ALLSENSORS 2020
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Designing a Livestock Monitoring System and Evaluating the Performance of LoRa for a Farm

— Reforming agriculture by information and communications technology in Society 5.0 —

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Introduction of the presenter

- Jinshan Luo is a Master's Course student of a department of engineering, Utsunomiya University. His research interest is ad hoc network technology using LoRa and applying it to construct a sensor network to monitor livestock on a farm.

Topics of this presentation

GOAL

(1) Clarify the relation between the quality of milk and grazing

(2) Monitor the behavior of cows during grazing, such as feeding glass, walking distance, active time, health condition.

What we developed

(1) To monitor the behavior and health condition of a cow, we developed a sensor network by using LoRa. The communication distance of a large farm in Japan is 4km x 4km. We confirmed that our system can send cow's data in a farm.
(2) The LoRa network works by a sloar battery.
(3) We developed sensor with GNSS and solar panel for a cow to monitor the behavior. Also, we developed a pH sensor to measure rumen pH levels .

The part of the research results was obtained from the commissioned research by the National Institute of Information and Communications Technology (NICT), JAPAN. Also, this research is supported by JSPS KAKENHI Grant Number JP17H02249 and JP18K11849.

Situation of livestock business in Japan (1)

The American large-scale herd management method has been promoted. As a result, the traditional Japanese-style breeding management, which has been built based on a trustful relationship with livestock, is being lost.

Fine-grained, low-stress feeding management can reduce morbidity, increase reproductive efficiency, and improve raw milk quality. Breeding management that takes care of each animal and maximizes its individuality and ability leads to the production of high-value-added milk.

Situation of livestock business in Japan (2)

In this situation, grazing is attracting attention. Grazing can manage cows without stress since cows are originally living in the field. Production of high-value-added milk by grazing, feeding behavior of cows during grazing, and health status are not fully elucidated.

We want to clarify the relationship between grazing and quality of raw milk and develop a milk quality estimating system by using sensors, Information and Communication Technology (ICT) and Artificial Intelligence (AI).

Motivation of the research

(1) Clarify the relation between the quality of milk and grazing

(2) Monitor the behavior of cows during grazing, such as feeding glass, walking distance, active time, health condition.

Feeding ⇒ Energy ⇒Milk

Understand the relation among cow’s health, behavior and milk quality

Monitor amount of Activity and Feeding glass

Ph levels of cow’s rumen is normal, bacteria digest glasses.

If eat too much, the rumen becomes acidity and bacteria is dead

If the bacteria is dead, toxin causes liver damage.

