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Review

Juxtaposing overpopulation, depopulation, and population optimum paradigms in the context of the Earth carrying capacity

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Abstract: Studies on the threat of overpopulation of the Earth have been, as a rule, closely related to optimum population studies. At the same time, studies on depopulation have been conducted entirely separately. This paper juxtaposes the main currents of research on these three issues, trying to find an answer to the question of whether the ideas of global overpopulation and local underpopulation can be reconciled on conceptual grounds. The main research method was an in-depth analysis of scientific texts on the three concepts mentioned above. It has been proposed, first, to come to terms with the irreversibility of demographic changes accompanying social change, and second, to appreciate the role of migration as a balancing factor reconciling the demands of proponents of both extreme concepts. The latter points to a research field that has been poorly marked in the literature, the subject of which should be the analysis of the possibility of balancing local population surpluses and shortages by means of migration processes.

Keywords: overpopulation; depopulation; population optimum; sustainable population; carrying capacity; migration

1. Introduction

The issue of the speed of growth of the world's population has troubled humanity since time immemorial. It was pondered by ancient Greek, Roman and Chinese thinkers alike [1,2]. The roots of modern scientific thought on overpopulation can be traced to Malthus' most famous work, An Essay on the Principle of Population [3]. Its modern reflections are the reports of the Club of Rome [4] or Ehrlich's widely cited *The Population Bomb* [5]. The common denominator of these works is concern for the living conditions of future generations, to whom the overexploitation of resources will leave a damaged environment.

Also dating back to antiquity are considerations about under-population of certain areas, with explicit pro-population policy pursued by Caesar Augustus as an example [6]. In the Middle Ages up to the Enlightenment, many European monarchies introduced laws to promote population growth [7], and some states continued these measures before WWII [8–10]. The rationale was usually the belief that larger population was advantageous due to increased military potential and economic development opportunities. Even today many countries implement pro-population policies in order to halt population decline or reduce the population ageing rate [11–15].

Simultaneous implementation of demands of both sides is not possible. The first pursue population reduction, while the second desire its increase.

Perhaps an effective attempt to reconcile the above contradictions could be the

concept of the population optimum, according to which there is such a population size of the Earth that will keep the long-term environmental equilibrium, while allowing its human inhabitants to develop in a social sense and live good life [16].

Confronting the above three concepts could lead to an indication of the need to pursue one of the postulated directions—reducing population or stimulating its growth—in order to achieve optimal population. The operational goal of this paper is to juxtapose the results of research on the three strands and to critically analyse selected texts. Expectedly, this will make it possible to answer the question of whether mankind should take measures to reduce population or to stimulate its growth.

2. Theoretical framework

Scientific works whose authors consider the Earth's population too large in relation to the planet's carrying capacity usually ignore the fact that there are works proving the need to stimulate further population growth. It can be attributed to a different perspective and differently defined goals. Those anxious about depopulation are focused on political, economic and social consequences and usually work within the dominant economic growth paradigm, while those concerned with overpopulation are focused on the idea of environmental carrying capacity or environmental sustainability. Development in the spirit of respect for the latter is usually understood as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [17] (p. 16), where balance between the environment, economy and society is emphasised [18–20]. In this context, a sustainable population can be understood as one that will allow nature and humans on Earth to operate undisturbed in the long term.

Among works combining considerations on both threads is the work of Kuhlemann. She describes concerns about population decline and ageing as 'primal' and 'tribal' while finding the answer to the economic and social problems of today's world in rejecting "*primitive rhetoric of irrational fears about population degrowth and aging ...*" (p. 187). These authoritative statements do not leave much room for discussion.

Daily et al. [21] express themselves in similarly harsh terms. The Earth's population reaching 5.5 billion at the time of their work was too large, and the Earth's capacity was exceeded. They comment the works proving that the Earth can support 150 billion people stating that these "*(...) assertions are based on preposterous assumptions, and we do not deal with them here*" (p. 470).

