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Traditional Low-Efficient and Anti-Ecological Agriculture Must Be Replaced with Modern Cellular and Hydroponic Agriculture

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Abstract— *The article analyzes traditional agriculture as low-efficient, excessively resource-intensive, and anti-ecological and substantiates the need for its transition to modern cellular and hydroponic agriculture against the backdrop of an unfavorably changing climate.*

Keywords— ***climate change, climate resilience, cellular agriculture, hydroponic agriculture***

I. INTRODUCTION

It is evident that completely halting global climate change is unattainable. Alas, traditional agriculture is a low-efficient, excessively resource-intensive, and anti-ecological industry, and it is completely unsuitable under conditions of rapid unfavorable climate change.

So, huge losses of crops and livestock occur during becoming more frequent now extreme weather conditions: droughts, hurricanes, floods, etc. [1]. Agriculture consumes about 70% of freshwater and its consumption is growing every year (Fig. 1) [2, 3]. At the same time, both the area of arable land in the world and global freshwater reserves are rapidly declining (Fig. 2) [4, 5].

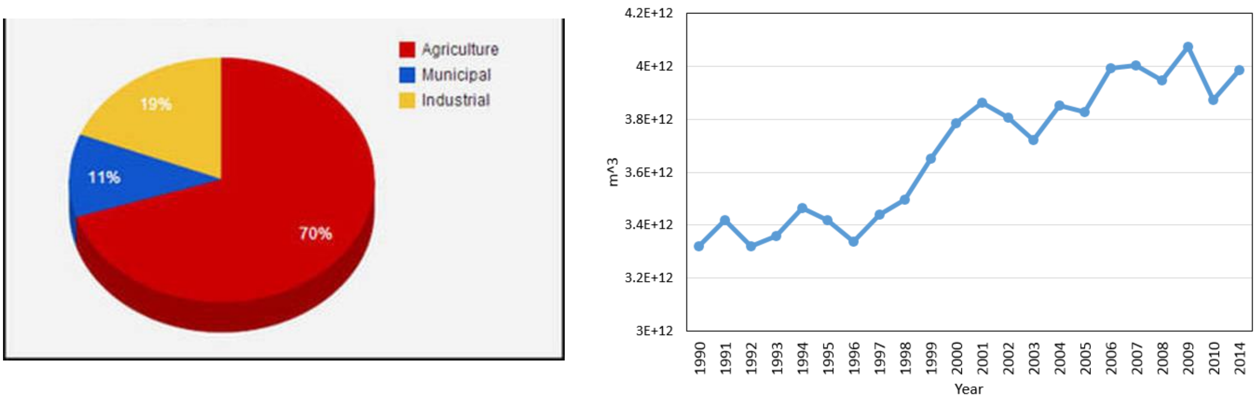


Fig. 1. Global water using (left, [2]) and World water consumption (right, [3])

It's worth noting that approximately 3 million tons of pesticides are produced and sprayed annually worldwide, which poses significant risks to environment and public health but current agriculture cannot do without it [6].

The "Lindeman ten percent rule" underscores that energy transfer from one trophic level to the next in ecosystems typically amounts to just 10% (see Fig. 3, left) [7]. Therefore, around the world, about 40% of arable land (150 million acres or 63 million hectares) is using for growing crops as food for breeding livestock and poultry (it is about 150 million tons) [8].