Product from high quality milk, butter and cheese

Construct new business model and food chain

Milk

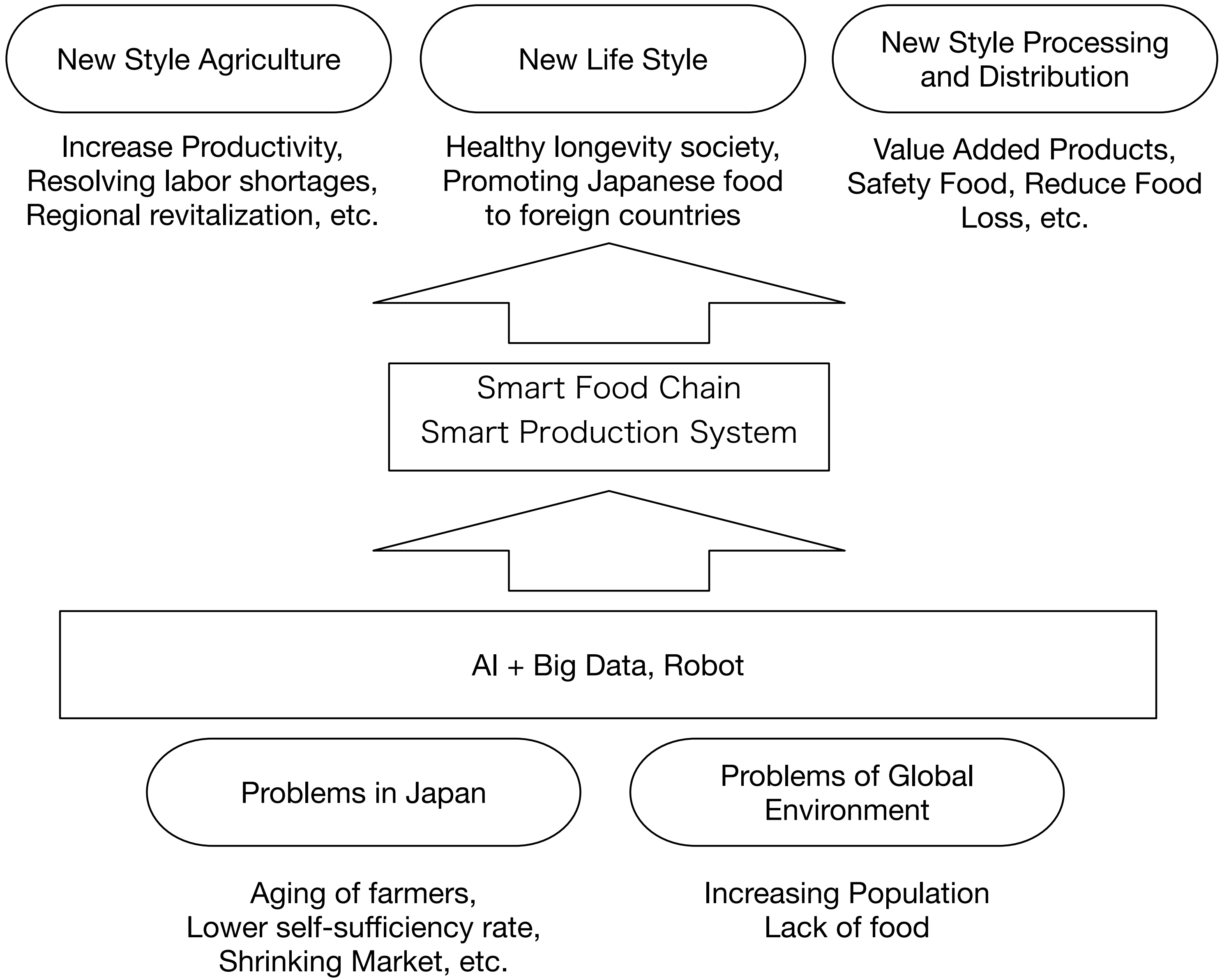
Butter/Cheese

Sweets

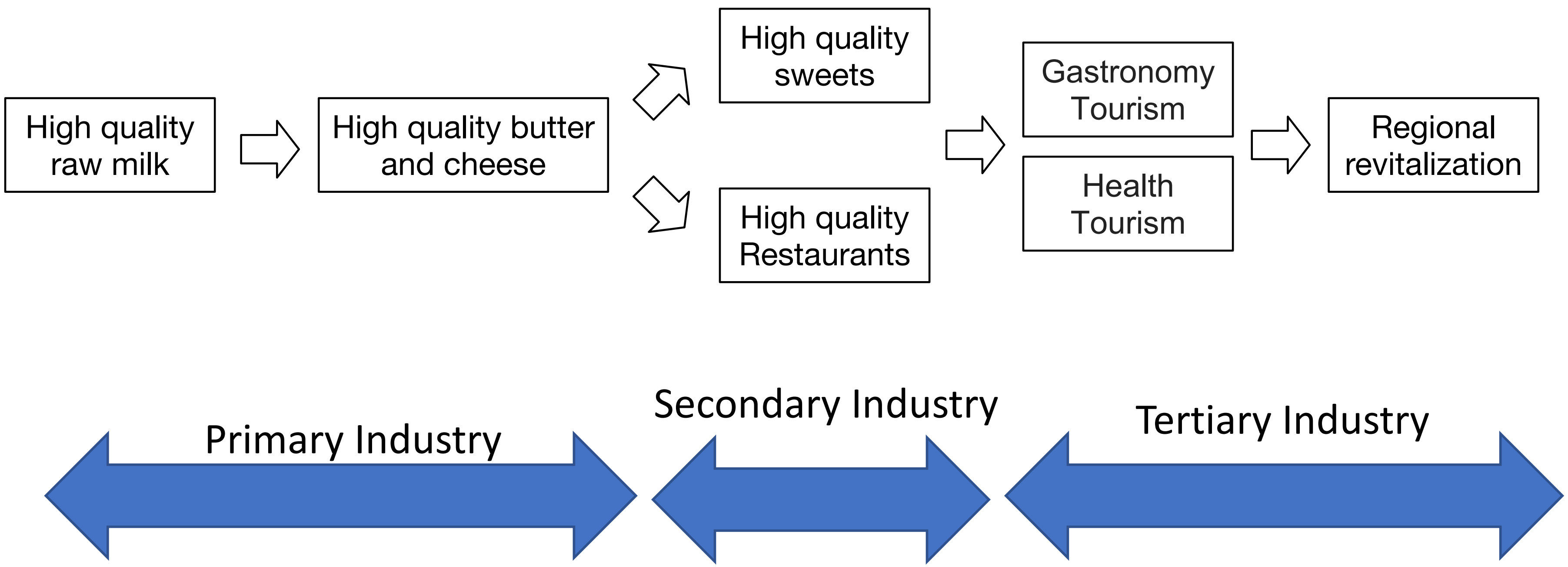
Restaurant

We would like to develop a relation between farmers and local residents and visitors to use and eat products in Tochigi Prefecture