The bibliographic search revealed no scholarly work that would juxtapose these contradictory considerations in a balanced way. In the face of hundreds of thousands of papers dealing separately either with depopulation or with overpopulation this is surprisingly few—a refseek.com search indicates 237,000 documents on "depopulation", 382,000 papers on "overpopulation" and 13,300,000 documents on optimal population, while a combination of these three words yields only 12,600 texts. Papers that touch both overpopulation and underpopulation in most cases either search for optimum population of the planet, or aim at finding a solution for future worldwide ageing [22,23]. Not a single paper was found that conceptually confronted all three concepts. Perhaps this shortage is the result of fundamental differences in approach

and differently defined aims. After all, some view overpopulation as a problem for nature, while others for human well-being. For this reason, all three concepts will be presented in sequential order and discussed in the next section.

3. Results

3.1. Overpopulation

The fear of overpopulation has accompanied mankind since ancient times. Its expression was manifested in numerous attempts to determine the optimal population size, and then to eliminate excess population by physically eliminating selected categories of people [24]. In the Middle Ages and modern times, ideas of population control were also common and they generally led to the conclusion of the need to reduce the population size [25,26].

Contemporary consideration of overpopulation begins with an attempt to define the term in the spirit of academic rigor. The common denominator of various definitions may be that it is a population that exceeds a size calculated according to selected criteria [27]. The choice of criteria varies widely. Often the starting point is the well-known equation $I = PAT$, indicating the magnitude of human impact on the environment as the product of Population, its Affluence level, and level of Technological development [28].

Daily et al. [21] used the amount of energy consumption as a proxy variable of human impact. They concluded that the Earth could safely support 2 billion people. Pimentel et al. [29], using the criterion of agricultural areas, arrived at 3 billion people, while Pimentel et al. [30] indicate that only 2 billion people can live at European-like level. Dasgupta and Beard [31] give two surprisingly different numbers: 2.4 billion and 80 billion, as they adopt two different ethical assumptions of interpreting what is good. We can find further estimates in the works of Barney [32], Keyfitz [33], Demeny [34], Hardin [35], Holden [36], Cohen [16,37], Dixson-Declève et al. [38] and many others.

Many authors recognise that there is no way to objectively determine the optimal population, so they turn to the search for the maximum sustainable size. Lianos and Pseiridis [39] assume that the ecological footprint to biocapacity ratio should be like 1:1, because only then we can maintain long-term sustainability. They derive between 3.1 and 7 billion people, depending on the level of production. Lianos [40] obtains 2.5 billion people, using similar assumptions. Tucker [41] gets 3 billion, hedging this figure with the need to re-naturalise large areas and making optimistic assumptions about technological development. O'Neill et al. [42] and also Callegari and Stoknes [43] emphasise the importance of intentional reduction of social inequality to achieve long-term sustainability, from which it can be deduced that the latter is to a large extent a political and not technical problem.

A comprehensive summary of estimates of the Earth's capacity can be found in Rosset's [44] multi-threaded work. He recalls that in the 19th century the Earth's maximum sustainable population was put at 5–6 billion people. By mid-20th century, it dropped to 0.5 billion, and then rose to 2.2 billion, 8, 9, 15, 18, 27, 47, 50, 130 and finally 157 billion.

The clear majority of contemporary estimates point to values much lower than

the planet's current population, and to negative consequences of the status quo. Lianos [27] speaks of living at the expense of future generations, while Dasgupta and Dasgupta [45] emphasise imminent collapse of a system unfit for regeneration. Pimentel et al. [29] warn about condemning "*(...) future humans to a lifetime of absolute poverty, suffering, starvation, disease, and associated violent conflicts (...)*", while Bajaj and Stade [46] claim the need to challenge pronatalism, which they perceive to be the key to sustainable population.

Estimates indicating that further growth of human population is not a threat, because we still have a safe supply of resources and can continue to expand, are few. Some explain their approach using the concept of classical utilitarianism. It assumes that the goal is to maximise the sum of production of goods and services in the world, which is the good by itself [47]. Increasing the Earth's population results in an increase in total production, which is good, despite the unavoidable deterioration of the average standard of living.

3.2. Depopulation

Population decline also raises concerns, but mostly at regional scale. Declining birth rates lead to decline in the size of successive age cohorts, which undercuts the economic base over time, causing the working-age population to shrink, and accelerates population ageing processes [44]. It gives rise to negative economic consequences, particularly for the labour market and retirement pension systems. This process intensifies with outmigration, as the most mobile middle-aged people leave.

