The Evolution and History of Environment-friendly Products and Services

Evolution and History of Kubota Tractors

Since creating the walk-behind cultivator in 1947, the Kubota Group has launched various compact, lightweight, high-powered tractors designed for upland or rice farming in Japan. Over time, we played a key role in the shift to mechanized, efficient farming methods by developing a wide range of new capabilities that reduced the burden of agricultural work. Looking ahead, we aim to help reduce the impact of farming on the environment through smart agriculture, which brings together high-precision farming methods based on ICT and IoT, and ultra-labor-saving farming using automated tractors.

Kubota Tractors: Evolution and Environmental Contribution

Decade	Social trends	Kubota's progress in tractor development	Environmental contribution
1940s	• End of World War II	• Started sales of diesel engine walk-behind cultivator (1947)	Phase 1: Develop compact, lightweight, high-powered products
1950s	• Depleted food resources and famine • Economic growth in Japan spurs shift in labor from rural areas to cities	• **Starts work on developing domestic tractors designed for Japanese agriculture**	
1960s	• Increase in farmers with a side job, elderly people and women working in agriculture	• **Develops Japan's first pure domestic upland farming tractor, the T15 (1960)** • **Launches first tractor for rice cultivation, the L15 (1962)**	
1970s	• Shift from "walk-behind" to "riding" farming • Boom in mechanized agriculture • Economic growth gathers pace	• **Launches ultra-compact four-wheel-drive tractor Bulltra, the B6000 (1971)**	
1980s	• Growing need for reduction of the burden from agricultural work	• **Develops automatic leveling control technology, Monroe Matic (1981)** • **Develops Bi-Speed Turn mechanism (1986)** • **Develops microcomputer-based automated control system for tractor attachments (1986)** • Switches to cleaner TVCS engines with lower exhaust gas emissions (1987)	Phase 2: Improve operating efficiency with additional functions
1990s	• EU introduces rules for exhaust gas emissions	• Develops transmission system with no need for clutch (1992) • Launches Power Krawler tractors (1997) • Complies with EPA Tier 1 regulations (1999)*1	
2000s		• Complies with EPA Tier 2 regulations (2004) • **Develops new energy-efficient and energy-saving functions, e-Assist Turn and e-Cruise (2007)** • Launches products compatible with biodiesel fuel (2008)*2 • Complies with EPA Tier 3 regulations (2008)	
2010s	• High fuel prices • Emergence of high-precision farming using ICT • Shift to robot technologies that enable driverless farming	• Complies with EPA Interim Tier 4 regulations (2012) • **Starts trial providing the Kubota Smart Agri System (KSAS) (2014)** • **Launches first tractor compatible with KSAS (2014)** • Complies with EPA Final Tier 4 regulations (2015) • **Starts trial sales of tractors with autonomous driving technology (2017)**	Phase 3: Eliminate inefficiencies with precision farming Phase 4: Shift to ultra labor-saving methods with automation

*1 Exhaust gas emission regulations based on US Environmental Protection Agency (EPA) standards for non-road diesel engines with power rating of 56–75kW

Click on the link below for more details about our shift to cleaner engines with low emissions
www.kubota.com/company/environment/ecopro/img/The_Evolution_of_Engines.pdf

*2 Please ask to your Kubota Group distributor about using biodiesel

(Phase 1) Developed Compact, Lightweight, High-Powered Models, Contributing to Conservation of Resources

Tractors imported from the US and Europe in the 1950s were large and expensive, making them unsuitable for agriculture in Japan from an operational and economic perspective. In contrast, Kubota developed compact, lightweight, high-powered tractors designed for Japanese farming methods. We also helped to reduce resource usage by lowering vehicle weight for each unit of horsepower.