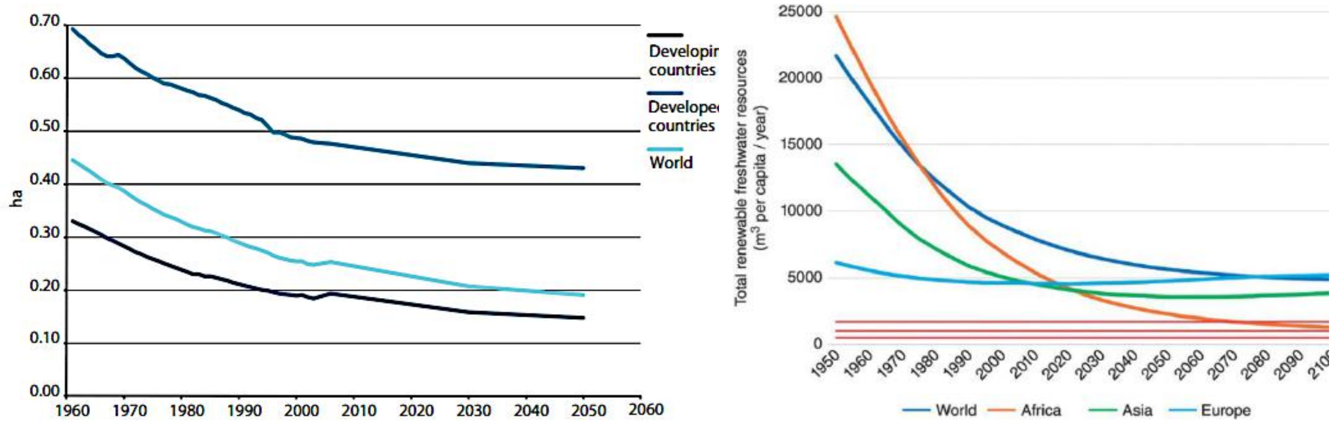
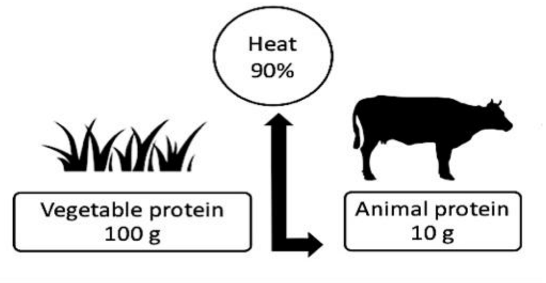
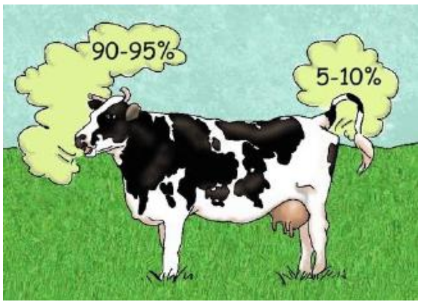


Fig. 2. Decreasing of global arable land area (left, [4]) and global water availability (right, [5])



Progressive loss of efficiency in food chain ("Lindeman rule") - only 10% of the vegetable protein will convert into meat protein, it is the efficiency of a 1900 steam locomotive!



Cow methane emission (burping – 90-95%, flatulence – 5-10%) –

total about 100 million tons of methane annually

Fig. 3. Low-efficiency and anti-ecological cow

Furthermore, the world's bovine population (exceeding one billion) emits roughly 100 million tons of methane annually, equivalent to 3 billion tons of CO_2 (see Fig. 3, right) [9]. With the planet's limited resources and threats of negative climate change, sustaining a billion cows is no longer viable.

Thus, in 20-30 years, under a significantly changed climate, the current agricultural system will become dangerously unworkable. But all of the above problems can (and should!) be eliminated by transitioning traditional agriculture to modern hydroponic and cellular agriculture.

