
Where We're Going, We Don't Need Roads



By Robert U. Ayres , INSEAD

Infrastructure investment needs to change for the sake of sustainability.

Private investment in the automobile industry was a huge win-win for the United States in the early years of the 20th century. Led by Henry Ford's assembly line Model T, automobiles rapidly replaced horses for urban transportation. This eliminated a huge source of pollution at the time (horse manure) that had to be cleaned up and removed every day. The removal of horses also eliminated the need for grain to feed them, which freed up around 25 percent of crop land previously needed to feed horses.

This land could then be used to grow wheat for export and as the city motorised, the farms mechanised. This freed up workers, who moved to cities like Chicago and Detroit where they worked in factories making cars and tractors and earning more money than they did on the farms. Or they got jobs in the construction industry building highways and houses. This combination of factors helped the US to rapid growth in the "Roaring" 1920s.

But such a model of development is not working in developing markets such as China. The immense construction of roads has brought transport costs down but new roads have become clogged with cars and trucks. With a dense population and the slow process of clearing residents to build highways, infrastructure development has not kept pace with demand. Slow-moving traffic is one major reason for deadly air pollution levels in China.

Moreover, building new multi-lane highways involved paving over valuable farmland that had formerly provided food. Of course, new high-rise housing for the displaced people was built, but usually outside the central city, so the workers had to take long bus rides of three or more hours per day on congested roads to their jobs.

In China's race for development, power plants and factories have also contributed to the build-up of carbon dioxide in the atmosphere, which is a direct cause of climate change. Unlike US President Donald Trump, the Chinese leadership has recognised this fact and started decommissioning coal-burning power plants and shutting down coal mines. But the obsession with roads and car ownership continues. Meanwhile, China is littered with half-built steel structures originally intended for housing but now abandoned. This is a planning failure. The future needs plenty of infrastructure investment, but more bicycle paths and trams and less emphasis on highways.

Report from China

I was recently invited to Kunming in Yunnan province, China, to deliver a talk at a conference on planning. The host was the newly appointed provincial governor who is also the Communist Party Chairman for Yunnan. The organiser was the former chief planner of Singapore, Liu Thai Ker. The audience was high-level bureaucrats and planners who were interested in looking at methods of land usage and urban development.

I wanted to advise the planners to plan less for more highways and petrol-powered cars to fill them (which is what they are currently doing) and more for pedestrians, bicycles and public transport (especially by electrified rail). I needed a way to offer this advice without just focusing on negatives like climate change.

I told the delegates that the huge win-win the US achieved in the early 20th century by mass-producing cars does not apply to 21st century China. In fact,

there are strong arguments that more roads and cars will be a lose-lose proposition, the only winners being foreign auto manufacturers.

There is another investment opportunity, still in its infancy, that, if pursued intelligently, could be a true win-win for densely populated, urbanising countries such as China.

A vision for “vertical villages”

In brief, I call the win-win proposition the “vertical village”. While the US spread out with roads and freed up farm land to feed its growing population, China’s spreading and crowded cities need a different model. China’s cities are bigger than those in the US and they’re clogged with increasing numbers of cars. China has 14 cities of more than 5 million people, with the populations of Beijing and Shanghai around 20 million people each. Due to the distance of the inland interior from the big cities, huge supply chains exist to ferry farm produce to populated areas, contributing to the congestion.

The vertical village takes the form of urban agriculture integrated with high-rise residential structures. In this vision, vertical towers should produce all of the green vegetables, root crops, berries, poultry and fish consumed within each cluster. They would utilise programmable LED lights to grow the crops. LEDs also consume less power than standard high-pressure sodium lamps and can be adjusted to produce light in specific wavelengths for photosynthesis to occur, optimising crop growth. Methods of farming would include vertical aquaponics or hydroponics, cutting water consumption dramatically.

help feed the world's growing population. How it would work:

SOLAR PANEL

Energy is supplied by a rotating solar panel that follows the sun; drives interior cooling/heating system.