	Example of European tractor models at the time	Kubota tractors		
Year	Around 1960	1960	1962	1971
Product name	Fiat tractor 411C* 	T15 tractor for upland farming 	L15 tractor for rice cultivation 	Bulltra B6000 utility tractor 
Weight (kg)	2,300	900	800	455
Power (PS)	40	15	17	11
Weight-to-power ratio (Compared with T15)	57.5	60.0	47.1 **(-22%)**	39.1 **(-35%)**

* Example of Fiat tractor that Kubota imported and sold in Japan

(Phase 2) Added Functions to Improve Operating Efficiency and Help Reduce Environmental Loads

Starting with the development of the Monroe Matic in 1981, the industry's first automatic leveling system, Kubota developed a range of additional new functions that made farm work easier and improved accuracy and efficiency, helping to reduce environmental loads.

Examples of Additional Functions That Reduce Environmental Loads

Monroe Matic

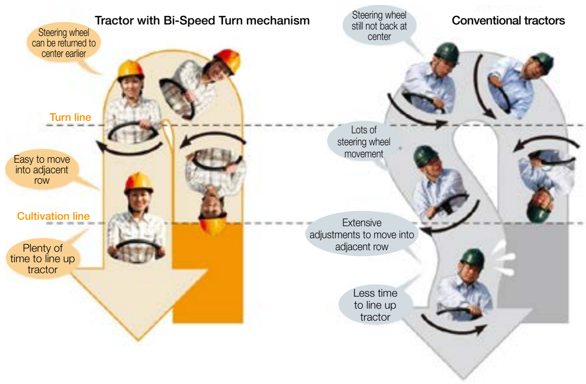
Monroe Matic is an automatic leveling control mechanism for tractor attachments that combines electronic control and hydraulic technologies. The mechanism allows farmers to level off fields and rice paddies in a single operation by preventing any slant in the tractor attachment, eliminating the consolidation of soil.

Labor saving | Energy saving | Soil cultivation

Bi-Speed Turn

When the steering wheel is turned sharply, Kubota's Bi-Speed Turn mechanism rotates the front wheels at around twice the speed of the rear wheels, resulting in a smoother, tighter turn that does not disturb the soil.

Reduced work | Energy saving | Soil cultivation



Microcomputer control

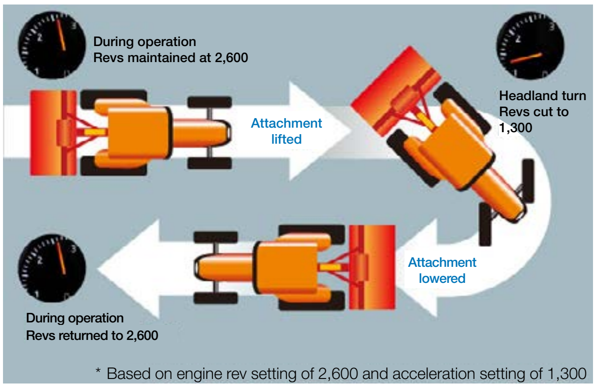
Kubota's microcomputer control systems enable automated control, allowing predetermined tillage depths and pulling power for tractor attachments and non-clutch operation of transmission systems.

Reduced work | Energy saving

e-Assist Turn

During turning, engine revs are automatically reduced by 50% when tractor attachments are lifted and automatically returned to normal levels when attachments are lowered. The system ensures safe and stable turning by giving operators more time, and also helps to save energy by controlling engine revs at appropriate levels.

Reduced work | Energy saving



* Based on engine rev setting of 2,600 and acceleration setting of 1,300

e-Cruise

During light operation, engine revs are reduced while ensuring tractor speed is maintained at a predetermined level. e-Cruise can reduce fuel consumption by up to approximately 38%*. The reduction in engine revs also helps to lower noise in the surrounding area.

* Based on reduction of 800 engine revs versus rated level

Energy saving | Low noise

Expected effects		Area
Labor saving	Work can be completed with less effort	Easy to work for customers
Reduced work	Tractors can be operated by anybody	
Energy saving	Fuel consumption can be limited when work load declines or greater precision is needed	Environmental conservation
Soil cultivation	Encourages crop root growth and ensures water permeability and affinity to protect crops against drought, reducing the need for excessive use of chemical fertilizers and other agrochemicals.	
Low noise	Lower noise levels during operation	

(Phase 3) Introduced Precision Farming to Eliminate Inefficiencies in Operations and Reduce Environmental Loads

