Agricultural Machinery and Smart Agriculture Which Contribute to Achieving "Sustainable Development Goals" (SDGs)

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1. Kubota Mission and SDGs

Since its foundation in 1890, Kubota has delivered a variety of products that contribute to people's lives and society, including iron water pipes for the development of modern waterworks, and agricultural machinery to increase food production and save labour.

The Kubota believes that its mission is to utilize its superior products, technologies and services to comprehensively solve problems of food, water and the environment, and to contribute to abundant and stable food production, safe water supply and regeneration, and the creation of comfortable living environments, thereby continuing to support the future of the earth and humanity (**Fig. 1**).

In 2015, the United Nations adopted 17 sustainable development goals (SDGs), including "ZERO HUNGER" and "CLEAN WATER AND SANITATION," as a set of common goals for the international community. We recognize that the direction of the SDGs is the same direction that the Kubota Group should aim for as a company by contributing to the world in the areas of food, water and the environment under the brand statement "For Earth, For Life." The Kubota Group will contribute to achieving SDGs in the areas of food, water, and the environment (**Fig. 2**).

2. Kubota Challenges for 2030 (Target Year for the SDGs)

2.1 Changes in Global Demographics and Land Area Under Cultivation

When we turn our attention to 2030, which is also the target year for the SDGs, we see that the world's population is expected to grow from the current 7.5 billion to 8.5 billion. This growth will coincide with a host of issues related to food, water and the environment - the business areas of the Kubota Group.

According to statistical data from the FAO (Food and Agriculture Association), the area of land under cultivation worldwide increased by only 12% from 1961 to 2008. Due to the growing global population, this means that the per-capita area of land under population is continuing to decline (**Fig. 3**). However, because further expanding the cultivated land area results in destruction of nature and the environment, in order to achieve sustainable agriculture, it will be necessary to increase the crop yield per unit of land area.

For this reason, Kubota is carrying out programs to address three major issues resulting from global demographic changes.

2.2 Growing Global Population

In addition to the greater demand for food throughout the world that will result from explosive population growth, diets will also be enriched with the higher personal incomes that follow economic development. Likewise, these changes are expected to not only increase the demand for food for human consumption, but also the demand for grains used for feed in the livestock industry (**Fig. 4**). In response to this issue, the Kubota Group is accelerating the development and supply of large upland farming tractors and implements as a way of supporting this global increase in food demand that requires further increases in productivity.

2.3 Growing Populations in Asia and Africa

In Africa, and particularly in Asia, urbanization is accelerating, and populations are flowing from rural areas to cities in search of prosperity. As a result, the populations of rural areas and farming areas in particular are declining, and there is a lack of persons engaging in agricultural work (**Fig. 5**). However, demand for food in Asia and Africa is increasing, requiring enhanced efficiency in food production. To address this issue, the Kubota Group is pushing ahead with the mechanization of agriculture to help improve agricultural productivity and boost food production in Asia and Africa.

2.4 Declining Farming Population in Japan

In Japan, the number of farms sending food to the market is declining as farming families age and more people give up on the agricultural life. Further declines are expected over the next 10 years (**Fig. 6**). On the other hand, the consolidation of farmland is accelerating, with an expansion in professional farms (run by agricultural business operators and leading farmers) that have 5 ha or more of land under cultivation. Improving profitability and productivity are important issues for these professional farms. To address these issues, the Kubota Group is supporting Japanese agriculture by promoting the “smart agriculture” that has become important worldwide.

3. Kubota Programs for Smart Agriculture

3.1 The Smart Agriculture Envisioned by Kubota

The twin foundations of the smart agriculture which Kubota is carrying out are automated operation of agricultural machinery and data-based precision farming. Linking the data from these two areas will make possible stable agricultural production with higher quality and lower costs. This is the smart agriculture envisioned by Kubota (**Fig. 7**).

3.2 Automated Operation of Agricultural Machinery

In order to address the large-scale decline in the number of farm workers, Kubota is conducting research and development for automated, unmanned operation of agricultural machinery utilizing IoT and robotics technologies. The change to automated, unmanned operation of agricultural machinery involves 3 steps (**Fig. 8**).

- Step 1 is automated steering technologies utilizing GNSS (Global Navigation Satellite System).
- Step 2 is automated and unmanned operation with manned supervision. At Step 2, the machine autonomously drives and performs the work while the person is primarily responsible for supervision. This can be done either while riding on the machine or from the nearby area. Cooperative work by manned and unmanned machines is also included in Step 2.

- Step 3 is complete unmanned operation by remote control. This includes control of multiple machines (multi-robot systems) and travel on agricultural roads.

Kubota has developed products for the Step 1 and Step 2 categories, and these have been on the market since 2016.