Society 5.0 for Agriculture

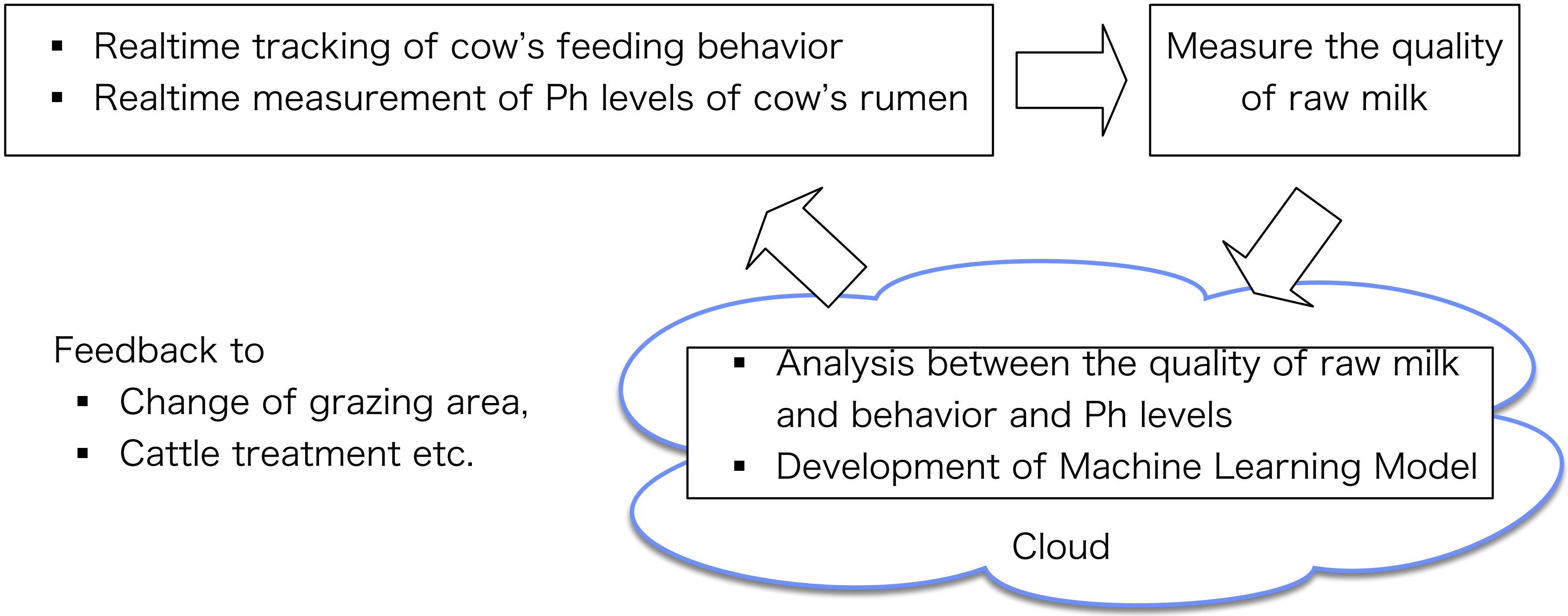


Sixth sector industrialization of milk



Outline of the research

To support sixth sector industrialization of milk by ICT and AI



R&D Items of this project

Realtime tracking of cow's feeding behavior

Realtime measurement of Ph levels of cow's rumen (Under construction)

Develop machine learning model to estimate the quality of milk (Under construction)

Realtime tracking of cow's feeding behavior

Development:

Develop a sensor that has GPS and accelerometer.

From the accelerometer we can get the number of steps and chewing

Problem:

(1) Design of the sensor box

(2) Low power consumption (sensors and transmission)

For the transmission, we decided to use LoRa

Devices for experiment of LoRa

Transmitter

Receiver

- BW: 62.5KHz
- SF: 12
- Tx power: 13dbm
- LoRa chip: ES920LR
- gain of the antenna: 0dbi

The LoRa chip: ES920LR

The effect of SF and BW (from the data sheet of ES920LR)

Payload is 10 bytes

Combination
of BW x SF
good for the long range
communication
(62.5KHz, SF=12)

		Spreading Factor (SF)					
		7	8	9	10	11	12
Band Width (BW) (KHz)	62.5	144	247	453	823	1483	2966
	125	72	123	226	412	741	1483
	250	36	62	113	206	371	741
	500	18	31	57	103	185	371

(ms)

Combination of BW x SF
good to send large data
(500KHz, SF=7)