Projections pointing to radically lower future population of many countries raise fears about the future. Vollset et al. [48] estimate that populations of most highly developed countries (HDCs) will fall, sometimes even by half. Hidekazu [49] (p. 1), facing earlier projections for Japan's population falling to 50–60 million by 2100, says: "*Japan's social vitality and the vital forces of the state will be debilitated, jealous political rivalries will be unleashed, and people will lose confidence and become trapped in a spiral of pessimism and nihilism... It must not be allowed to happen*". In Poland, for which Vollset et al. [48] forecast a decline from 38 to 15 million inhabitants, serious online portals scare their readers with statements such as: "*One should sound the alarm!... Demography in Poland in the 21st century will be one of the worst in the world*" [50], "*The worst is ahead*" [51], or *"Fatal data. CSO confirms that we are facing a demographic disaster"* [52].

Public administrations in many countries have tried to counteract the threat since decades. By 2003 thirteen OECD countries claimed to have policies regarding fertility [53,54]. Globally, by 2005, approximately 30 countries had total fertility rates (TFR) below 1.5 Achieving TFR of 1.7 and implementation of prudent migration policies to compensate for population shortages was considered possible.

Also today, many countries implement similar policies. Sometimes these are planned actions resulting from adopted strategies, while sometimes they are a collection of individual impacts on society and the economy, not connected by any conceptual thread, but leading in a similar direction. It was in this vein that the report *Czech Demographic Success* [55], prepared in Poland and glorifying the effectiveness of Czech demographic policy, was referred to during its first public presentation by a

representative of the Czech embassy, who said that in his country no one knew that they had a demographic policy.

Advocates of regional population growth unanimously ignore the very existence of the opposing trend for the world, as if they did not notice that an increase at regional level resulting from natural growth always translates into an increase in the world population. They also fail to note that the growing pronatalist pressure may often have clearly oppressive character and undermine reproductive autonomy [46].

3.3. Population optimum

In ancient times one can find clear indications of the need to control population size. It was justified by pointing to the optimal population, a golden mean between the extreme states of underpopulation and overpopulation, supposedly corresponding to the maximum achievable standard of living [21,24,44,56,57]. The very existence of the extreme states was taken for granted.

Contemporary works on the subject often aim at calculating the population optimum. Computations are made for various spatial scales, from cities, to municipalities, regions, countries and the entire world [58–61]. Most often, they result in a specific number.

What population can be considered optimal? Thomlinson [62] believes that one that allows living at high standard. Too many people means too much pressure on resources, while too few means not being able to achieve economies of scale and reach a critical mass necessary for development. How then to indicate when the standard of living is optimal? According to Dasgupta [63], the starting point is the adoption of ethical foundation for the analysis: either average or classical utilitarianism. Average utilitarianism is a philosophical concept that assumes that further population growth is beneficial when, due to it, the average standard of living will continue to rise. Classical utilitarianism sets as its goal the maximisation of the sum of individual well-beings.

Parfit [64] reduces the above dilemma to the question: is it better to have fewer people living better lives, because a better life is better, or is it better to have more people, because each life is a value—assuming that these lives are worth living. Hence, we face the question of what is the relative value of quality and quantity. More transparently, is it better to live a shorter and good life, or a longer and barely worth living life? Option one is more tempting, and this means average utilitarianism and limiting the population size to optimum. The second option, although it also finds many supporters, is often rejected because of what Parfit [65] already indicated in his fundamental work and called “repugnant conclusion”, as it leads to almost infinite growth of population [66].

According to the dynamic optimum population theory, the optimal size depends on available resources, environmental conditions, and socio-economic variables, so it changes over time [67]. Additionally, it depends on the criteria adopted, so there may be many possible optima at any time, but they must all fall between the minimum viable population and the biophysical carrying capacity of the planet to keep living conditions of future generations at present level [21]. In this view, the relationship between population optimum and sustainable population is particularly clear, where

planetary boundaries define the limits of population growth [42,68]. Odum [69] states that the higher the level of development of a country, the lower its population optimum, because development translates to greater consumption and more waste. Answering the optimum question requires therefore answering the question of how we want to live.

There is no univocal answer to this question though. For this reason, many authors skip this phase of considerations and move on to calculations based on selected parameters, such as energy consumption, availability of farmland, human pressure on the environment, and others. Thus, when writing about the population optimum, many researchers de facto calculate the maximum population, or sustainable population.