For Step 1, the company is selling rice transplanters with straight traveling function and large tractors that include auto-steering. Of these, the rice transplanters with straight traveling function are the first such machines in Japan to include an auto-steering function that uses GNSS and can be described as the pioneer of GNSS-equipped agricultural machines. The total number of these machines sold since their release is more than 5,000 (**Fig. 9**).

The rice transplanters with straight traveling function are characterized by a high level of accuracy which is achieved by an original Kubota control system that combines simple operations specialized for straight driving with an inexpensive D-GPS inertial measurement unit (IMU).

The M7 series of large tractors with auto-steering are capable of automatic steering not only when the machine is driving straight but also on curved routes (**Fig. 10**).

For Step 2, which is machines capable of automated operation with human supervision, Kubota sells autonomous tractors and combines that include an automated driving assist function. Of these, the SL60A autonomous tractor began trial sales in June 2017. This is the first tractor capable of unmanned driving and unmanned work with manned supervision in Japan (**Fig. 11**). The features of this machine include the following.

- It includes a RTK-GNSS unit that was developed by Kubota and performs high-accuracy position measurement, making it possible to automatically calculate the optimal work route and perform unmanned driving.
- Two tractors - one manned and one unmanned - can be operated by a single operator. In this case, because the operator of the manned machine is the supervisor, work efficiency is increased by 50% or more.
- The auto-steering function can be used for other purposes in addition to unmanned tilling and puddling work.

Because it is an unmanned machine, the SL60A autonomous tractor includes a variety of safety functions. In order to detect obstacles and persons, it is equipped with 2 laser scanners on the front and 1 on the rear for mid-range detection and a total of 8 ultrasonic sonar sensors for close-range detection. When these detect an obstacle or person within a certain area around the machine, the machine stops automatically (**Fig. 12**). 4 cameras for monitoring the surroundings are installed on the front, rear, left, and right of the cabin. The all-around image synthesized from these 4 cameras can be sent to the supervisor. The supervisor can view this image on a tablet terminal or on a monitor installed in the manned machine.

The other type of machine that is capable of Step 2 operation is a combine harvester that includes an automated driving assist function. This machine is an automated driving agricultural machine where the operator rides on the machine to monitor its operation (**Fig. 13**). The features of this machine include the following.

- The route is calculated to produce the shortest work time when harvesting work is performed. When the grain tank is full, the machine drives automatically to the location of the grain transport truck. When grain ejection ends, it moves to the optimal point to resume harvesting. This optimal route creation can be expected to reduce work times by approximately 10% compared to even an experienced operator.
- It allows efficient and accurate harvesting even by an operator who is not experienced, and places little physical or mental burden on the operator.

These combine harvesters with automated driving assist function have been on the market since December 2018.

Kubota is working to expand its lineup of autonomous agricultural machines. **Figure 14** shows the automated driving-capable rice transplanter, 100 h.p. class tractor, and head feeding combine which the company is developing. Of these, the 100 h.p. class tractor and head feeding combine are scheduled for release in the very near future.

For Step 3 - fully unmanned operation, Kubota is working together with government research agencies and universities for identifying issues and for developing element technologies. As one example, Kubota is collaborating with the Japanese government research agency NARO (National Agriculture and Food Research Organization) for the development of remotely monitored tractors. The company is also conducting research together with Kyoto University for the development of robot combines.

3.2 Data-Based Precision Farming

The core of Kubota precision farming is the Kubota Smart Agri System (KSAS). KSAS is a system that supports farm operations by utilizing agricultural machinery and ICT to collect work and crop information, and then using that information to achieve PDCA-type farm operations. Centered on the KSAS Cloud service, it is used to connect the office of the farm operator, KSAS-capable agricultural machines, machine operators, and others, and to exchange information among them. Visualizing and connecting various agricultural equipment and farm work data make it possible to minimize agricultural machinery down time, improve productivity, and produce high-quality crops (**Fig. 15**).

The starting point for PDCA cycle farm operations utilizing KSAS is a KSAS-capable combine harvester. This combine harvester contains 2 types of sensors that measure the taste and harvest yield of rice or barley as it is harvested and create data for each field. The first sensor is the taste sensor that uses infrared spectroscopy to measure the amount of proteins and moisture contained in rice or barley approximately once each minute and creates quantified data of the taste. The second sensor is the yield sensor that uses a load cell installed on the bottom of the grain tank to measure the harvest yield (**Fig. 16**).

The measured taste and yield data is collected and stored by the KSAS Cloud service over the Internet.

