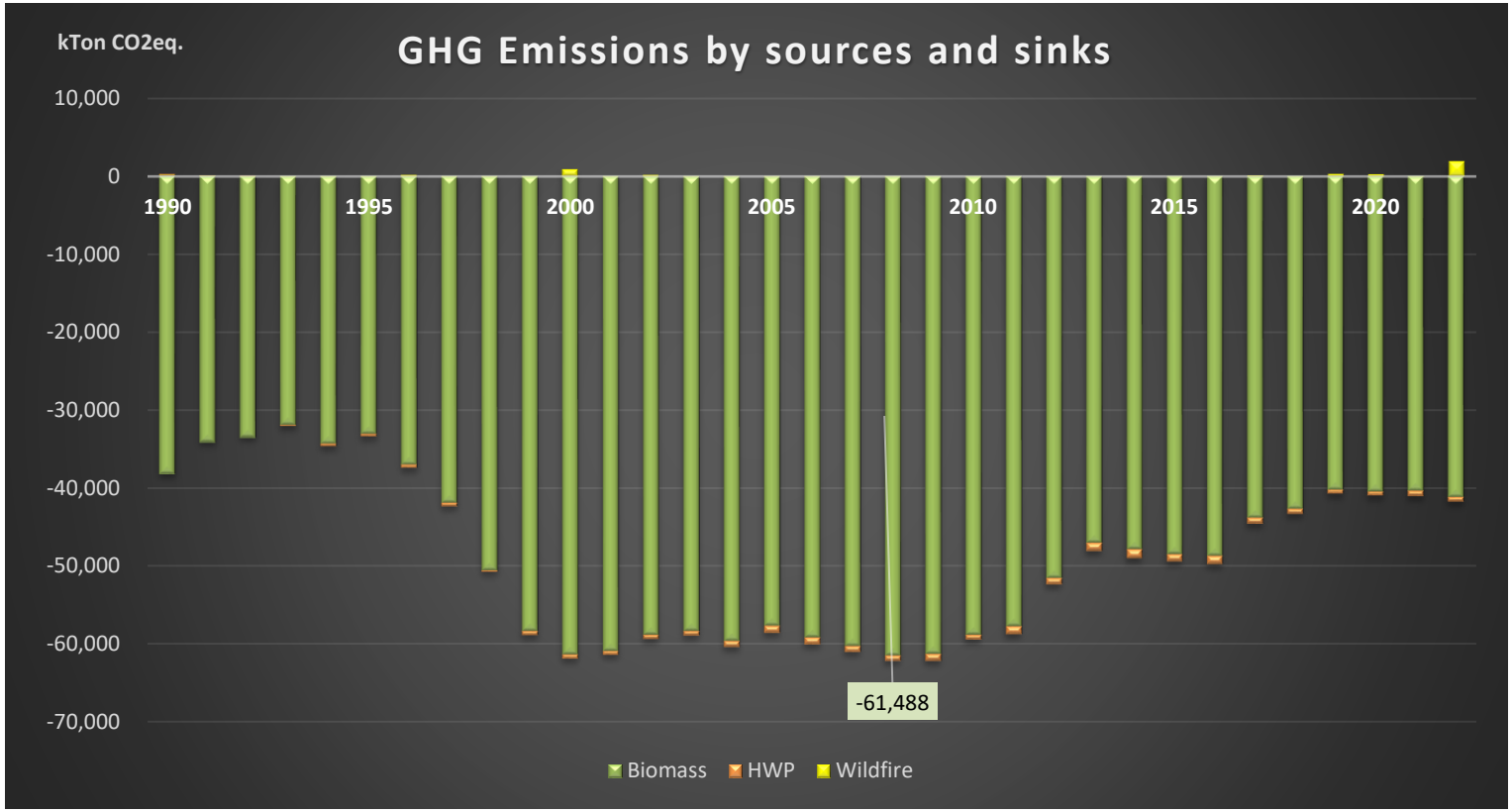


National GHG inventory for Forestry sector

➢ GHG emissions and removals in 2022

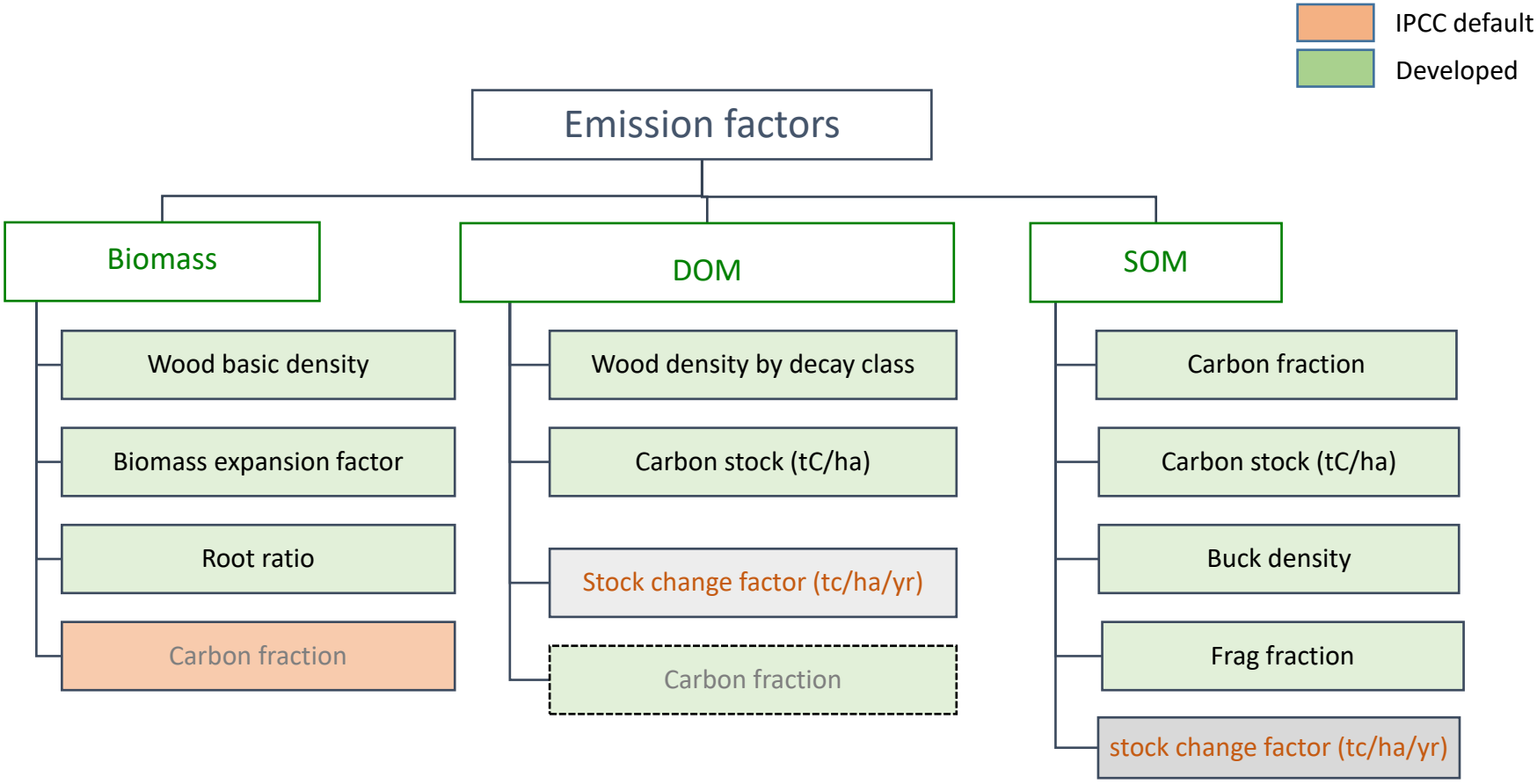
◆ Total Net Emissions in 2022: **- 40** M ton CO_2eq. (sink)

➢ Biomass (- 41,239 k Ton), HWP (- 543 k Ton), Wildfire (1,880 k Ton)



National GHG inventory for Forestry sector

➢ Development of Country-Specific Emission Factors



National GHG inventory for Forestry sector

➢ Development of Country-Specific Emission Factors (Biomass)

