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China, sustainable agriculture

China: vertical farming as a way to fight hunger

In 2050, huge food shortages are expected. By that time, farmers will not be able to provide enough food for the growing world population. In addition to this, we will not be able to use a lot of land for food production, because of climate change and salinization of agricultural land. The increasing shortage of agricultural land is putting our food production at risk. However, this is not just a problem of the future. In China, only 10 percent of land can be used for the production of food. This does not seem like a big problem, but a fifth of the world's population lives in China and is completely dependant on Chinese food production in emergencies. In conclusion: China soon needs to find a way to produce a lot of food, before disaster strikes.

Introduction to China

China is one of the biggest countries in the world, with about 1.44 billion inhabitants (Business Insider Nederland, 2019). 64% of the Chinese population lives in urban areas and 36% of the population lives in rural areas (Statista, 2021). The climate in China changes throughout the year. Summers in China can be very hot and rainy, whereas winters are dry and cold. Because China is such a large country, the climate is different depending on where you are (Encyclopedia Britannica, n.d.-b). China is a communist country, the Communist Party of China (CPC) makes most of the decisions in China (BBC, n.d.-b). There are some other parties, but they all support the CPC and there is no/barely any opposition (BBC, n.d.-a). Almost all media in China are government controlled, there is not a lot of press freedom. As in any country, wages are unequal in China. Some make \$172 a month, whereas others make thousands of dollars a month. Every area of China has a different minimum wage, so how much money you make depends on where you live (Zhou & Zhang, 2021).

Agriculture and food in China

Only 10 percent of Chinese land is suitable for cultivation, so there is not a lot of space for agriculture in China. More than half of the available land is not irrigated. In China, there are many environmental threats to agriculture, such as floods and droughts. Because of this, China's food production is constantly in danger (Encyclopedia Britannica, n.d.-a). Major crops and exports include rice, wheat, soybean, corn, tea, cotton and tobacco. The average farm size in China is about 2.5 acres, which is very small compared to farms in other countries. 2.5 acres is less than 2 football fields! In total, there are more than 200 million farms in China, 90 percent of which are 2.5 acres or less. Because of this, food security is not easily manageable (Mcmillan, 2018). Because of urbanisation and the production of processed food, Chinese people are eating more sugar, salt and oil and not enough fruit and vegetables. An unhealthy diet like this can lead to multiple diseases, such as cardiovascular diseases and cancer (World Health Organization, 2019). China should provide their citizens with more fresh fruit and fresh vegetables.

The challenge

China is a large country, and with the land that is currently available, they need to import a lot of food to feed all the citizens of China. If there are import restrictions in the future, because of pandemics or other disasters, China will need to provide lots of food for themselves. In order to do this, China needs a way to introduce sustainable agriculture to citizens. This is especially important for urban areas, as they fully rely on supplies from rural areas. Urban areas should be able to produce their own food, to remove pressure from rural farmers and to enhance food security. Sustainable agriculture is very important, because food production and agriculture lead to pollution. If China produces more food in traditional ways (on fields, in greenhouses etc.), it would take a huge toll on the environment. This is why China needs to produce food in modern and environmentally friendly ways.

The solution

There are a lot of possible solutions for the challenges China faces when it comes to sustainable agriculture, but one of the most promising solutions is vertical farming. Vertical farming means that crops grow in vertically stacked layers (Urban Green Farms, 2016). By doing this, it's possible to produce food on a large scale in tall buildings. In vertical farms, crops can grow year-round. In addition, vertical farming requires far less space than traditional agriculture. 1 hectare (2.471 acres) of land in a vertical farm is equal to 4-6 hectare (9.884-14.826 acres) of farmland (Kalantari et al., 2018; Wright, 2018; Wageningen University & Research, n.d.). In vertical farms, the conditions in which plants grow can be adjusted in such a way that the amount of vitamins in the product is perfect (Nederland Voedselland, 2017). This means you might not need to eat as much of a product to get enough nutrients. Because of this, we may be able to feed people with less food (per person) in the future. Vertical farming is extremely sustainable as well: for example, only a fraction of the water needed for traditional agriculture is needed in vertical farms and pesticides are not necessary.

In short, vertical farming sounds like a promising technique for China to cope with food shortages in the future. However, there are some drawbacks to vertical farming. The high costs of building and maintaining a vertical farm are often seen as the biggest disadvantages. So we need to find a way to lower these costs or to increase profits. One of the easiest ways to save money in a farm, is to optimize the pollination of crops. At the moment, the pollination of crops in vertical farms is very inefficient. In nature, insects pollinate plants, but this has proven to be very difficult for insects in vertical farms. For example, how would an insect orient without the sun? Because of this, all pollination in vertical farms is done by hand (Croptracker, 2019; E&C, 2020; Evergreen Farm Oy, 2018). This costs a lot of time and money (Leblanc, 2020). Vertical farms are mostly located in cities. In cities, wages are often higher than in rural areas. That is why owners of vertical farms need to pay their employees a lot of money. This way, costs continue to add up (The European Business Review, 2020). If this problem isn't solved, pollination might become a major obstacle when trying to realise a new vertical farm or when maintaining an already existing vertical farm.