Among the works that separate optimal from maximal values, the calculations of Lianos and Pseiridis [39] indicated that in 45 of the 52 countries they examined, the population should be reduced radically, with a global population reduction of 3.8 billion. Yet, it may be argued that they are more concerned with sustainable population than with optimal population.

Toney et al. [70] surveyed over 1200 researchers affiliated with the Population Association of America for their views on population issues. Nearly 97% stated that the rate of population growth was too high, while there was no agreement at all on the optimal population. Indications of the optimum for the United States ranged from 25 thousand to 3 billion people, while those for the world ranged from 100 million to more than 80 billion.

In brief, there is no consensus on the key questions: what criteria to adopt, what boundary values of indicators to accept, or what standard of living is the goal. The result is a huge scattering of results, which in itself is a clear indication that this analysis cannot be objectified.

4. Discussion

We will discuss the above three concepts together, in four sub-sections, so that we can confront the assumptions presented above in several different fields.

4.1. Simplifications

Describing any complex issue synthetically involves making simplifications. The key feature of each step of simplifying reality is to preserve the most important features of the examined phenomenon, despite the increasing level of information aggregation. In other words, the answer to the question of whether—despite the simplification—the picture being drawn is still true, although it is becoming increasingly blurred and fuzzy, should invariably be ‘yes’.

Dasgupta’s [63] well-known essay assumes that everyone is identical—ergo, they live and will live at identical levels. The justification is the laconic “for simplicity” [63] (p. 8). Parfit [64] (p. 146), making the assumption of people’s equality, explains it by the need to avoid “irrelevant complications.” It is hard not to notice that such simplifications ignore cultural differences, expectations regarding offspring, and different needs of the labour market in countries at different levels of development. They also ignore individual preferences and expectations regarding living standards, nutrition habits and family size. Thereby the assumption of lack of inequality may be

regarded as conceptually flawed.

Another simplification is the assumption that it is common that a woman or family can decide how many offspring to have. The percentage of women using modern contraception with medical and technical means ranges from 0.9% in South Sudan, through 56.5% in India and 80.5% in China, up to 81.6% in Finland, with the world average at 55.7% [71]. It indicates that the habit of family planning is still not widespread. The average unmet need for contraception in less developed countries (LDCs) is 21.7% [72] and it does not add up to 100 percent with the previous number in any country. For example, in South Sudan the total is 27.2%, in India 65.9%, and in China 82.8%. Hence, many women neither use nor report a need for contraception. Moreover, the expected number of children exceeds four in at least 20 countries in the world; given the limited availability of data it can be assumed that the real number is higher [73]. There is a profound variation in socio-cultural norms and woman's position in the family and society behind these numbers. Accordingly, the expectation that humanity will en masse reduce its own fertility due to planetary-scale constraints does not take into account either socio-cultural factors [74] or the inability to comply with these constraints.

Dasgupta [75] assumed also that people start working at birth and work until they die. He writes: "*I apologize for this assumption, which is bad (...) I have retained it because of its obvious analytical advantage*" (p. 297). One can't help but ask the question: does the submission of an apology for the flaw justify conducting a complex analysis on a biased foundation? In the same work, the author assumes that technical progress does not exist. Since the underestimation of progress as a factor significantly affecting reality is common, we will look at it more extensively in the next section.

4.2. Technological advance

Considerations regarding impact of technology on population optimum often start with a search of a proxy variable representing population. The question of the space required for living is often reduced to the question of how much energy humanity needs, and comparing it to the total amount of energy available. This way energy consumption has become a measure of human impact on the environment [21,28].

It seems that this take needs reconsidering. It is due mainly to the increasing share of energy production technologies and consumption patterns that are largely neutral to the environment, like renewable energy sources, growing electric car markets, and many more. They are all gradually decreasing humanity's dependence on fossil fuels. If humanity stops using them, treating energy consumption as a measure of overall consumption will no longer make sense—just as it doesn't make sense today to treat the world's volume of horse feed production as a measure of capacity for land transportation.