Classification	WBD	BEF	Root ratio (R)
P. densiflora in Gangwon	0.42	1.48	0.26
P. densiflora in Central	0.47	1.41	0.25
L. kaempferi	0.45	1.34	0.29
Q. variabilis	0.72	1.34	0.32
Q. acutissima	0.72	1.45	0.31
Q. mongolica	0.66	1.6	0.39
P. rigida	0.5	1.33	0.36
P. thunbergii	0.48	1.52	0.29
P. koraiensis	0.41	1.74	0.28
Cryptomeria japonica	0.35	1.31	0.23
Chamaecyparis obtusa	0.43	1.34	0.2
Other conifer spp.	**0.46**	**1.43**	**0.27**
Q. serrata	0.66	1.55	0.43
Quercus acuta	0.83	1.7	0.19
Other non-conifer spp.	**0.68**	**1.51**	**0.36**

National GHG inventory for Forestry sector

➢ Development of Country-Specific Emission Factors (DOM/SOM)

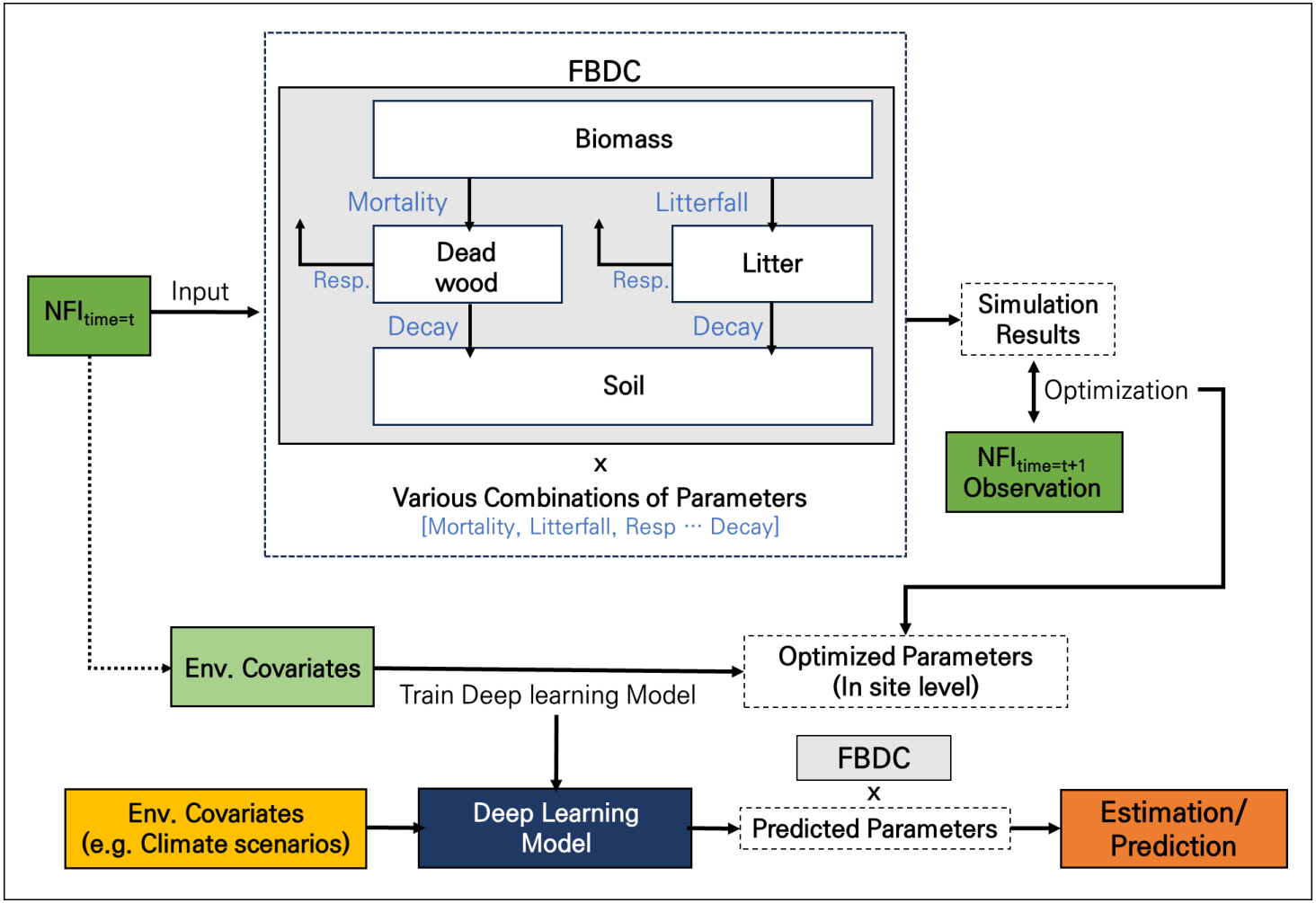
나무 종류	Forest Soil			
	단위면적당 tC/ha	Carbon fraction	Bulk density	Frag fraction
P. Densiflora (GW)	53.16	18.04	1.14	0.32
P. Densiflora (cen)	37.83	16.31	1.10	0.30

