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Creating Sustainable Climate Change Havens for Migrating Populations in the United States and Other Global Sites

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Abstract: A model for constructing sustainable Climate Change Haven communities in appropriate areas of the United States and globally is presented. The model proposes the construction of walkable communities of 20,000 to 30,000 residents with electricity provided by hydropower generators and biofuel combustion. The remediation of surface-mined areas using switchgrass and flood control dams to redirect excess rainfall will be required in some areas. This model also addresses the multiple social and cultural considerations required to resettle groups of migrants in Climate Change Haven communities, together with the preparation and preservation of nearby farmland for feeding the community.

Keywords: sustainable communities; climate change; population migration; hydropower electricity; biofuel; localized agriculture

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1. Introduction

The much-discussed boundary of maintaining Earth's heating below an increase of 1.5 degrees Celsius will likely be crossed in the next few years (United Nations Climate Report 2023). The present research puts forward migrant resettlement plans for managing this event and outlines the advance preparations that must be made in order to create sustainable communities for incoming populations. These are termed Climate Change Haven communities (Hirschman 2022). Few prior studies have taken a holistic look at the locational, social, and cultural aspects of relocating migrants from endangered regions of the globe to areas where they can live safely and be successfully integrated into the pre-existing population (Abbass et al. 2022b). The present study presents a multifaceted model for creating successfully integrated communities in climate-safe regions of the world. Examples are given of domestic resettlement plans for internal migration in the United States.

In the United States and in most other countries, actions responding to climate change ride on waves of postponement and compromise as varied stakeholders come into power and advance agendas that are favorable to climate change response or in opposition to it (Tyson et al. 2023). Because of this political reality, the United States and most other economically dominant countries are unlikely to reach the goals necessary for them to contribute their 'fair share' to the global effort (Abbass et al. 2022b). Therefore, it is prudent for Northern Hemisphere regions that could serve as potential Climate Change Havens to prepare themselves for high levels of incoming migration (Jenkins 2014).

The map below in Figure 1 shows global projections for habitability as climate change occurs over a three-decade time span. It indicates that areas in the Northern Hemisphere that are presently uninhabitable due to extremely cold conditions will soon become habitable by humans and support a wide variety of plant and animal life, while heat and drought will force many persons living in the Equatorial Zone to migrate northward. These newly habitable Northern Hemisphere regions will be able to serve as Climate Change Havens, if they are prepared appropriately in advance. To do so, not only the construction of habitable communities will be required, but also sociological and cultural preparation will be required (Adger et al. 2020; Atapattu 2020).