GLASS PANELS

Clear coating of titanium oxide collects pollutants and makes rain slide down the glass where it is collected and used for watering.

ARCHITECTURE

Circular design allows maximum light into center.

ECONOMY

The plan combines farming with office and residential stories.

IRRIGATION

Filtered, sterilized wastewater from sewage system can be used for irrigation.

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SOURCE: Vertical Farm Project



Tree crops (fruits and nuts) and vines, requiring pollination, can be grown outdoors, where they can be integrated into recreational parks. Sewage from

clusters should be recycled in each cluster to recover plant nutrients and ('grey') water for irrigation. Seed crops (grain) and large animals will still be produced on more conventional farms (at least for the present), but some of the land formerly occupied by houses and roads can be reclaimed for agriculture or recreation. Moreover, food produced locally is fresher and tastier than food produced far away.

All of this frees up agricultural land that can be used for animal husbandry or fish farming. Given the increasing demand for meat from the growing middle class in developing countries, this will be a welcome development.

But how do we power vertical villages? While solar panels and wind farms present opportunities for zero emission power generation, they cannot provide for all human needs at all times. This makes it difficult to integrate solar and wind farms into power grids, which now require significant "base load" capacity (coal-fired, hydro-electric or nuclear).

Another alternative is an idea borrowed from hydroelectric power generation called "pumped storage". At times of surplus solar or wind power, water is pumped uphill to a reservoir, and then released downwards through a generator when needed to generate off-peak power. A fully integrated electric power system for a cluster would include pumped storage in high-rise buildings.

Vertical villages could also be linked to each other, like beads on a necklace, leaving more "green space" between them than existing suburban settlements depending exclusively or largely on roads. One of the major advantages of this scheme, especially for a densely populated country like China, is reduced land requirements for transportation, releasing urban land for recreational and other purposes.

In practice

There are already some versions of vertical farms in operation. One firm, called *Local Roots*, was founded in 2013 in Los Angeles and exemplifies this idea. It "designs, builds, deploys and operates productive indoor farming solutions" around the world. It mainly promotes hydroponics as an answer to California's continuing drought (it claims 97 percent less water use than conventional irrigated farms).

But the signature product of the firm is a “farm” in a packing case, using LEDs, that produces baby salad greens equivalent to the production of a five-acre field. The first crops coming from the shipping containers may be baby salad greens, but they will be followed soon by other greens like kale and spinach, then tomatoes, strawberries, blueberries, maybe even root crops like carrots and beets.

A more recent ‘start-up’ (2016) called *Square Roots* (co-founded by Elon Musk’s younger brother, Kimbal) is located on a Brooklyn parking lot in an urban vertical farming incubator. Entrepreneurs farm and sell produce raised in shipping containers onsite. It requires electric power – comparable to a refrigerator -- and some water, but 80 percent less than a conventional greenhouse. The farm in a shipping container uses no natural light, but depends entirely on artificial light provided by low power red and blue LEDs. Incidentally, the area inside the shipping containers (320 square feet), is said to be equivalent to two acres (87,120 square feet) of horizontal ground. That is a ratio of slightly over 27:1. If successful, young Musk’s company will open more farms in New York and other urban areas in the US.

There is a huge opportunity for China, given that there are literally thousands of clusters of partly built steel structures that were intended for housing but have since been abandoned after the housing bubble burst several years ago. Reviving such structures as vertical villages to re-house rural populations releasing yet more land could quickly and easily demonstrate a path toward a much more sustainable future. China has the political power and will to make it happen. In the absence of American leadership on climate change under President Trump, let’s hope they do.

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About the author(s)

Robert U. Ayres was an Emeritus Professor of Economics and Political Science and Technology Management and the Novartis Chair in Management and the Environment, Emeritus at INSEAD until his passing in 2023.