Minato, Tokyo, a global innovator in urban farming, has the largest growth rate in the Tokyo Metropolitan Prefecture. Centered on the subtropical Japanese archipelago and bordered by Tokyo Bay, Minato is a densely populated, multi-level city. A nighttime population of 314,159 swells daily when commuters arrive. Citizens enjoy the highest longevity worldwide attributed to traditional cuisine. FACTories™ (Farming with Agriculture-Control-Technology) are technologically advanced indoor farms, which responsibly and sustainably ensure food security.

Dynamic farming practices were necessary to create an agricultural revolution. Food imports reached nine hundred billion ton-kilometers annually, resulting in increased fuel costs, environmental concerns, and spoilage during transit and storage. The average farmer was over sixty-five years old, and Japanese youth lacked interest. With only three percent arable land peppered with debris, saltwater, and toxins from past tsunamis, the solution was to implement farming in an indoor environment.

Structural and geotechnical engineers designed FACTories and determined locations – approximately 4,000 square meters each, forty meters underground. Rotating shield tunneling methods designed by mechanical engineers were used in combination with the installation of the maglev train. Utilizing vacated shafts cut start-up costs, and city resources provided affordable, ninety-nine year leases for the FACTories. Benefits of FACTory locations are geothermal mass reducing heating and
cooling needs, and secure structures that are less prone to disasters. Proper ventilation, firefighting equipment, system shut-off valves, and triple layer inflatable tunnel plugs ensure safety by blocking flood waters, smoke, and gas leaks. Earthquake-resistant support beams and the underground location allow FACTories to safely move with the earth. City planners project future underground development to provide ongoing connectivity.

FACTories are equipped with the most innovative hydroponic energy, light, water, nutrients, and air systems. Benefits include:

✔ Reduced fossil fuel usage
✔ Controlled lighting and climate
✔ Reduced natural resource usage
✔ Minimal labor costs
✔ Pesticide-free produce
✔ Vertical design requiring less land

FACTories are powered by hydrogen fuel cells which provide efficient, clean, and dependable electricity, heat, and water. Electricity operates the lights, water pumps, monitoring and automated nutrient systems. Heat pumps regulate temperature. Water supplies grow trays. Hydrogen is affordable by extracting hydrogen from steam, and rusted, recycled metal using a solar-thermal system. Double mirrored solar satellites reflect to a man-made island in Tokyo Bay, maximizing heat for the solar thermal system. Garbage and plant waste are converted into pellets using fluidized pyrolyzer technology to generate biofuel.

Broad-spectrum LED's illuminate above the plants between stacked shelves. Material engineers increase production with shatterproof bulbs, emitting only 3.4 BTU's of heat per hour. Most crucial to
this solution, agricultural engineers partnered with electrical engineers to optimize the perfect combination of red to blue lights: a four to one ratio, which replicates photosynthesis-fueling wavelengths. Cool-white light encourages leafy growth and is excellent for seedlings. By alternating light with darkness and dimming lights to mimic dawn, dusk, and seasons, optimal growth is achieved.

Water generated by hydrogen fuel cells fills grow trays (Figure 1) under each stack of shelves. The nutrient film technique gently bathes roots. Quartz-porphyry (QP), a natural, porous mineral, ionizes the water, improving quality and helps plants grow uniformly and vigorously. Ninety percent less water is used than in traditional farming since the only water consumed is what plants absorb.

The multidisciplinary Research and Development department invented an automated method that provides nutrients to accurately feed plants at optimal concentration levels, maximizing crop yield. Near-infrared spectrometers measure light absorption patterns of molecules within plants, ensuring ideal composition. Nutrients and pH are adjusted throughout every stage of the plant's growth.

Nanosensors monitor air quality and temperature. Air circulates through a crystal plasma field, filtering contaminates and providing necessary oxygen. Daytime temperatures range ten to fifteen degrees higher than nighttime. Relative humidity is maintained under sixty percent.
Traditional produce, dwarf soybeans (Leguminosae family) and komatsuna (Brassicaceae family), were selected by agricultural engineers as primary agricultural products. High in protein, soybeans are the main ingredient in tofu, soy milk, and soy sauce. Soybeans contain isoflavins, which neutralize cell-damaging free radicals. Indeterminate soy varieties use nitrogen-fixing rhizobia bacteria to convert nitrogen into usable form. They mature in forty-five days and are harvested using robotic arms which act as mini-combines. Komatsuna is a vitamin-packed, mustard spinach green that matures in twenty-four days. Upon harvest, the root is left behind for a second crop. This unique harvest reduces the strong traditional flavor to a mild leaf, complementing many traditional dishes and is often served stir-fried, boiled, or pickled. 100,000 soy plants and 350,000 heads of komatsuna are grown per season, per FACTory, adequately feeding Minato's citizens. FACTory produce is retailed in transit stations and on ground level through robotic silo elevator shafts. (Figure 2)

![Cutaway City View (Figure 2)](image)
With Japanese culture embracing this fresh outlook, quality produce is in high demand.

Education starts from the roots up with schools and businesses implementing FACTocubes™, scalable FACTories. FACTofridges™ (Figure 3) are revisions of the home refrigerator. No longer a haven for frozen, fatty, and sugary packaged foods, the efficient units now grow a variety of fresh produce with snap-in trays. Nutrient formulas and recycled plant waste are exchanged at silos for start-up trays. Healthier choices are made, leftovers are minimized, and fewer trips to the market are necessary. Industry standards are set, and social connectivity ensures that everyone has a “green-thumb.”
Start-up costs were a concern, and risks and tradeoffs were carefully considered. The probability for crop failure is low because separate water systems supply each tray. Portable hydrogen fuel cells are in place to overcome power failure. Solar energy and hydrogen fuel cells were chosen over natural sunlight to provide year-round growing seasons. No solution is perfect, but because of technological advancements and research, food sustainability has blossomed in Minato.

Word Count: 997


Food Inc. n.d. 2009. Film.