The KSAS user can design the optimal amount of fertilizer for each field based on the taste and yield data that was collected in the previous year. For example, if there is a field where both yield and the amount of contained proteins were low, the user can increase the amount of fertilizer in order to increase yield. The KSAS user can also refer to the collected data in order to easily allocate appropriate amounts of fertilizer to multiple fields. This aims to reduce impacts on the environment and achieve sustainable farming by eliminating excessive fertilizer application (**Fig. 17**).

By repeating this improvement cycle year after year, it will be possible to achieve farm operations that deliver both good taste and high yield while also reducing costs.

4. Conclusions

The expansion of smart agriculture which utilizes robot technologies and ICT for ultra labor-savings and high-quality production will be essential in order to achieve environmentally friendly sustainable agriculture in the future.

Kubota is continuing to develop agricultural machinery and ICT systems that support this smart agriculture. In addition to smart agriculture, Kubota also operates a sales business and service business and intends to provide total agriculture solutions that contribute to the achievement of SDGs (**Fig. 18**).

References

[1] FAO (2011) The state of the world's land and water resources for food and agriculture (SOLAW) – Managing systems at risk. Summary Report.

[2] Kubota Corporation, based on Cabinet Office and OECD materials.

[3] Kubota Corporation, based on Asia Development Bank data.

[4] Kubota Corporation, based on data from the Ministry of Agriculture, Forestry and Fisheries.

FIGURES

Figure 1 – Mission of Kubota – Kubota Global Loop.

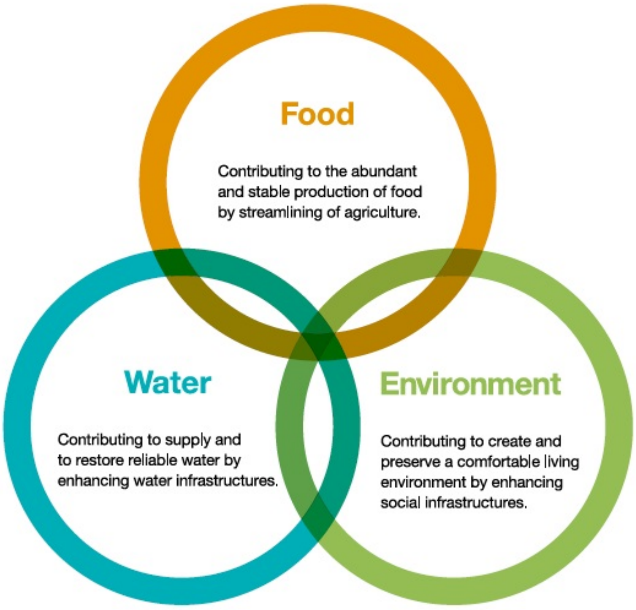

Figure 2 - The Kubota Group is Committed to Achieving SDGs.

Figure 3 - Evolution of Land under Irrigated and Rainfed Cropping *(Source: [1]).*