As for now, discrediting technological progress as a factor shaping the number of people the Earth is likely to accommodate, or assigning it a solely negative role, is widespread. Lianos [27] (p. 82) writes that "*arguing that technology can solve the problem of ecological disequilibrium is the same thing as arguing that one can step out of their shadow*." For Kuhlemann [76] (p. 182), technological progress facilitates

exploitation of raw materials, so it contributes to increased consumption, and the future will not change anything, because our actions "*(...) do not stop being unsustainable because things might change in the future*". This may probably be due to the belief, stemming from the groundbreaking work of Jevons [77], that an increase in the efficiency of energy-consuming devices will cause an increase of total energy consumption. Takkinen and Pulkki [78] emphasise that technology is often at odds with sustainability, while Abirami and Keerthika [79] note that rapid technological change can outpace society's ability to respond, creating new policy and sustainability risks. Even those who notice a potentially positive impact of future technological inventions, usually postulate that calculations of the population optimum should be guided by changes in technology that are known today and foreseeable (compare [21]).

Kuhlemann [76] (p. 185) writes also that she is "*not aware of any credible proposals for feeding a world of 16 billion or more*." This shifts the centre of gravity of the discussion from energy to food production, which been addressed since ancient times [1,6,25,26,33,80,81]. Modern thinking on this issue is undisputedly dominated by Malthus [3]. Despite the widespread criticism of his concept [82–86], neo-Malthusianism continues to dominate the popular consciousness.

For the record, it should be noted that there are works whose authors recognise positive impact of technological progress or general economic progress on planetary carrying capacity and argue that technical and social change combined with a focus on sufficiency could give an equally good life to 7 billion [38,42].

It is worth noting that the authors of the most of above analyses tacitly assume that they are able to accurately assess whether or not future inventions will manage to save humanity from trouble. Yet, as Taleb [87] writes, in order to predict what will happen in the future, one must anticipate technological innovations that are fundamentally unpredictable. We don't know what we will invent—if we knew it now, we would have invented it by now. Therefore, it is appropriate to assume that technological developments will lead to the invention of new solutions we cannot imagine today, rather than to assume their stagnation. It is equally appropriate, however, to assume that the inventions we expect won't come soon enough, that they won't produce the desired results in a short enough time, or that unforeseen side effects of new technologies will cause more harm than good on a planetary scale. The concerns of those reluctant to consider future inventions in their forecasts are summed up by Bregman [88] (p. 232): "But the inability to imagine a world in which things are different is evidence only of a poor imagination, not of the impossibility of change".

Yet, detailed considerations of technological progress are definitely beyond the scope of this paper, so this discussion should rather be regarded only as an attempt to show that—given the existence of uncertainty about future events—both excessive pessimism and excessive optimism are inadvisable. Technology should neither be attributed the qualities of magical silver bullets, nor apparent increase of human impact on the environment.

4.3. Fundamentals

Pimentel et al. [29] (p. 363) write that: "*overpopulation, maldistribution of resources, and environmental degradation are causing serious malnourishment and*

poverty throughout the world." Combining these five terms—three causes and two effects—in one sentence makes cause-and-effect analysis difficult, so let's look at them more closely. If poverty is the lack of sufficient resources to meet needs, then malnutrition is a result of poverty—a wealthy person will not be malnourished, because by definition they can afford to meet more than their basic needs.

Can overpopulation be a cause of poverty so that it later translates into malnutrition? If we understand overpopulation in a classical way as exceeding the maximum population that an area can feed at its maximum production, then Singapore or Monaco are overpopulated much more than Somalia or South Sudan. At the same time, in the first two countries poverty is marginal and malnutrition is essentially zero, unlike the second pair of countries. In the age of the global market no country needs to produce food in order to feed its people. Ergo, considering overpopulation within national borders has lost its raison d'être (compare [39,89]). Such considerations would have made sense in prehistoric times, when each community had to feed itself, which had an overwhelming effect on the population size that could live in an area.

Global food production today is greater than the sum of food needs, and the number of the obese is far greater than the number of the undernourished [90]. Despite this, numerous authors argue that providing food for 1 person requires 0.5 hectares of agricultural land, so there should be maximum of 3 billion people on Earth (e.g., [29]). 30 years after this publication, there are some 8 billion people on Earth, and the number of the hungry has been decreasing consistently. In 2022 about 735 million people faced hunger [91]. The problem, therefore, is not a shortage of food, but poverty, which does not allow many to buy food. The ability to purchase food is a derivative of both buyer affluence and food prices shaped by many factors, including the price of food inputs, climate change, food preferences and many others. However, these considerations, along with analysis of causes of poverty, are far beyond the limits of this paper. It is clear that on a planetary scale there must be a physical limit to the amount of agricultural production possible. Yet, today global overpopulation considered from the perspective of the ability to feed the human species does not exist (see also [38]).