PAYLOAD IS 50 BYTES

		Spreading Factor (SF)					
		7	8	9	10	11	12
Band Width (BW) (KHz)	62.5	308	534	903	1642	2957	5587
	125	154	267	452	821	1479	2793
	250	77	133	226	411	739	1397
	500	38	67	113	205	370	698

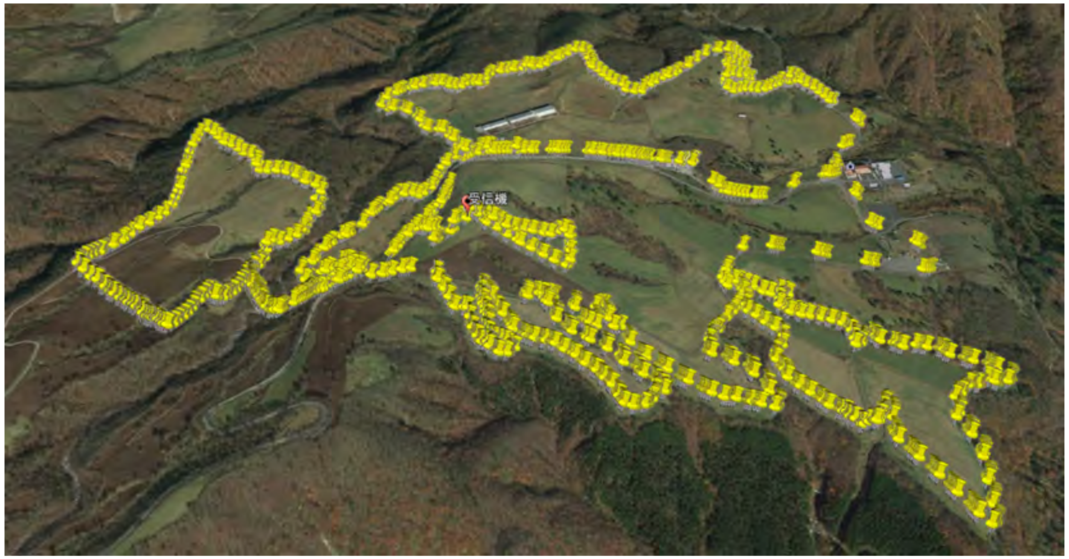
(ms)

Ozasa Farm

One of the largest farm in Japan. About 400 ha (4km x 4km)

Experiment at Ozasa farm

Trace of transmitter
(sending GPS data)



Plot of received
GPS data

Receiving rate of LoRa at Ozasa Farm

	Transmitter 1	Transmitter 2	Total
The number of transmitted messages	2884	2507	5391
The number of received messages	2272	2113	4385
Message Receiving Rate	78.78%	84.28%	81.34%

Okumura-Hata Model

Okumura Hata Model was developed in Japan to design the mobile communication network.

$Loss(dB)$=A+$Blog(d)$−α+C

where

A=69.55+26.16log[$f(MHz)$]−13.82log[$h_b(m)$]

B=44.9−6.55log[$h_b(m)$]