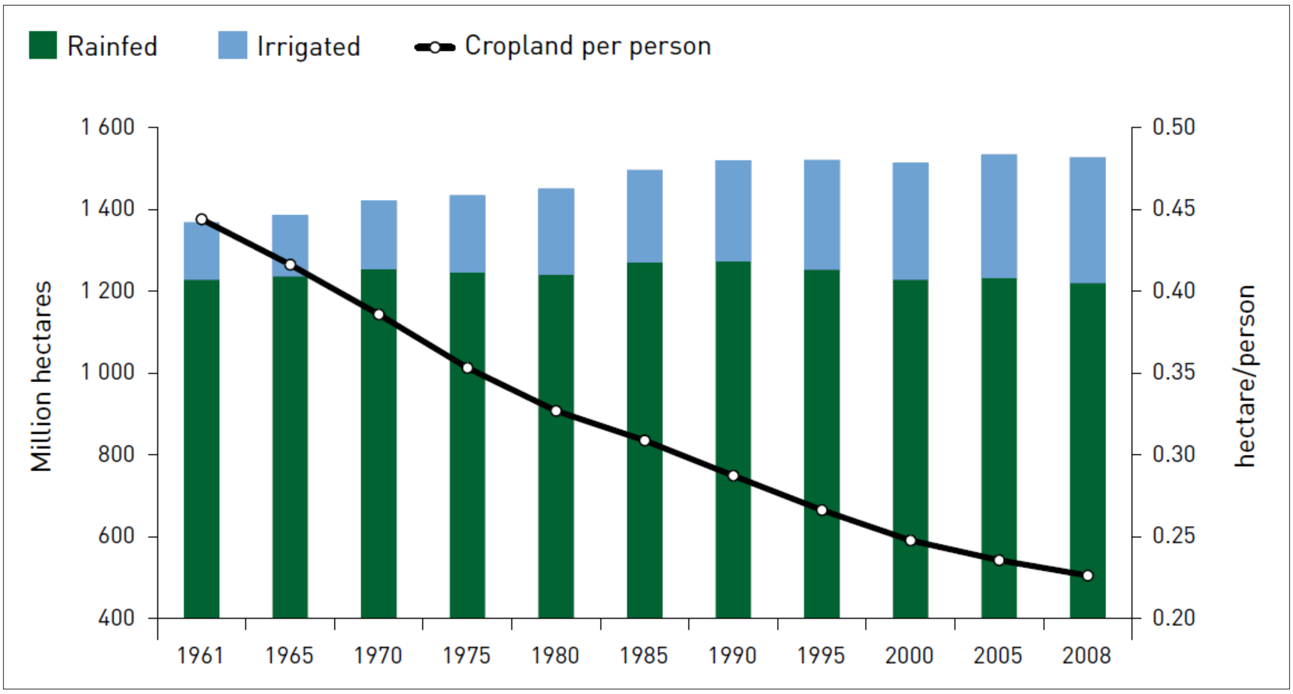

Figure 4 - The Middle-income Group's Share of the World's Population *(Source: [2]).*

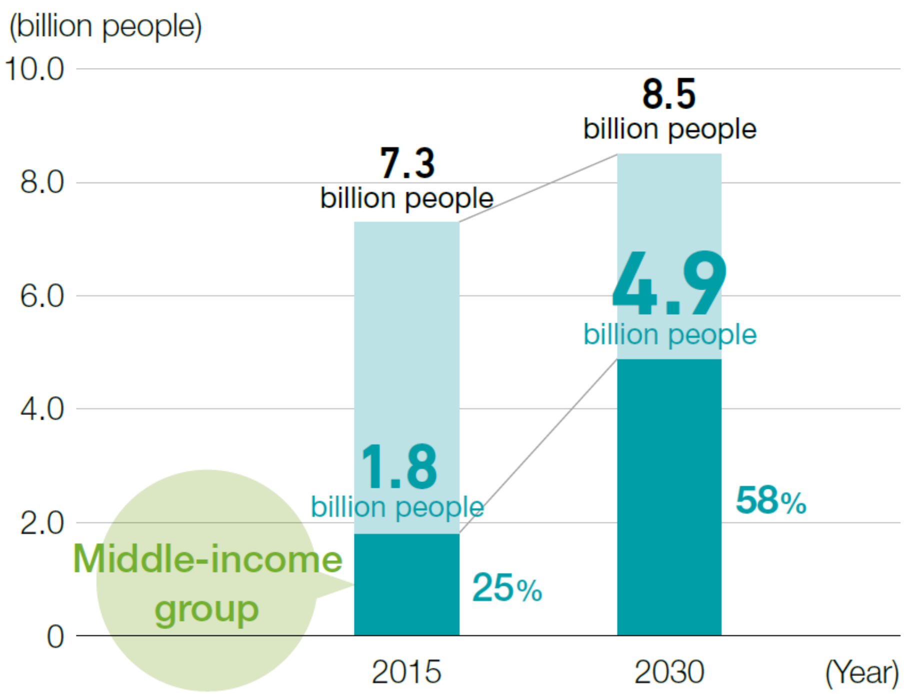

Figure 5 - Population Trends in Asian Cities and Regions *(Source: [3]).*

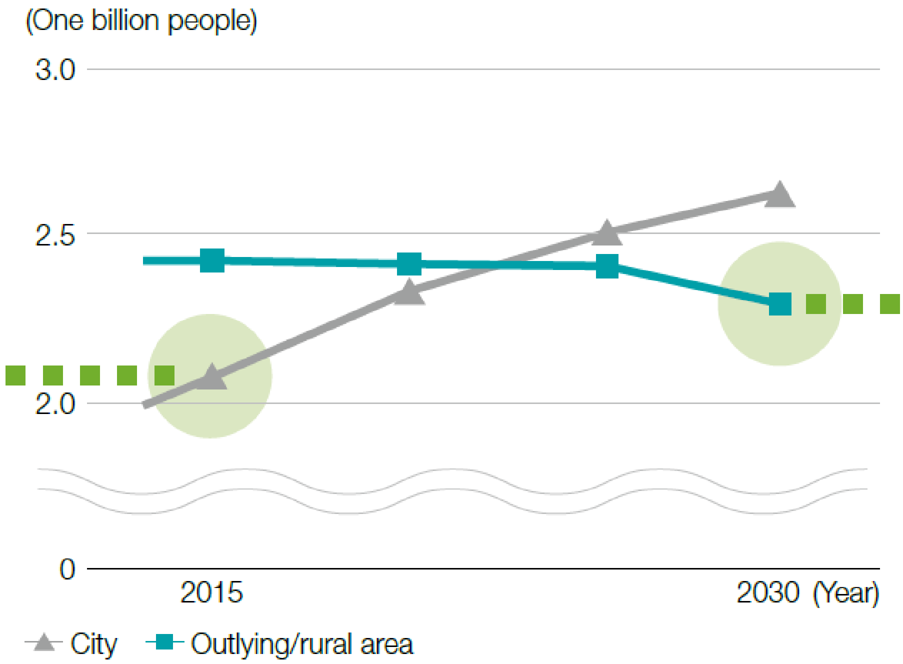

Figure 6 - Trends in Commercial Farming Households and the Average Age of Core Agricultural Workers *(Source: [4]).*