수종구분	DW (tc/ha)	Litter	
		단위면적당 tC/ha	Carbon fraction
P. Densiflora (GW)	0.51	9.03	0.47
P. Densiflora (cen)	0.49	11.85	0.45

나무종류	Decay class	Wood density	Carbon fraction	나무종류	Wood density	Carbon fraction
P. densiflora	1	0.35	0.51	Q. mongolica	0.58	0.49
	2	0.32	0.50		0.43	0.48
	3	0.27	0.50		0.40	0.48
	4	0.18	0.50		0.24	0.49
L. Kaempferi	1	0.44	0.50	Other non-conifer spp.	0.55	0.49
	2	0.41	0.49		0.41	0.48
	3	0.31	0.50		0.37	0.49
	4	0.19	0.49		0.23	0.49

National GHG Inventory for LULUCF(Forestry) Sector

➢ **D**eveloping K forest carbon circle model (Tier 3)



Improvement plans

◆ Strengthening TACCC of National GHG Inventory

- Improve accuracy and reliability of GHG emissions/removals in forestry sector
- Improve IPCC tier level for DOM / SOM and carbon cycle model (Tier 1 → Tier 2 / Tier 3)
- Production of Land use change matrix through cooperation with relevant ministries
- Development of an automated program for MRV of GHG emissions

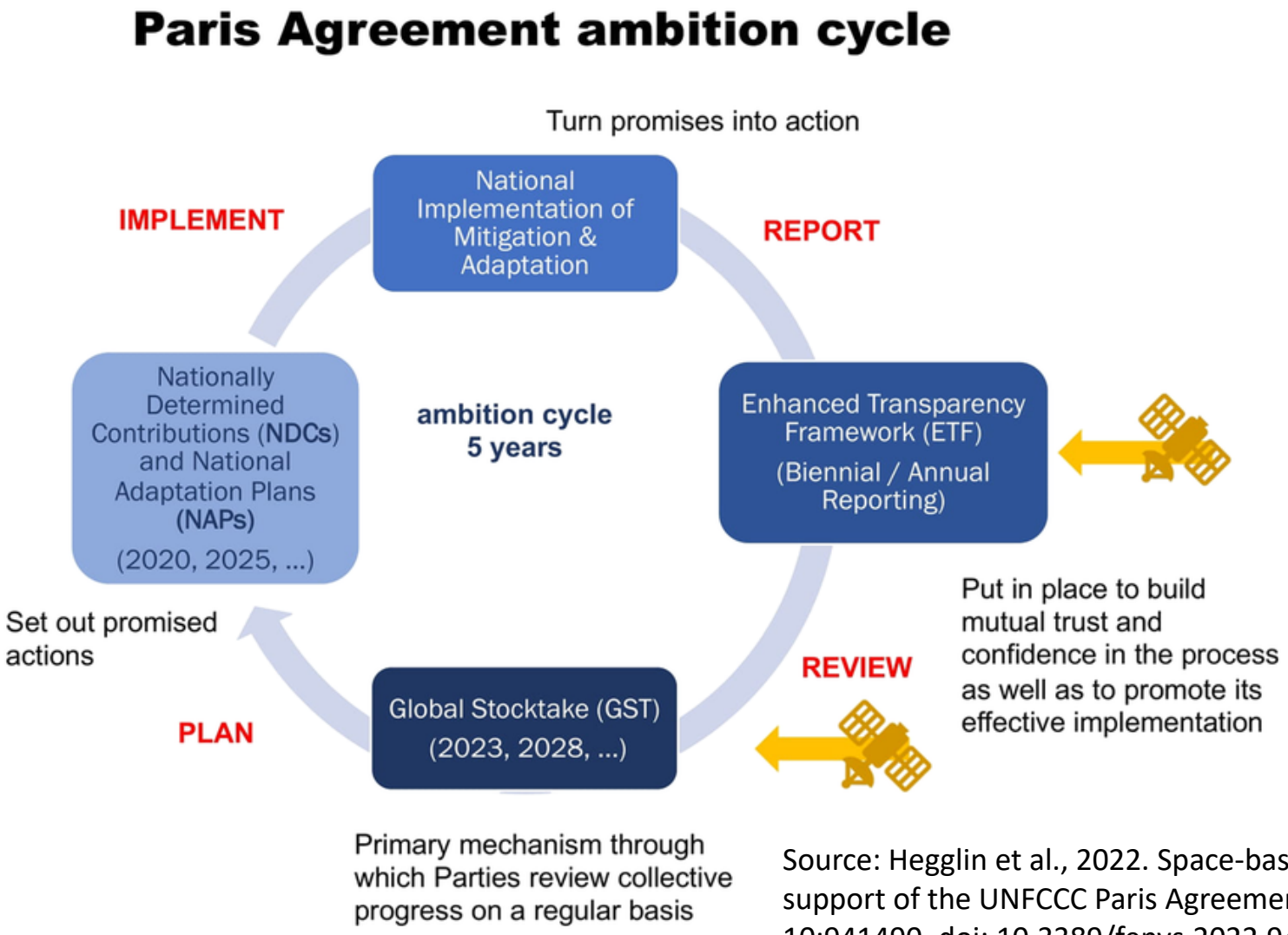
◆ Supporting GHG inventory at the Local Government Level