f(MHz): Frequency,

d(km): Distance,

h_b(m): Base station height

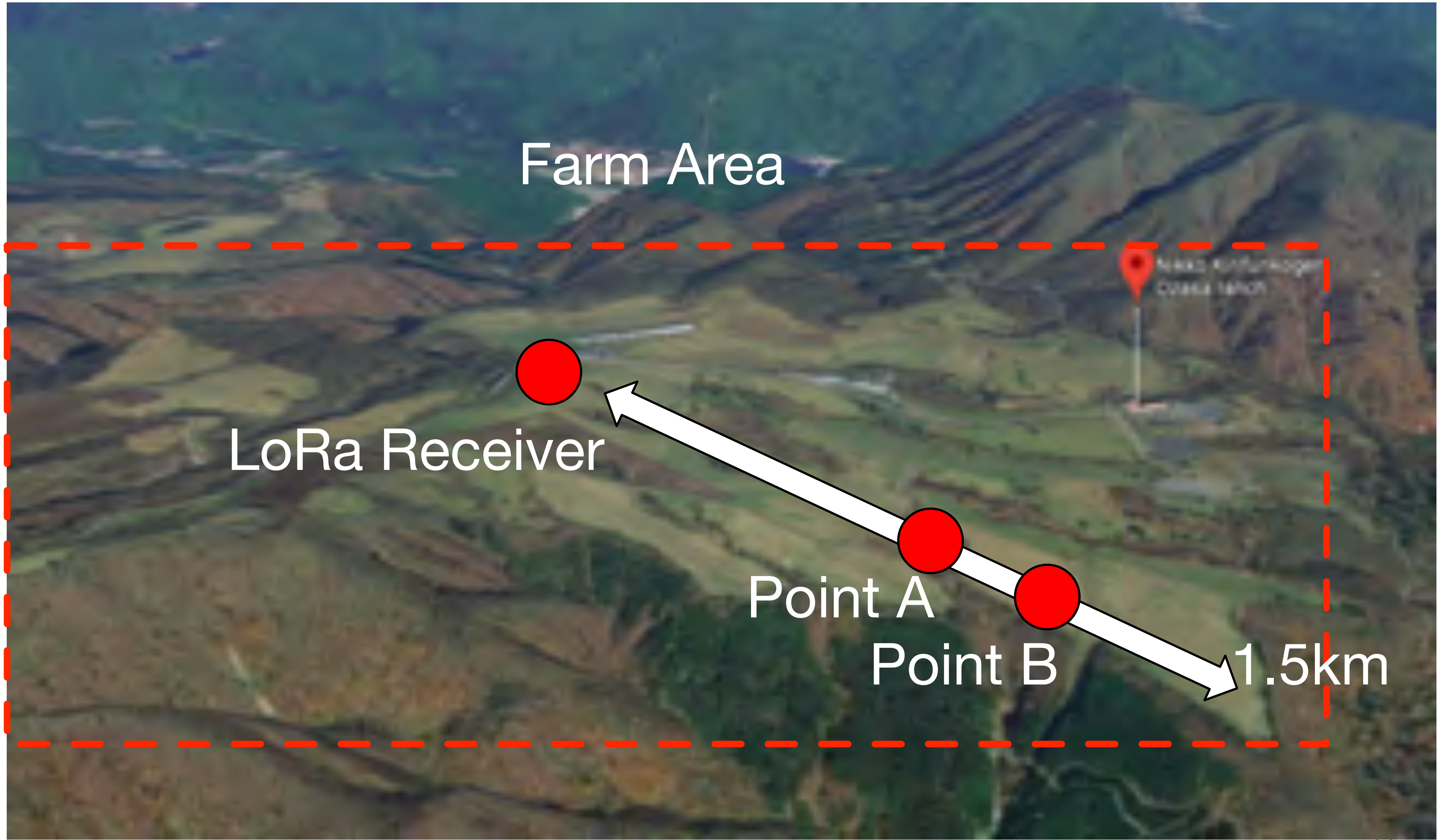
α and C depend on the location.

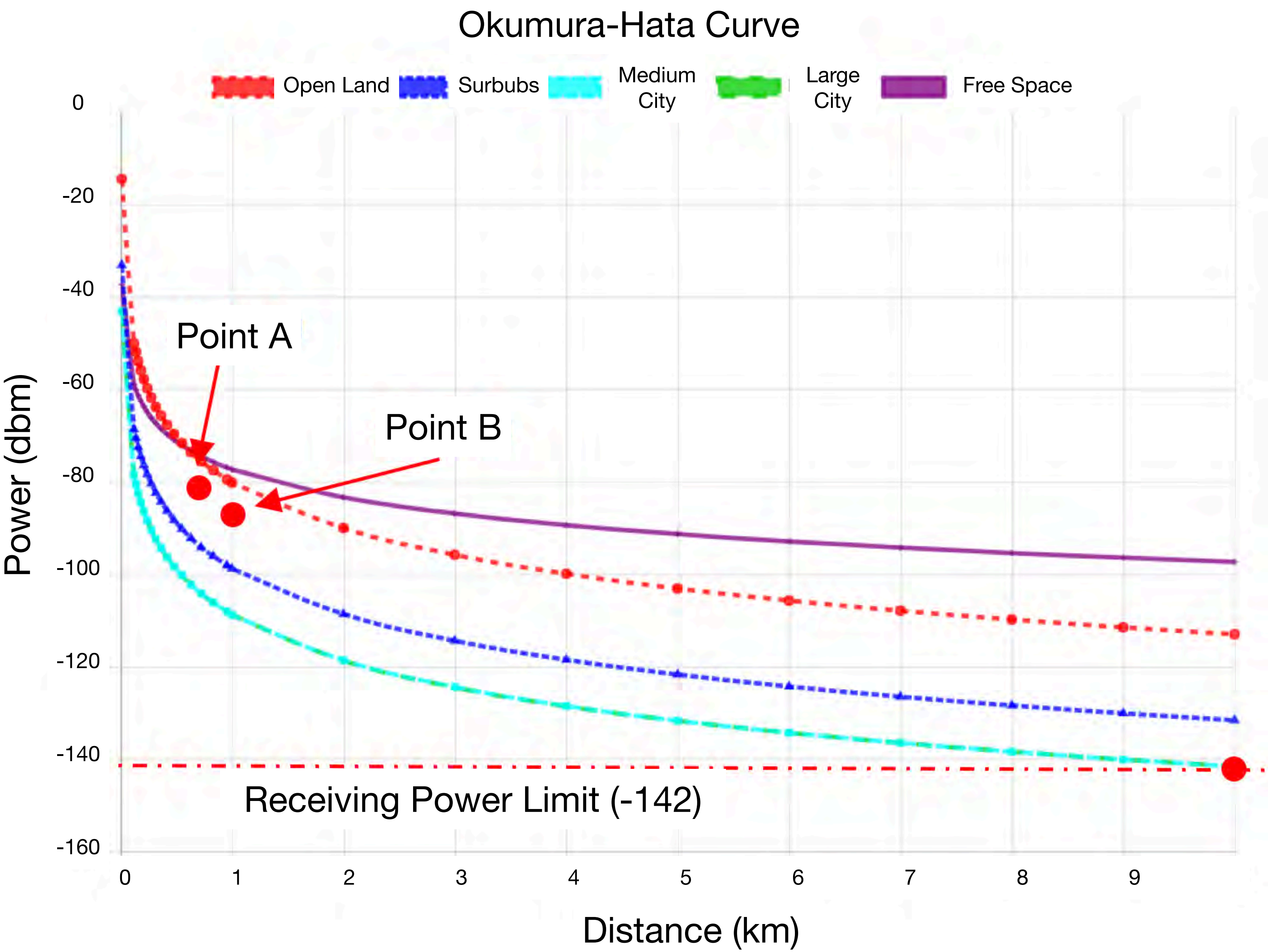
For example, the location is an open space, α and C are defined as follows;