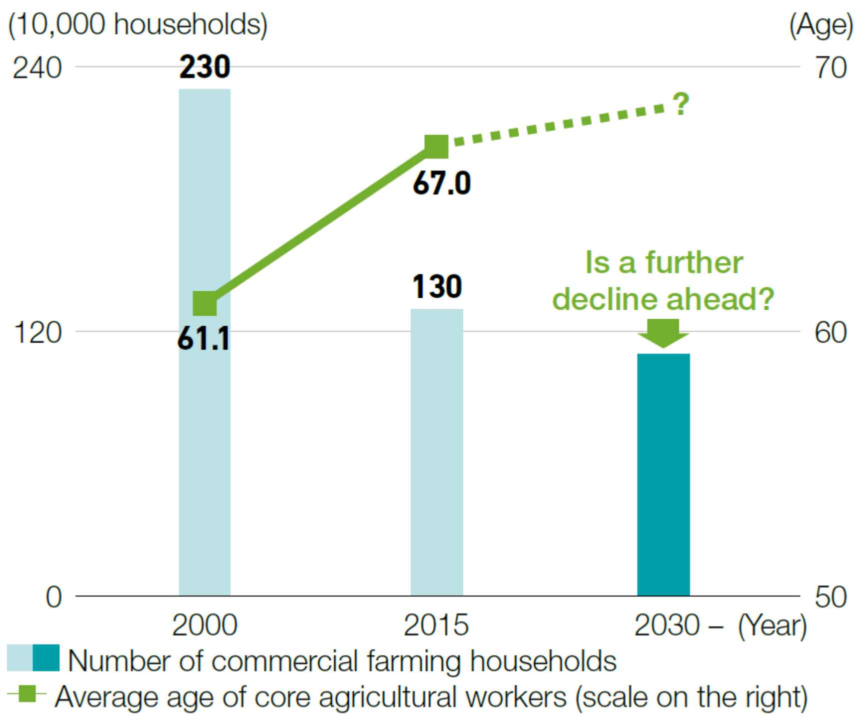

Figure 7 - Kubota Aims for Smart Agriculture.