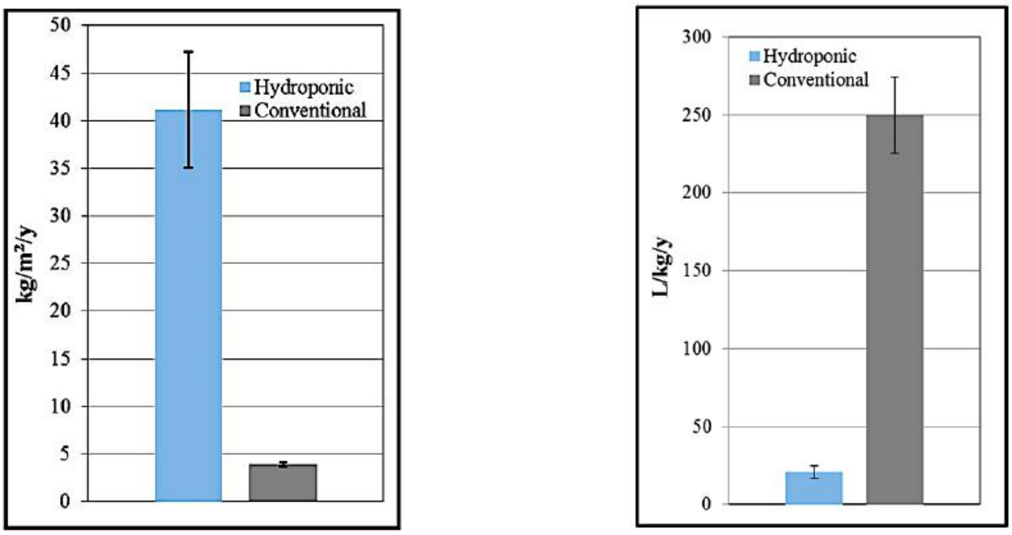
II. DISCUSSION

1. Vertical farms against crop failures, drought, and world hunger. The cultivation of numerous agricultural crops should transition to vertical farms using hydroponic methods within specially designed multi-storey buildings and 10-20-shelf racks on each floor of the farm [10] (see also Fig. 4 [11]). Additionally, numerous suitable unused buildings can be repurposed for vertical farming.

Fig. 4. Europe's biggest vertical farm "Nordic Harvest" in Copenhagen [11]

Vertical farms offer the following advantages:

- complete automation of growth and harvest processes;
- harvesting time is halved, and here you can have several harvests a year;
- crop stability independent of natural conditions including increased resilience to natural disasters, and this is the most effective counteraction to severe droughts;
- implementation of water collection and purification systems, reducing water consumption by up to 90% compared to traditional agriculture;
- potential for location within city limits, leading to a drastic reduction in transportation costs;
- vertical farming conditions negate the occurrence of pests, rendering the use of pesticides unnecessary;
- if a vertical farm is equipped with solar panels, mini-wind generators, and heat pumps, it will provide itself (partially or completely) with electricity and heat.



Modeled annual yield in kilograms per square meter of lettuce grown in southwestern Arizona

Modeled annual water use in liters per kilogram of lettuce grown in southwestern Arizona

Fig. 5. Comparison of water and yield for lettuce grown using hydroponic vs conventional agricultural methods [12]

As shown in Fig. 5 [12], the estimated yield of lettuce in hydroponics is approximately 10 times higher (kg/m²/year) than in an open field, while water consumption (L/kg/year) is 12 times less.

You must also understand: if there is a 20-story vertical farm building with an "internal" area of 20x50 = 1000 m², and on each floor there are 5 racks with hydroponics, then the real area of such a "field" is 1000x20x5 = 100,000 m².

Yes, even one vertical farm facility may require millions of dollars in upfront infrastructural costs and equipment but based on the totality of all factors, a vertical farm exhibits approximately 10-15 times the efficiency than of open-field cultivation. In addition, agriculture in Europe and the United States is hopelessly unprofitable. So, the US Department of Agriculture, in 2018, received 140 billion US$ of subsidies [13]. Wouldn't it be better to use this 140 billion to finance vertical farms?

P.S. As for fruits, we need to learn how to grow them using the hydroponic method too. For example, to grow in natural conditions 1 avocado, you need an average of 70 liters of fresh water, which is 14 times the amount of water needed to grow one tomato [14].