- Ensure consistency in GHG emissions between national and local levels

◆ Advancing forest growth projection model

- Updated NFI data considering forest soil development and climate impacts
- Scale up from national to local level with spatial distribution

2030 NDC & the 1st BTR of Korea



Source: Hegglin et al., 2022. Space-based Earth observation in support of the UNFCCC Paris Agreement. Front. Environ. Sci. 10:941490. doi: 10.3389/fenvs.2022.941490

2030 NDC & the 1st BTR of Korea

- ✓ (2023) **adjusted 2030 NDC,** (2023) Finalized **2030 NDC Roadmap**
- ✓ **Carbon sink** : 26.7 $MCO_2eq.$ (Forestry: 25.5 $MCO_2eq.$)

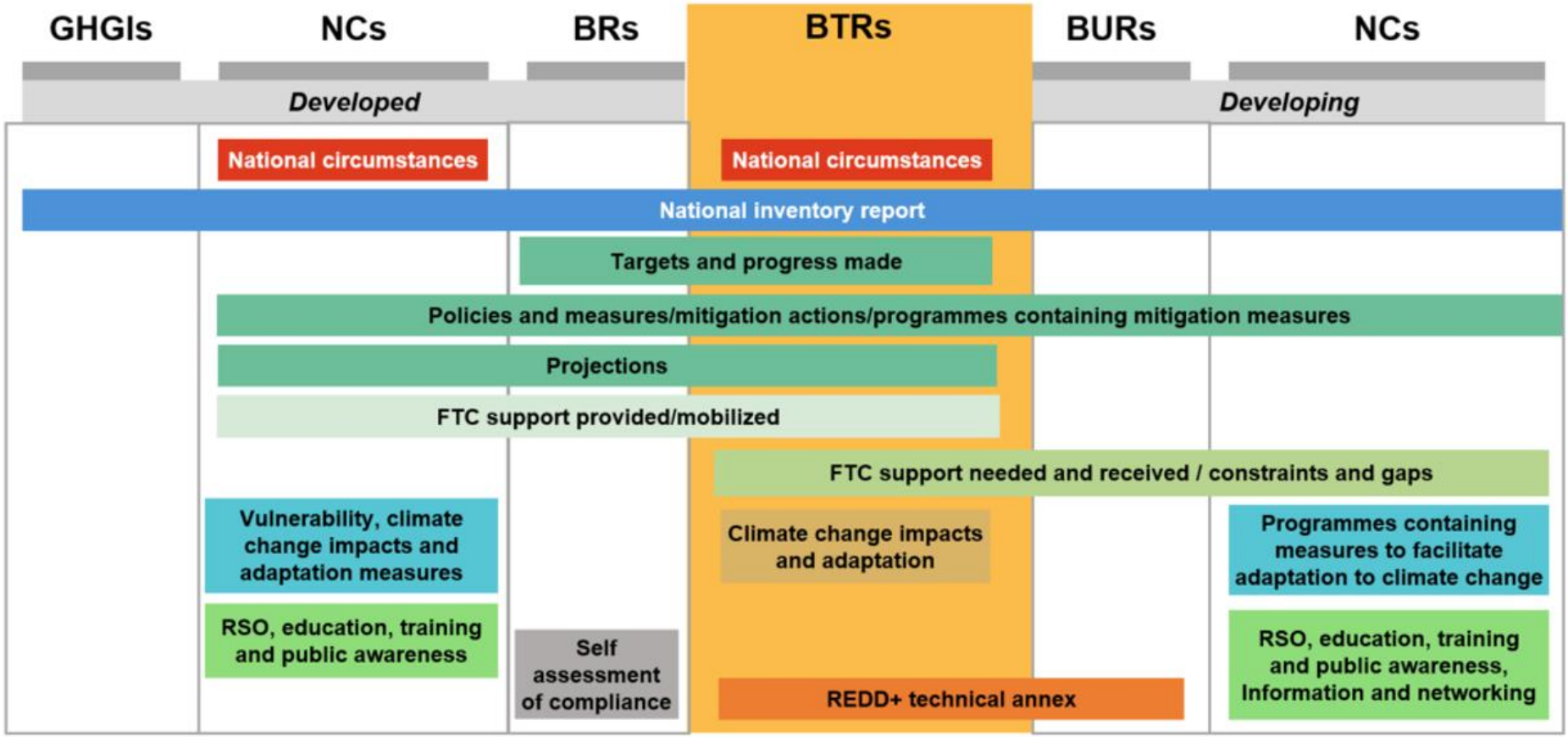
Source: 2050cnc.go.kr/eng

ITEM	Sector	2018 emissions	2030 emissions	
			Previous (Oct 2021)	Adjusted (Apr 2023)
Total emissions		727.6	436.6 (40.0%)	436.6 (40.0%)
Emissions	Transition	269.6	149.9 (44.4%)	145.9 (45.9%)
	Industry	260.5	222.6 (14.5%)	230.7 (11.4%)
	Buildings	52.1	35.0 (32.8%)	35.0 (32.8%)
	Transportation	98.1	61.0 (37.8%)	61.0 (37.8%)
	Agriculture, livestock, and fisheries	24.7	18.0 (27.1%)	18.0 (27.1%)
	Waste	17.1	9.1 (46.8%)	9.1 (46.8%)
	Hydrogen	(-)	7.6	8.4
	Fugitive emissions, etc.	5.6	3.9	3.9
Absorption / removal	Carbon sinks	(-41.3)	-26.7	-26.7
	CCUS	(-)	-10.3	-11.2
	International reduction	(-)	-33.5	-37.5

※ Base year (2018) emissions are total emissions / 2030 emissions are net emissions (total emissions − amount absorbed or removed)

2030 NDC & the 1st BTR of Korea

- ✓ Biannual Transparency Report(BTR) : **For tracking Implementation of NDCs by Country**.
- ✓ Parties to submit BTR **every two years**, with the first submission due by 31 December 2024.