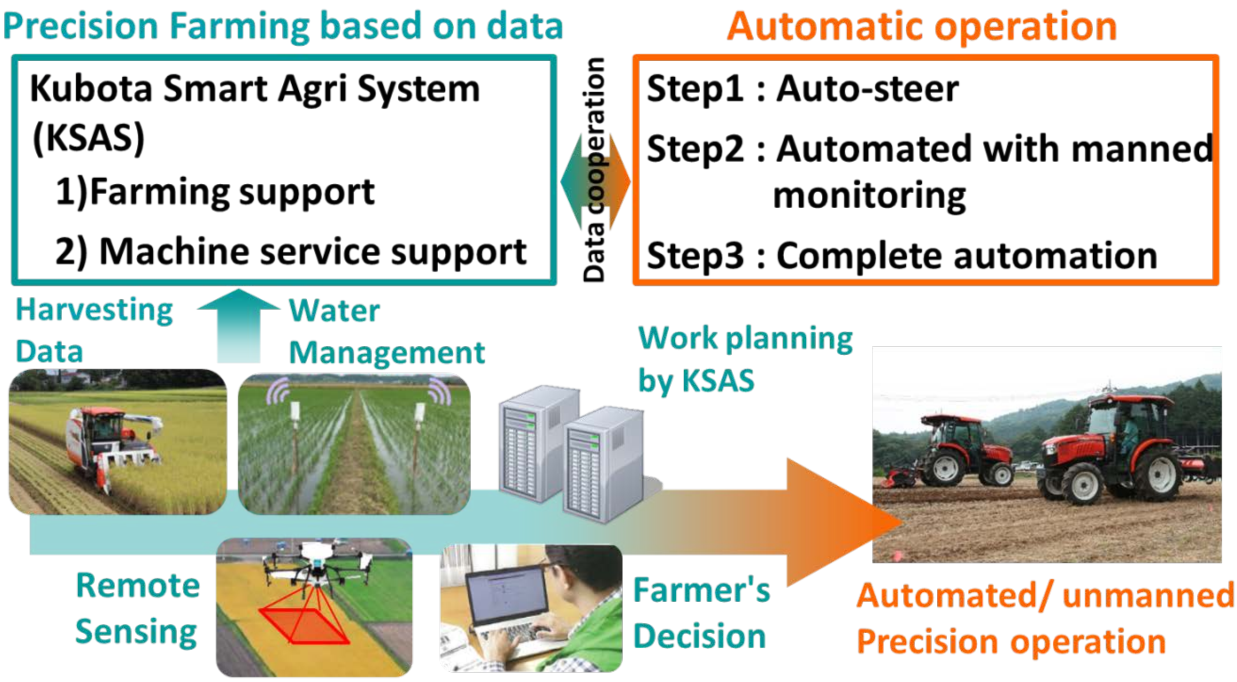

Figure 8 - Promoting Automated/Unmanned Agricultural Machinery.

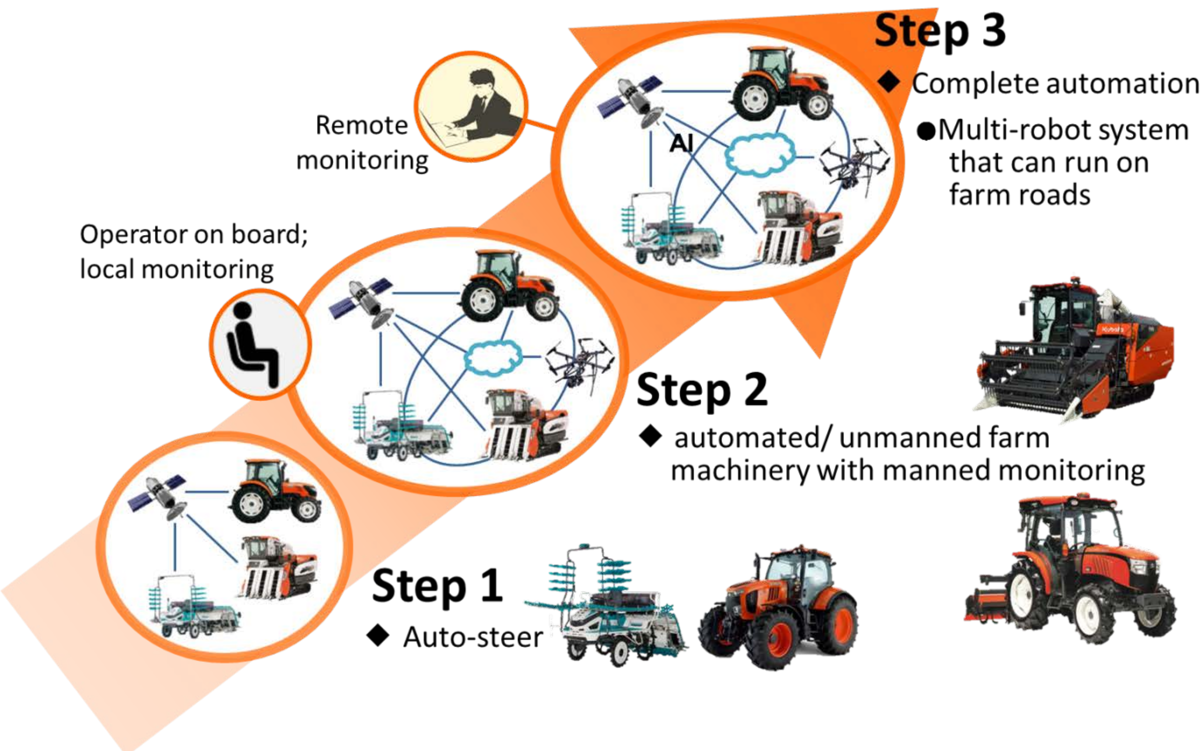

Figure 9 - Rice Transplanter with Straight Traveling Function: EP8D-GS.

Figure 10 - Agricultural Tractor: M7 series (Auto-Steer Capable).

Figure 11 - Autonomous Tractor: SL60A.

Figure 12 - Area to Detect Obstacles with Laser and Sonar (SL60A).