To take up the pollination challenge, China will need a lot of knowledge about the pollination of crops. Crops can be pollinated in numerous ways, but not every technique is applicable in a vertical farm. On traditional farm land, most crops are pollinated by the European honey bee (*Apis mellifera*). However, these bees cannot function in a vertical farm without direct sunlight (Molenaar, n.d.). It is often assumed that this is the case for all insects. However, nothing could be further from the truth: the bumblebee (*Bombus terrestris*) and lots of types of hoverflies (Syrphidae) can pollinate crops in vertical farms (own research, unpublished). These insects don't orient with the position of the sun, but they do need UV-light to be able to see (Tom, 2019). Using bumblebees or hoverflies is way more efficient than manual pollination. There have been experiments with bumblebees in vertical farms: in the vertical farm RIAT in Russia, bumblebees are used for the pollination of crops (Signify, 2020).

These bumblebees don't experience any disadvantages due to the lack of daylight. Using hoverflies for pollination is also an option, but there has not been a lot of research in that area. Hoverflies are extremely territorial in the wild and they usually migrate as well (Doyle et al., 2020). We don't know whether this affects the pollination in vertical farms.

At the moment, the most efficient solution for China is to use bumblebees for the pollination of crops in vertical farms. In the meantime, we need to do research regarding hoverflies and we need to develop new, more efficient ways of pollination in vertical farms. In the future, robots might take up this task. However, lots of research is needed before we can do that (James, 2020; Boffey, 2018).

The most important thing while developing and improving vertical farms is international cooperation. Technological progress can best be achieved through collaboration between experts and governments. The main authorities that are involved in introducing bumblebees in vertical farms in China are owners of vertical farms in China, the Chinese government, companies that sell bumblebees, international bumblebee-experts, electricity companies and researchers.

In order to be able to introduce bumblebees in vertical farms, a number of adjustments are necessary. First of all, the owners of vertical farms must ensure that their farm is safe for bumblebees to live in. In order to do this, they need advice from bumblebee experts. These experts can give advice on which adjustments need to be made in vertical farms. Some of the adjustments that are necessary include installing UV lamps and placing 'landmarks' for bumblebees. Bumblebees and bees often orient using landmarks (Abrol, 2015). An example of a landmark is a coloured sign. When placing a coloured sign, the colours that bumblebees can see must be taken into account. Bumblebees can only see yellow light, green light and UV light (Tom, 2019). A green sign is easy to see for a bumblebee, but a red sign is not. Special UV lamps must be installed as well, because bumblebees orient using UV light (Valoya, 2013). In the absence of this light, bumblebees see very little. Electricity companies can install these lamps. After all the adjustments have been made, the owner of a vertical farm should buy some bumblebee colonies. This can be done online, on the website of a company that sells bumblebee colonies. When the bumblebees have been delivered, the owner of the vertical farm should ensure that the bumblebees do not carry any parasites or diseases (Kaftanoglu, 2000). After this, the bumblebee nest can be placed in the vertical farm. The location of the nest must be chosen carefully so bumblebees do not fly against the wall and so they can easily find the nest again after flying off. A bumblebee expert can help with this. In addition, bumblebees should not be let out of their nest immediately, but after at least half an hour. Bumblebees also need food: sugar water solution. Once the bumblebees have started pollinating crops, constant research is still essential to maintain and improve pollination efficiency. To finance all this, government support is important. Ultimately, a lot of money will be saved in vertical farms, because the costs of pollination by bumblebees are much lower than the costs of manual pollination (Dogterom et al., 1998). Due to the lower production costs, the price of crops grown in vertical farms will be lower. As a result, owners of vertical farms may find themselves selling their products to more people than before.

At the moment, bumblebees are the most efficient pollinators in vertical farms, but in the future more efficient pollination-techniques may be introduced. An example of a promising technique is the use of robot-bees (Boffey, 2018). These robot-bees are not efficient enough yet, but research could improve their efficiency. For this, research is desperately needed. The Chinese government could fund this research.

Not only the use of robot-bees seems promising, but hoverflies seem to have a lot of potential to be marketed as commercially deployable pollinators (Doyle et al., 2020). Research is also needed to explore the full potential of hoverflies.

And last but not least: new ways of pollination can be developed. In order to do this, China needs to work together with other countries, because cooperation between countries often leads to new and innovative ideas. This way, vertical farms can be improved worldwide.

Conclusion

In conclusion, China needs more food security. Especially in times like these, where pandemics and natural disasters are no longer an exception. Sustainable agriculture is the key to food security. A promising and sustainable way of producing food is vertical farming. Vertical farms can provide China with a safe and stable food supply year-round. In order to make vertical farming more affordable, bumblebees can pollinate crops in vertical farms. Bumblebees can replace manual pollination to make products from vertical farms more accessible for consumers.

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