α={1.1log[$f(MHz)$]-0.7}$hm(m)$-{1.56log[$f(MHz)$]-0.8}

C=−4.78{log[$f(MHz)$]}2+18.33log[$f(MHz)$]−40.94

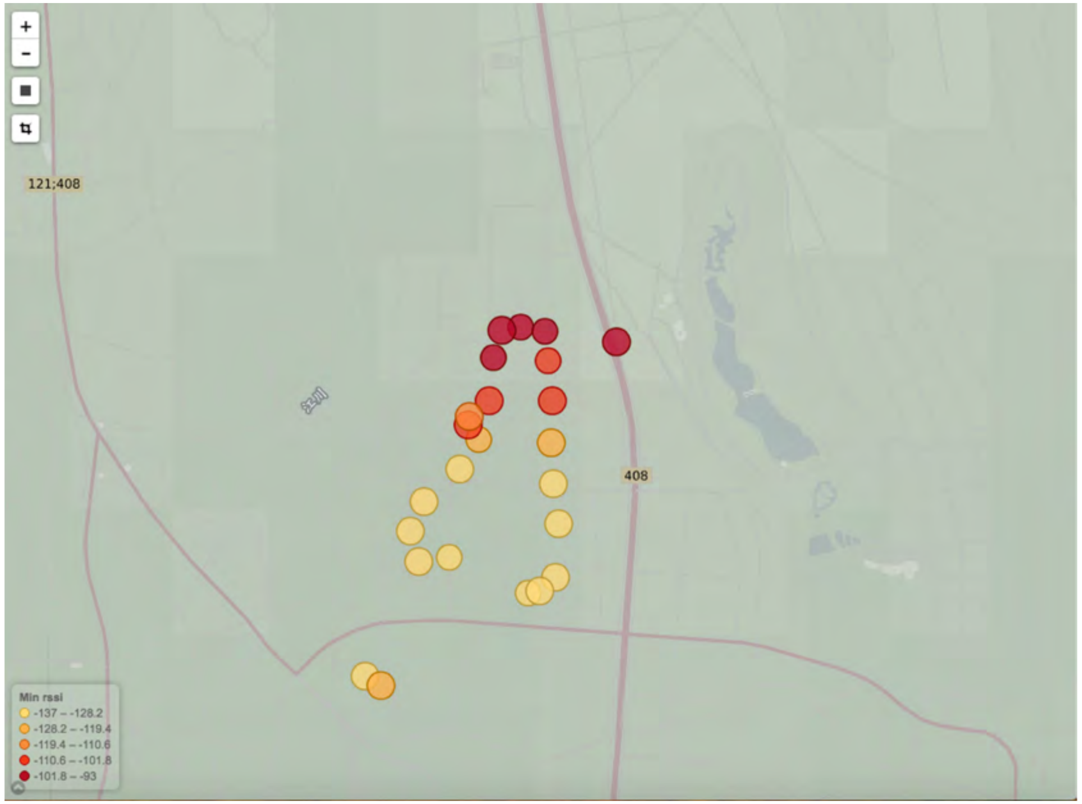
h_m(m): Mobile station height


Farm Area
LoRa Receiver
Point A
Point B
1.5km



Okumura-Hata Curve
Open Land
Surbubs
Medium City
Large City
Free Space
Power (dbm)
0
-20
-40
-60
-80
-100
-120
-140
-160
Point A
Point B
Receiving Power Limit (-142)
0
1
2
3
4
5
6
7
8
9
Distance (km)