In their calculations many authors for years tacitly assumed that the sum of resources available on Earth was fixed [64]. This corresponded to the static theory of resources, which assumed that the amount of resources at our disposal would never increase, since we had no guarantee of future findings or inventions. After all, there is a competing, dynamic resource theory that assumes that we will continue finding new resources or new ways of collecting them, as it used to be in the past. The key resource is human knowledge and skills, because they determine our ability to replace a depleting resource with another one [92], see also current an example of application of dynamic concept by Edwards et al. [93]. Thus, any calculation of the availability of food, raw materials or other factors shaping the Earth's future population should take into account changes in their supply, not just demand for them. The choice of resource theory—static or dynamic—is crucial to the calculation. As carrying out reliable calculations in the absence of future data is not possible, many works refer to static theory and known resources.

A conceptual starting point for all calculations is that the environment must be able to support people living either at the optimal level—for the population

optimum—or at the limit of the acceptable level—for the maximum population. Already here, variables of absolutely fundamental importance to the entire analysis appear to be impossible to agree on unambiguously: where is the boundary between acceptable and non-acceptable standard of living? Is this 1000 kilocalories per day, because it allows survival, or perhaps 1800 or 2500 kilocalories? Is it 500 kWh per year per household, or is 250 kWh enough? Or can we do without electricity, like nearly 13% of the planet's population [94]? Is public transportation enough, or a bicycle, or is at least one car in a family an acceptable minimum?

The number of such questions is unlimited. Their common denominator is the unresolved problem of what the welfare subsistence rate actually is. Dasgupta [75] discusses whether it is a level of consumption below which someone is all the same whether they live or die, or whether they were born or not. Alternatively, is it the level of welfare that parents want to guarantee for their child before they conceive. It is impossible to answer any of these questions directly (compare [95] or [96]). The boundary for each of us may lie elsewhere, which depends on individual expectations, place where we live, the intrinsic diversity of the community in which we live and many other conditions.

Parfit [64] infers that a shorter life at a high level ("Century of Ecstasy") is better than a longer life at a low level ("Drab Eternity"). However, it still does not help find minimum acceptable or optimal values of happiness or well-being. A population that is optimal from one perspective may not be so from another. Additionally, a change in circumstances changes the optimum [97]. Thus, it is impossible to point to any minimum or any optimum, in the absence of objective reference points.

We can come to similar conclusions by studying the changing approaches to demographics in different countries. Hidekazu [49] provides a detailed analysis of how Japan's population was alternately considered too small or too large during the short period of 1918–1970. Governments changed social policies once allowing abortion, once banning it, once encouraging emigration, and once encouraging childbearing. It was only in the late 1980s that Japanese experts admitted that the fertility decline was permanent. The same was true in Poland, where in the post-WWII period both increases and decreases in birth rates were alternately commented on as either favourable or unfavourable for society and economy [44,98].

4.4. Solution proposals

Despite the widespread awareness of the impossibility of establishing fundamental assumptions, calculations of the optimal and maximum sustainable population show up one after another. Usually estimated numbers are much smaller than the Earth's population today, so the proposals demand a population reduction and then follow-up with solutions to achieve it.

Dasgupta [75] (p. 296) claimed that "*(...) perfectly egalitarian distribution of the generation's consumption allotment is the best distribution*." The examples of the Soviet Union, Cuba, North Korea, Venezuela and many others amply demonstrate that it is impossible to achieve equality at a high level of life—decreed equality in practice translates only into widespread poverty.