2030 NDC & the 1st BTR of Korea

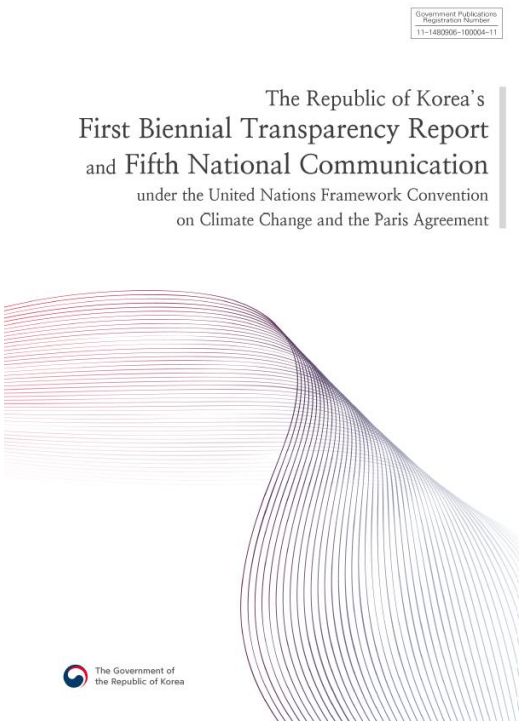
✓ Forestry sector promotion strategy to achieve carbon neutrality by 2050(KFS, 2021)

- **2050 Removals: (Baseline) -16 → (Target) -27 M ton**

Policies	2020	2030	2050
Urban forest area per person (m^2/person)	11	15	20
Afforestation (ha/yr)	200	500	1500
Harvesting (m^3/yr)	4.6 M	5.5 M	8.0 M
Forest tending (kha/yr)	217	300	480
Wood usage per person (m^3/person)	0.6	1.2	2.0

2030 NDC & the 1st BTR of Korea

- ✓ The 1st BTR submitted in February 2025.
- ✓ GHG reduction assessment for each reduction policies by sector
- ✓ In 2022, reduction rate is approximately 8.4% compared to 2018 levels



Information on Tracking Progress in Implementing and Achieving NDC (CTF II.4)

	Unit	Reference Point[1] (2018)	NDC Implementation Period		Target Level[2]	Target Year	NDC Progress Status
			2021	2022			
Annual Total GHG Emissions	MtCO2-eq	732.9	690.8	671.2	40%	2030	As of 2022, approx. 8.4% reduction compared to 2018
ITMOs Utilization	As international mitigation projects are at the initial stage, the ROK plans to report on NDC utilization of ITMOs and double counting prevention in its subsequent BTRs.						

1) Updated figures due to recalculation (727.6 → 732.9)
2) The ROK plans to use voluntary cooperation under Article 6 of the Paris Agreement as a complementary measure to its domestic mitigation efforts including LULUCF to achieve its target

2030 NDC & the 1st BTR of Korea

- ✓ GHG reduction assessment for each reduction policies by sector
- ✓ Forestry sector: Reforestation / Timber utilization / Forest tending / Revegetation (urban forest)

Sector	Name	Description	Objective	Typeg	Status	Affected Sectors	Affected Gases	Implementation Start Year	Implementing Agency	GHG Reduction ($ktCO_2$-eq)		
										Achieved Reduction (2021)	Achieved Reduction (2022)	Expected Reduction (2030)
Waste	Organic Waste Biogas Facilities	Installs organic waste biogas facilities that produce biogas using organic waste resources such as food waste and livestock excreta	Prevents methane generation from organic waste resources and reduce GHGs by utilizing methane as alternative fuel through biogas production	Economic Measure	In Progress	Energy, Waste	CO_2 CH_4	2022	Ministry of Environment	-	-	115
Carbon Sinks, Carbon Capture, and Hydrogen	Reforestation	Promotes afforestation projects to enhance forest carbon sink functions as part of sustainable forest management	Maintains and enhances carbon storage functions through afforestation	Regulation	In Progress	LULUCF	CO_2	2021	Korea Forest Service	117	228	1,202
Carbon Sinks, Carbon Capture, and Hydrogen	Forest Tending	Implements forest tending by dividing the work into afforestation site management, young tree management, and large tree management according to the growth stage of trees	Strengthens the carbon sink function of forests and reduce GHGs through forest tending	Regulation	In Progress	LULUCF	CO_2	2021	Korea Forest Service	-	-	-
Carbon Sinks, Carbon Capture, and Hydrogen	High Value-Added Timber Utilization	Promoting the use of wood in building and infrastructure construction to enhance carbon storage capacity.	Enhances the carbon storage capacity of wood and reduce GHGs by encouraging wood use	Regulation	In Progress	LULUCF	CO_2	2021	Korea Forest Service	2,106	1,744	1,871

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Research fields

- Forest resources Assessment and Monitoring
- GHG inventory for Forestry sector
- Remote Sensing
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