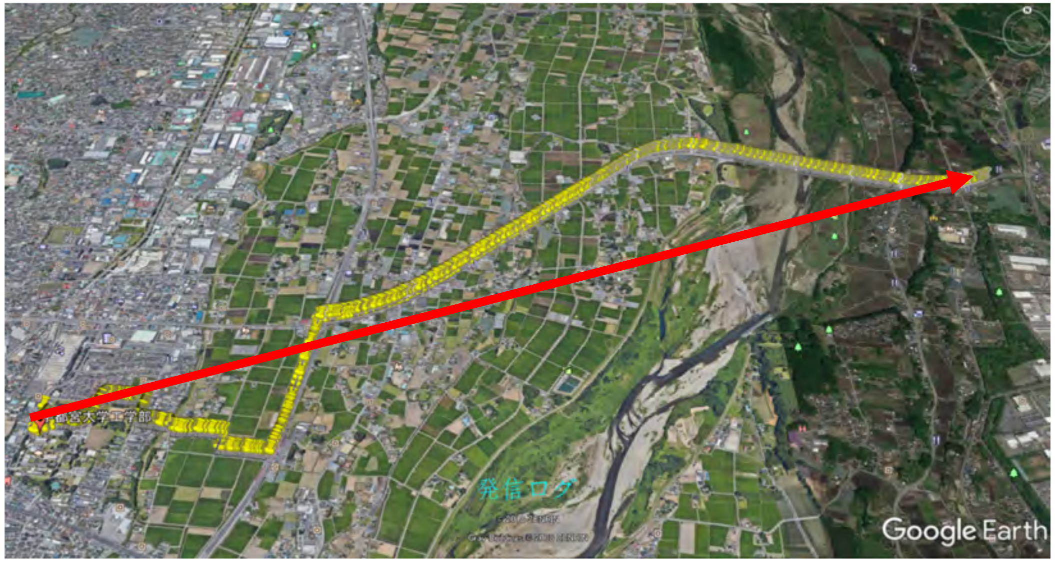
The farm of Utsunomiya University



1km x 0.5km

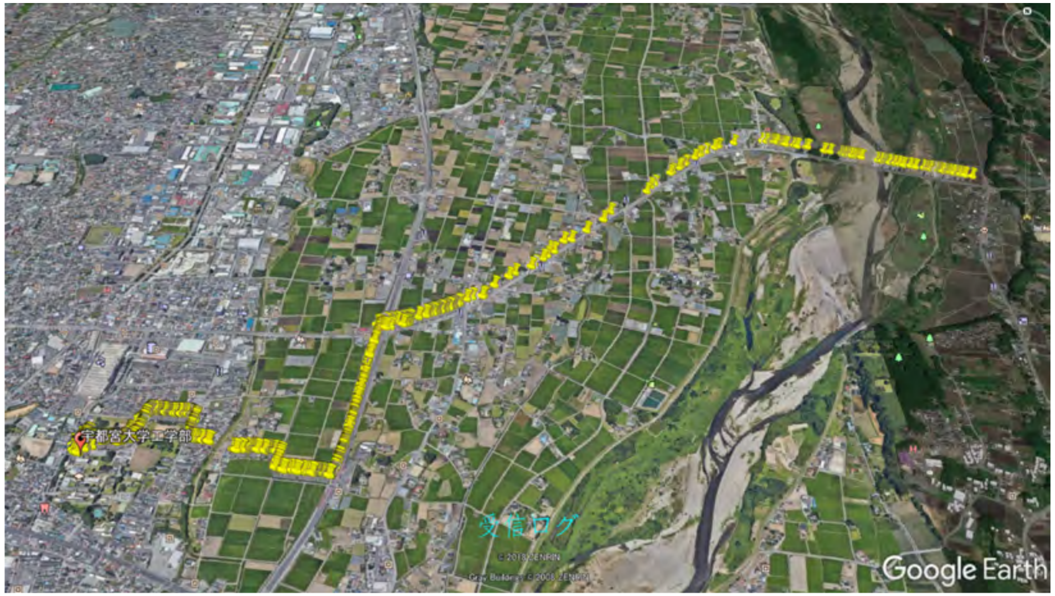
Another trial in Utsunomiya

Trace of transmitter
(sending GPS data)