2. Cultivated (cell-based) meat against anti-ecological and low efficiency animal breeding. The imperative lies in shifting away from conventional animal husbandry towards cultivated

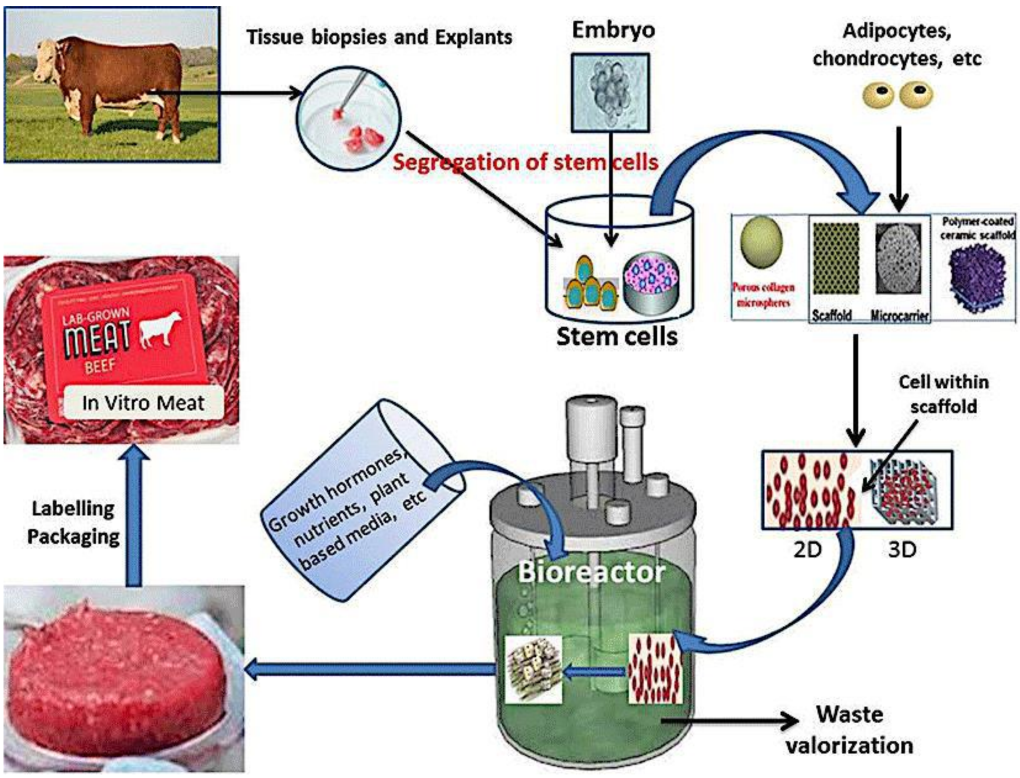


Fig. 6. Scheme of a possible technology for the production of cell-grown meat [15]

(cell-grown) meat produced from cow, pig, or chicken stem cells extracted from their muscles (see Fig. 6 [15]). Production of artificial meat requires five times less energy and 10 times less water than conventional beef production for the same quantity. It also reduces greenhouse gas emissions by 20 times compared to livestock farming. In sterile conditions, artificial meat eliminates the presence of parasitic worms, salmonella, and toxic metals often found in raw meat. The meat-grown technology in vitro should imitate the in-vivo conditions to get cultured tissue similar to natural. Tissue culturing is needed for preparation of high volume of structured meat.

Fig. 7. A future workshop for the production of 150 tons/year cell-grown meat, which will replace a herd of 2000 cows/year, will vacate 5000 hectares for sowing feed for them, and also will save environment from the emission of 200 tons/year "cow methane" (illustration by https://www.voxelmatters.com/meatech-wants-to-establish-and-operate-a-pilot-plant-in-2022/)

Fig. 8. Dr. Mark Post with the first cultivated beef burger, Aug. 5, 2013, Maastricht University

https://www.greenqueen.com.hk/10-years-since-that-burger-10-highlights-the-cultivated-meat-journey/

Moreover, an artificial "meat plant" occupies only 1% of the land compared to a conventional meat farm. In addition, 63 million hectares will be freed up, since there will be no need to sow them for feeding livestock and poultry.