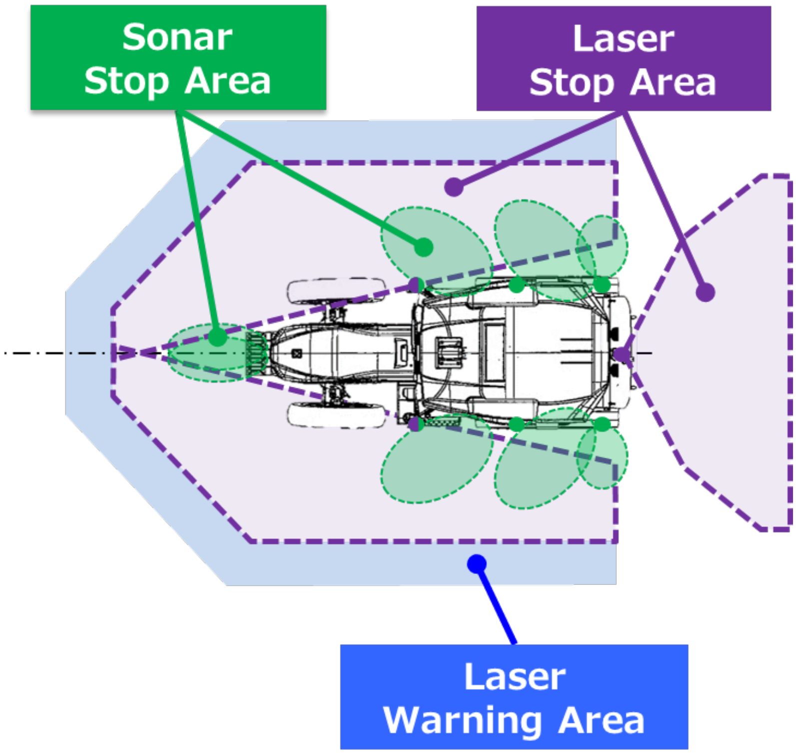

Figure 13 - Combine Harvester with Driving Assist Function: WRH1200A.

Figure 14 - Expansion of Lineup Automatic Driving Agricultural Machinery.

Figure 15 - Kubota Smart Agri System (KSAS).

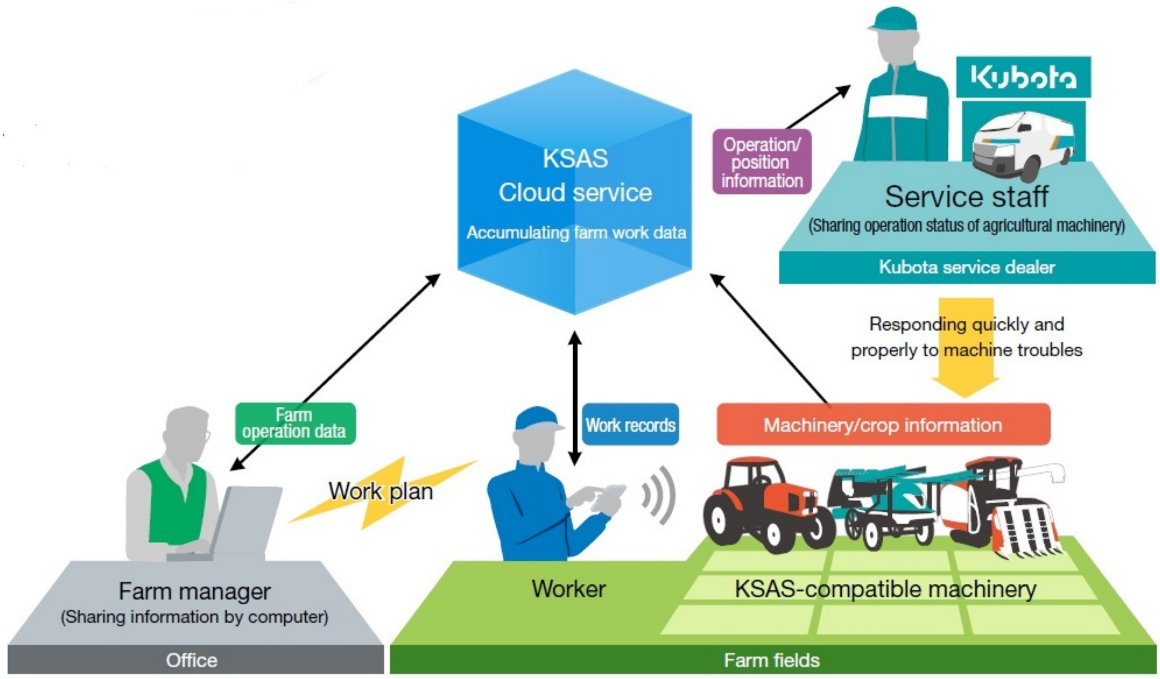

Figure 16 - Combine Harvester Mounting Taste and Yield Sensor (KSAS-Compatible Machinery).