Kuhlemann [76] points to one-child family as the ideal. Expecting a 2 + 1 family

to become the world standard would probably require a world government to address the problem of overpopulation, as postulated by Lianos and Pseiridis [39]. Lianos [27] (p. 75) proposes that each family be allowed to have only 1.5 children. The means to achieve this would be "*(...) the creation of an international market for human reproduction rights,*" in which each couple would have three saleable half-child allowances. The plan would cut the world's population in half within 3–4 generations. China's One Child Policy project, despite different means, had similar goals. The country withdrew from the policy in 2016, and in 2021 launched a campaign promoting three child families, in the face of a looming demographic crisis [99]. In Singapore, where the TFR was intentionally limited and has fallen from a record 7.68 in 1939 to 1.27 in 2003, and presently remains below the 1.3 mark despite all government efforts and incentives to increase it [100]. The creation of a reproductive rights market could end similarly—first with a diagnosis of the adverse effects of the solutions adopted, and then with a failed attempt to reverse the unfavourable trend. As these examples show, state interference in natural demographic processes can lead to imbalances that are difficult to regain.

Are there any other solutions? We will look at this in the next chapter.

5. Alternative solutions

There is a clear contradiction between the desire to reduce the world's population, and to stimulate its growth at regional level. If we were to accept the validity of both of concerns—for future generations and for economic stability—then we should focus our efforts on finding solutions that can reconcile these goals. Since there is room for population increase in countries facing depopulation, then—according to the laws of physics transferred to society—a surplus should naturally shift to a place where there is shortage. It is migration that answers deficits in HDCs' labour markets, not an attempt to raise fertility rates. The efficacy of the latest is often questioned (see [101–107]) and the fertility has not reached replacement level of 2.1 in any of the countries that implemented pro-natalist policies in last 20 years [12].

HDCs need a steady supply of cheap labour, and a set of measures to cushion the effects of ageing. Although the idea of saving the demographic and economic structures of HDCs by increasing immigration from LDCs is debatable, at the same time it is most often pointed out that at least in some sectors of the labour market immigrants are able to reduce the problem of labour shortages (cf. [108–113]).

At the same time less developed countries (LDCs) are a potential source of millions of people willing to migrate. These countries benefit from the emigration of their citizens, and sometimes even urge them to emigrate [110,114–117]. The main benefits are remittances, increase of emigrants' human capital, investments in the country of origin after re-emigration, and in some cases also reduction of malnutrition of local overpopulation.

The needs of HDCs and LDCs seem to find common ground in international migrations. While in many LDCs there is surplus of population, as stated by Lianos and Pseiridis [39], the HDCs needs it.

Despite advantages of immigration for the HDCs economies, many governments consider it a problem rather than a solution, exposing its socio-cultural negative

outcomes and allowing for public resistance against immigrants [118,119]. Balancing between the expectations of the economy and employers, on the one hand, and workers and the general public, on the other, is driving some governments to declare non-acceptance to admitting immigrants and to admitting them the same time. In 2022 alone, Poland granted 700 thousand residence permits to non-EU nationals, the highest number in the entire European Union, despite government narrative clearly opposing immigration [120,121].

6. Conclusions

Proponents of overpopulation concept argue that there are far too many people on Earth today. Proponents of population optimum, most often using similar tools and arising from the same ideas, usually conclude that the optimum has been exceeded. Proponents of underpopulation, focusing on a more local level, ignore fears of overpopulation of the planet and point to the need for population growth, particularly in HDCs. At the same time, they are discredited by proponents of both previous concepts.

Faced with the impossibility of determining where the world's population optimum or maximum is, this text has proposed coming to terms with the irreversibility of demographic changes resulting from economic, social and also technological change. It is also postulated to appreciate the role of migration as a factor potentially reconciling the demands of proponents of both extreme concepts. Local population surpluses could thus find a place where there are shortages. Therefore, both the demands of those who signal the need for population reduction in some countries and those who postulate population growth in other countries would be met. This conclusion opens up a new field of research in which research on overpopulation or underpopulation can be combined with research on the determinants of migration and migration policies to meet the needs and demands of both sides of the debate.

The conclusions drawn from the above analysis have certain limitations. The fact that it has not yet been possible to define the optimal or maximum world population in a universally accepted way does not mean that this will not be achieved in the future. If this happens, then the conclusions drawn from the analysis presented in this text would be of limited use. Furthermore, treating migration as a remedy for the problems of ageing societies in HDCs, shrinking working-age cohorts, or population decline in general has been severely criticised in the UN report already cited [109]. If, therefore, migration cannot solve these HDCs' problems, is there any chance of solving the problem of local overpopulation and local population shortages with migration? Answering this question undoubtedly requires detailed research based on numerical analysis. This task goes beyond the scope of this paper and thus points to the direction of further research.

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