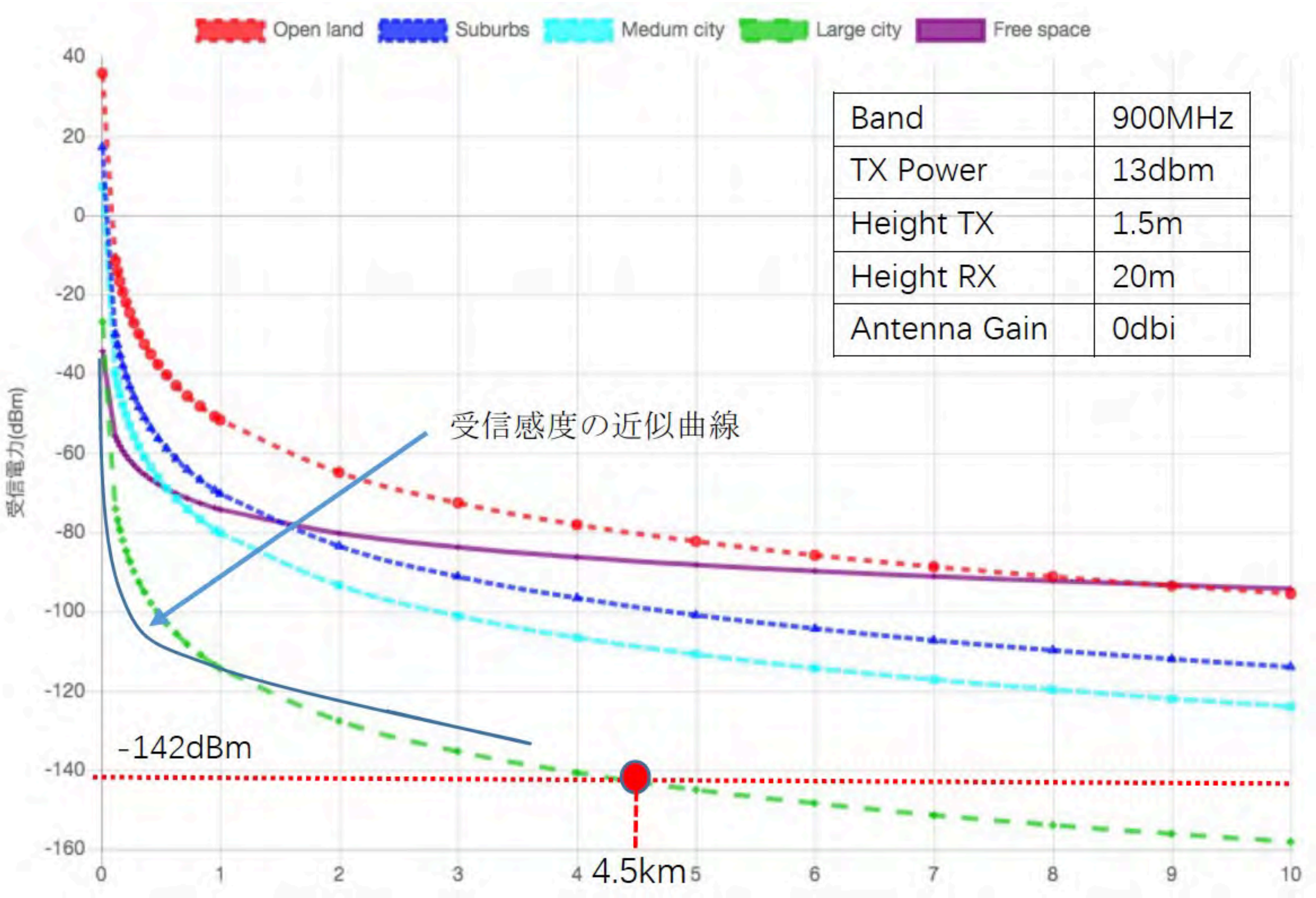


4.2km

Plot of received
GPS data



Okumura-Hata curve



Band	900MHz
TX Power	13dbm
Height TX	1.5m
Height RX	20m
Antenna Gain	0dbi

Devices

Cloud

3G/4G

Cow's sensor with solar panel

LoRa

Zigbee

LoRa Basestation with solar panel

Conclusion

- The feasibility of using LoRa to monitor cows' behavior and health condition was proved because LoRa can send data such as location (GNNSS) about 2km on the real farm in mountain area (Ozasa farm).
- As the next step, we would like to estimate a cow's health condition and find the effectiveness of grazing to increase the quality of milk by AI.
- As we briefly addressed the broader scope of a new food chain business model based on the Society 5.0 context, we would like to construct the "sixth sector industrialization" of milk by using these technologies.

- Thank you for reading this slide.
- If you have questions, please contact the following email addresses.
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- Jinshan Luo (kingsamlawsan@gmail.com)