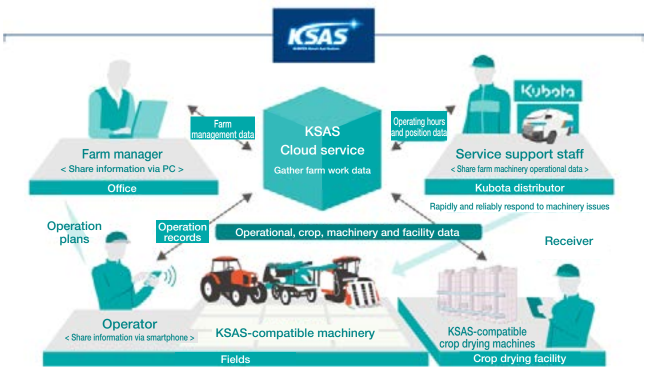
In 2014, Kubota started selling the Kubota Smart Agri System (KSAS), a farm management and service support system that uses ICT to link and integrate the operation of agricultural machinery. The system eliminates inefficiencies in operations and helps to reduce environmental loads through precision farming based on farm land, crop and other data.

Kubota Smart Agri System (KSAS)

KSAS visualizes farm management by integrating all types of information about farm land, crops and operations. The system can be accessed via smartphones and PCs. KSAS information can also be shared with compatible agricultural machinery.

Functions and environmental contribution of KSAS-compatible tractors

- Operational history automatically sent to KSAS. Farm work management based on operational history helps to prevent mistakes.
- Work according to the amount of fertilizer applied to each field set by KSAS. Prevents soil and water pollution caused by excessive application of fertilizer.
- Operating hours automatically sent to KSAS. Data is used to send appropriate maintenance information to customers, helping to prolong the life of tractors.



Click on the link below for more details about KSAS
https://ksas.kubota.co.jp/
* Japanese only

(Phase 4) Introduced Automation for Ultra-Labor Saving and Lower Environmental Loads

In 2017, Kubota started trial sales of the AGRIROBO tractor, which can operate autonomously under manned surveillance and is planning to launch on the market in 2020. To realize our vision for smart agriculture, we are improving integration between KSAS, autonomous tractors and other farm machinery to minimize the cost and environmental loads of farming.

Kubota Tractors – Auto-Steering and Autonomous Operation Functions

Auto-steering function

This function can automatically steer the tractor in straight lines or curves. Accuracy is high, with a margin of less than 10 cm in a straight line of 100 m. **High-precision operation can help to prevent wasteful fuel consumption.**

- Straight-line assist (GS: Go Straight) function: Automatic steering control for straight-line operation
- Auto-steering function: Automatic steering control for straight-line operation and curves

Straight-line test runs by GS-enabled Kubota GRANOVA Tractor (NB21GS)
Left picture shows results achieved with manual steering, right picture shows results with automatic steering, both by inexperienced operators. System also substantially reduces workload for experienced operators by maintaining straight-line accuracy

Autonomous operation function

This system allows machinery to be operated remotely under manual surveillance, with the operator starting or halting operations at any time. Precision GPS and autonomous operation technology enable highly accurate tilling and puddling work.
High-precision operation also has the potential to limit wasteful fuel consumption.

Test operation of one manned and one unmanned AGRIROBO tractor working in collaboration

Improving Integration with Tractor Attachments and KSAS

Tractor attachment integration

We have been developing control technologies based on information shared between the tractor and its attachment, helping to optimize operating speeds, engine revolutions and other performance criteria during operation. **Selecting the best operating speed for each attachment can help to limit wasteful fuel consumption.**

KSAS integration

We are using KSAS to build an operational support system for autonomous farm machinery. Our system will enable unmanned operation based on optimal routes, simply by transmitting predetermined plans for fertilizing and other farm operations to the autonomous tractor. **Appropriate application of fertilizer based on those plans will prevent soil and water pollution, while optimal routing has the potential to limit wasteful fuel consumption.**
Our aim is to further enhance data sharing between farm machinery and related equipment using KSAS in order to increase automation and establish autonomous control, helping to minimize the cost and environmental loads of farming.