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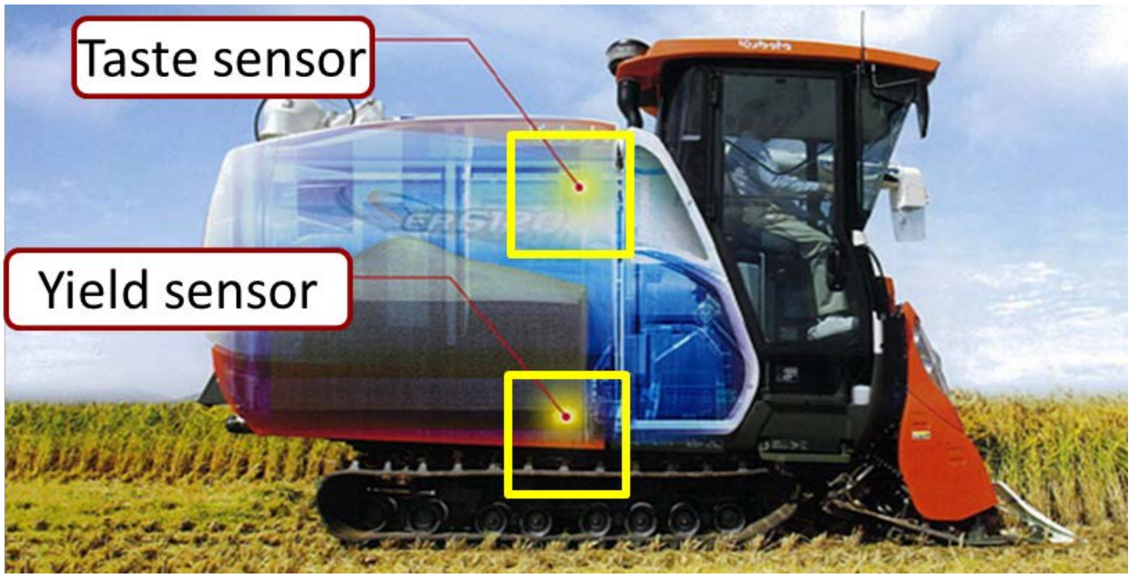

Figure 17 - KSAS Improvement Cycle (Harvesting Information and Appropriate Fertilizer).

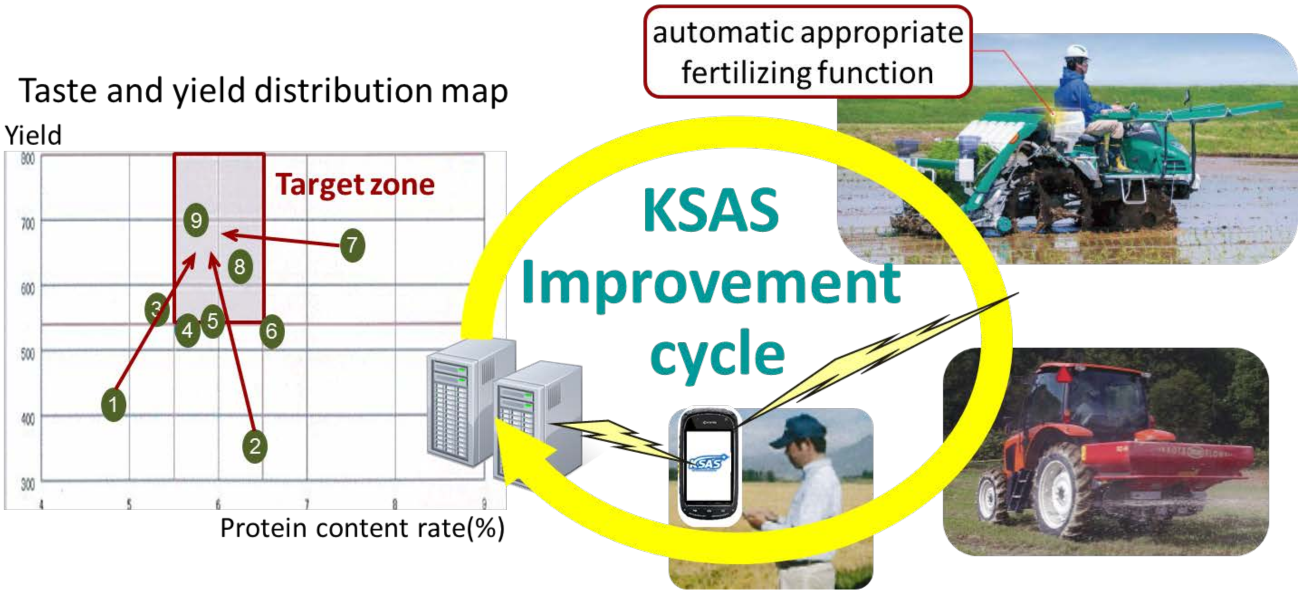

Figure 18 - Total Agricultural Solutions for SGDs (Provided by Kubota).