Over 100 startups were dedicated to producing cultivated meat and seafood by the end of 2022. In 2022, the calculated cost of cultivated meat was about $17 per pound (≈$38/kg) [16] but with the transition to its mass production, prices for cultivated meat will eventually become equal to prices for natural meat.

3. Minimizing food wastage – it is fight against world hunger and a huge waste of energy and fresh water at all stages of harvesting and storing crops up to grocery store shelves and home dining tables. Approximately 800 million people out of 8 billion on our planet experienced partial or complete hunger in 2020. Astonishingly, the world produces roughly 4-4.5 billion tons of food annually, sufficient to meet global needs if utilized judiciously. Unfortunately, around 1.3-1.5 billion tons (approximately 30-35% of the 4-4.5 billion tons produced) are lost or wasted each year [17, 18]. It also leads to uselessly spending

20% of global freshwater and 15% of the world's produced oil annually. Given this, the financial impact of global food losses can be estimated at approximately USD 2.5 trillion. This wastage occurs at every stage, from production and processing to storage, transportation, and ultimately reaching grocery store shelves and any dining tables. The United Nations World Food Program (UN WFP) reveals that approximately 14% of food produced is lost between harvest and retail due to transit, storage, or processing issues.

Fig. 9. Where does food wastage and losses occur? [19]

Additionally, about 17% of food is wasted in households. In total, this amounts to a staggering **31%** of global food loss and waste (review authors [19] believe 39% - see Fig. 9). This has significant economic repercussions, as the World Bank values the global food system at roughly $8 trillion, hence, the financial impact of global food losses can be estimated at approximately USD 2.5 trillion. Beyond economic concerns, there are also environmental one: unused food not only perpetuates hunger but also spend uselessly 20% of global freshwater and a corresponding 20% of the world's produced oil annually (i.e. 20 million barrels per day are burned in vain.) Cellular and hydroponic agriculture can reduce food wastage by about 3 times - up to **10%**, hence, losses will be reduced to 0.8 trillion USD, and the savings in lost finances will be (2.5 - 0.8 = 1.7) trillion USD.

So, cellular and hydroponic agriculture can reduce food wastage by about 3-3.5 times - up to 10%, hence, this will bring an additional approximately 0.8-1 billion tons of food and 1.5 billion USD in profit annually.

III. CONCLUSIONS

Our planet no longer has enough resources (arable land, fresh water, etc.) to support the traditional low-efficiency, excessively resource-intensive, and anti-ecological agriculture, also including the use of 3 million tons pesticides.

Approximately 800 million people out of 8 billion on our planet experienced partial or complete hunger in 2020. **Cellular and hydroponic agriculture will end world hunger forever.**

Cellular and hydroponic agriculture can (and should!) become the newest multi-billion dollar industry with millions of jobs for scientists, engineers and workers. *(Another emerging industry with similar potential is "cellular cookery." However, for this sector to gain popularity, regional and global "cellular chef" competitions need to be organized.)*

Besides:

1. It will increase the yield by 8-10 times per 1 m^2 of area, while reducing water consumption by 8-10 times and also making the harvest independent of weather conditions.
2. Will free up millions of hectares of fertile land for other purposes.
3. Meat will become environmentally and biologically clean.

4. The atmosphere will be rid of 100 million tons of methane per year.
5. The production of 3 million tons of pesticides and their spraying above the ground will stop.
6. Food losses will be reduced by 3 times.

Of course, cellular and hydroponic agriculture needs large investments, tax benefits, a loud advertising campaign, etc. But rest assured that cellular and hydroponic agriculture will achieve widespread success in any case, since, in the face of negative climate change and depletion of natural resources, **there is no alternative to it, its triumph is inevitable!**

So, whoever manages to occupy this trillion-dollar super-promising and super-modern market cellular-hydroponic agriculture will become the "king of agriculture" of the 21st century.

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