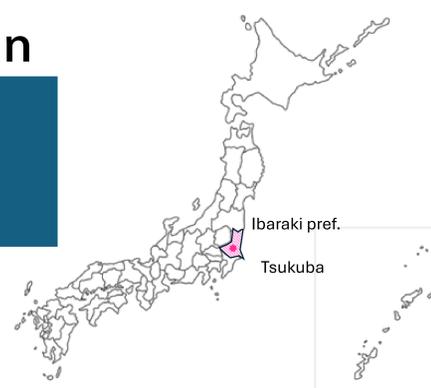NIES, Japan

Decarbonation through the land use change in a depopulated society in the future

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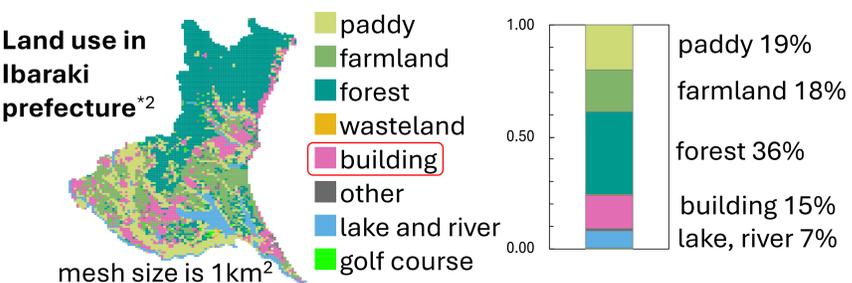Diego SILVA HERRAN*, Shuichi ASHINA* （*NIES, **JYURI）
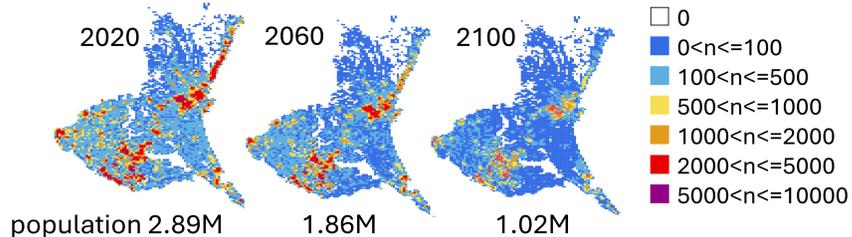
Ibaraki pref.
Tsukuba

Introduction

- The CO_2 sink function of forests is important for a decarbonized society by 2050. However, forest sinks peaked in 2003 and have been declining in Japan[1].
- The population began to decline around 2010 in Japan. Vacant houses are increasing. It is necessary to review of land use.
- Low-use building sites could be converted into forests and used as CO_2 sinks.
- Forestry workers are decreasing in Japan. On the other hand, there is a possibility to reduce forestry cost, because building sites are flat and are equipped roads.
- Ibaraki prefecture has a large building site and is expected to change land use largely. We conducted scenario analysis there.
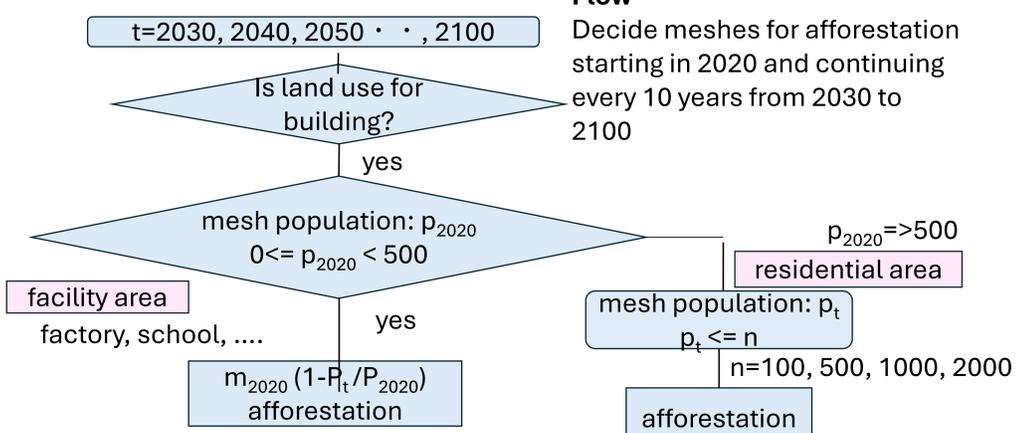
Aim

- How much will a land use change to create "sink forests" contribute to decarbonization?
- How will the population distribution change?
- Can we manage forests in the future?

Land use in Ibaraki prefecture[2]

- paddy
- farmland
- forest
- wasteland
- building
- other
- lake and river
- golf course

mesh size is 1km²

paddy 19%
farmland 18%
forest 36%
building 15%
lake, river 7%

Population prediction in Ibaraki[3]

2020 2060 2100

□ 0
■ 0<n<=100
■ 100<n<=500
■ 500<n<=1000
■ 1000<n<=2000
■ 2000<n<=5000
■ 5000<n<=10000

population 2.89M   1.86M   1.02M

Harvester

Forwarder
Moving through uneven terrain in the forest

Methods

Flow

t=2030, 2040, 2050・・, 2100

Is land use for building?

yes

mesh population: p_{2020}
$0 <= p_{2020} < 500$

facility area
factory, school, ...

yes

$m_{2020}(1 - P_t/P_{2020})$
afforestation

m_{2020}: No. of mesh for facility area in 2020
$P_t = \Sigma p_t$ （pref. population in t）

$p_{2020} => 500$

residential area

mesh population: p_t
$p_t <= n$
n=100, 500, 1000, 2000

afforestation

Decide meshes for afforestation starting in 2020 and continuing every 10 years from 2030 to 2100

- population in afforested mesh move to the other residential area
- coniferous plantation trees (*Cryptomeria japonica*, *Chamaecyparis obtusa*) are planted to mesh for afforestation.

Forest CO_2 absorption

The number of afforestation meshes was multiplied by the growth rate at that time and accumulated.[1]

Plantation growth in Ibaraki[4]

growth (m³/ha year)

forest age
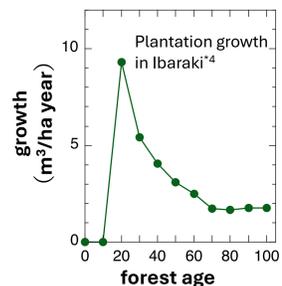
$$CO_{2\ absorption}(t) = \sum_t Growth(t) \cdot NO_{mesh} \cdot BEF \cdot (1+R) \cdot D \cdot CF \cdot 44/12$$

BEF: biomass expansion factor [1]
R: ratio of belowground biomass to aboveground biomass [1]
D: density [1]
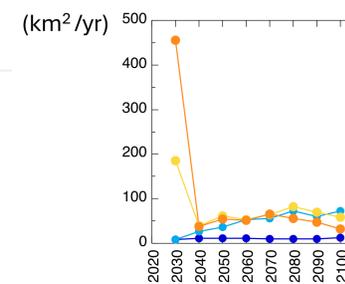CF: carbon fraction [1]

Forestry cost and efficiency

Cutting cost occupies large part of forestry cost and forestry efficiency depends on slope and presence of road/path. We assumed no need of forwarders for afforestation mesh because of flatness and presence of roads. Costs, productivity and number of workers were calculated by apportioning them based on the ratio of the gentle slope area, medium slope area[2] of present plantation, and afforestation area in 2100.
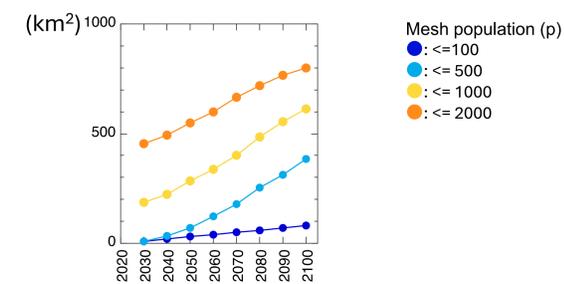
		Afforestation mesh 0-22 degree	Gentle slope[5] 0-22 degree	Middle slope[5] 22-31 degree
Facility cost (MJP¥)	Harvester	100	100	100
	Forwarder	no need	30	60
	Total	**100**	**130**	**160**
Productivity (m³/person day)	Clear cutting	150	75	50
	Thinning	75	38	25
	Total	**225**	**113**	**75**
Worker	Harvester	1	1	1
	Forwarder		1	2
	Total	**1**	**2**	**3**

Results and discussion

Afforestation area
(km²/yr)

Plantation forest area
(km²)

Mesh population (p)
■ : <=100
■ : <= 500
■ : <= 1000
■ : <= 2000

CO_2 absorption
(M-tonCO_2/yr)

Change in mesh population
(population/km²)

Forestry cost and efficiency
The current value is set to 1, and the ratios for the four mesh populations in 2100 are shown.

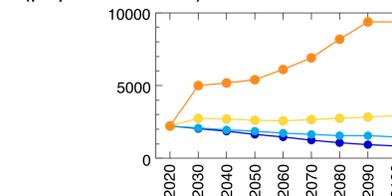| n <=	100	500	1000	2000
Facility cost	0.99	0.95	0.93	0.91
Productivity	1.06	1.22	1.31	1.37
Worker	0.97	0.89	0.84	0.81

- **Afforestation area:** 82-799 km² in 2100, which is 5-44% of the 2020 forest area.

- **CO_2 absorption:** Mesh population (n>=2000) shows a large peak in 2050, but the amount will decrease thereafter. n>=1000 shows around 0.2 M-ton after 2050. Absorption of n>=500 is increasing linearly. n>=100 shows small amount.

- **Change in mesh population:** n>=2000 will be over 9000. n>=1000 shows constant, around 3000. n>=500 and n>=100 are decreasing.

- **Forestry cost and efficiency:** The larger the mesh population, i.e., the larger the afforestation area, the lower the facility costs, the higher the productivity, and the fewer the number of workers.

- Conversion of building areas into "sink forests" is considered a decarbonization measure that avoids competition with farm land and the burden on the natural environment.
- Converting building sites into plantation forests makes it possible to reduce forestry costs and improve productivity by smaller number of workers.
- n>=2000 has a large cumulative CO_2 absorption amount by 2100. However, the population density in residential areas is equal to the current maximum. It needs high cost. n>=100 is thought to be appropriate, because of CO_2 absorption amount, mesh population, forestry cost.

Refferences
*1 National Greenhouse Gas Inventory Report of Japan 2023, *2 National Land Numerical Information: Land use, geographical 3rd mesh data 2021, *3 SSP (shared socio-economic pathways) in Japan 2nd ed. (2021/7/8), Use a moderate scenario SSP2 with moderate fertility and mortality rates and status、*4 Ibaraki pref. Forest resource 2020.04.01, The amount of resources in the entire prefecture, including national forests, was calculated proportionally based on the area of national forests. *5 Asada et al. 2017 J. Forest Res. 99: 187-194