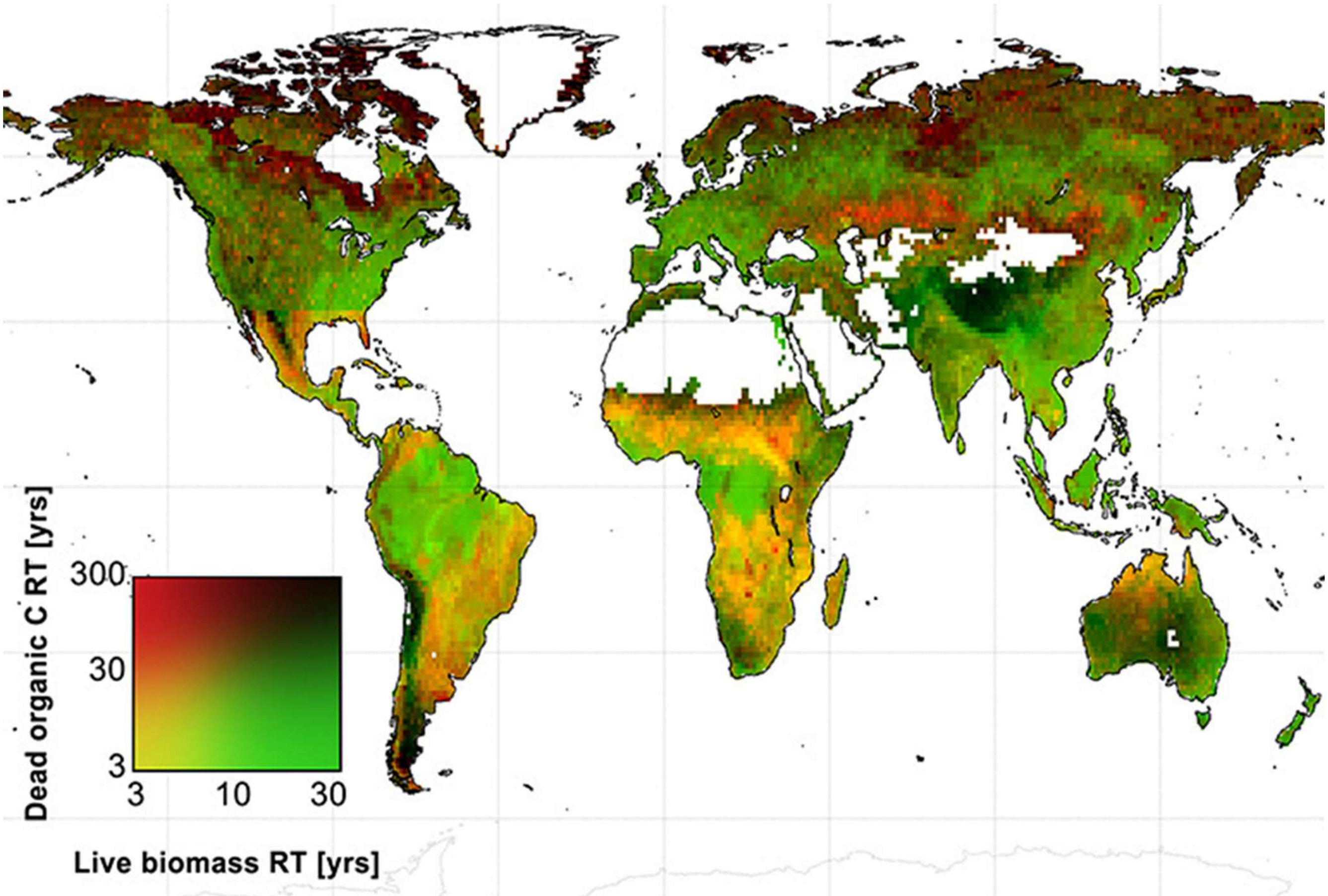

Figure 1. NASA map showing the expected effects of climate change on global habitability; the white areas on the continents indicate uninhabitable regions. Note that much of the Northern Hemisphere becomes habitable.

The construction models put forward in the present research can be used for creating habitable human communities in these northern areas of the planet. They include the remediation of any surface-mined land, installation of hydropower electric generators on rivers, reservoirs and lakes, flood control dams, and ecocommunities of 20,000 to 30,000 residents (see Hirschman 2022; Hirschman and Toomer 2023). An additional feature discussed in the present research is the extension of community preparation to include the extension of local agricultural productivity surrounding the Climate Change Haven communities so that much of the food required can be locally sourced. This will greatly reduce the need for external transportation of foodstuffs into each community, thereby reducing carbon emissions and supporting local agricultural producers. Each Climate Change Haven community will house both current residents and in-coming migrants. Because of the 'mixed' composition of these new communities, it will be vital to develop social education programs in advance which ease the integration of these diverse cultures (Atapattu 2020). We address the social and cultural factors that will impact the viability of incorporating migrant populations within existing populations in the Climate Change Haven areas.

Our present research discusses technical designs and social integration programs that were prepared for the United States. However, the political, cultural, and social factors governing migrant policies will differ across the globe and appropriate adjustments will need to be made (Fahad et al. 2022; Kaczan and Orgill-Meyer 2020). The discussion below focuses primarily upon creating Climate Change Havens in Appalachia, which will become the largest viable land area in the continental United States by 2030.

2. Constructing Climate Change Haven Communities in Appalachia

Appalachia has previously been identified as the largest locale for Climate Change Haven communities in the Continental United States (Hirschman 2022), and the plans developed for it will likely be applicable to other sites across the globe with appropriate modifications. A Climate Change Haven (CCH) is defined as a geographic area largely unaffected by climate change that can accommodate towns of 20,000 to 30,000 residents and supply its own power through solar, wind, hydropower generators and/or biofuel sources. Climate Change Havens use no carbon-based fuel sources such as petroleum, natural gas, or coal. Towns are limited to 20,000 to 30,000 residents to prevent larger populations, which would lead to environmental degradation (Abbass et al. 2022b; Koul et al. 2022).

As discussed later, this size limitation also helps promote community cohesion and enables nonpolluting means of transportation to be used exclusively throughout the town. Transportation within the Climate Change Haven community is restricted to electric vehicles, walking, biking and other self-propelled modes. Having small, walkable communities not only reduces transportation emissions, but also provides more opportunities for residents to interact socially, creating a stronger sense of community identity and encouraging exercise across the population.

Creating a viable Climate Change Haven community requires an integrated set of activities to be undertaken in advance of the arrival of new residents. Among these are (1) identification of viable building sites; (2) remediation of any existing environmental hazards, e.g., flooding, contaminated land; (3) installation of nonpolluting electrical sources capable of providing sufficient power for a population of 20,000 to 30,000 residents; (4) selection of contractors capable of constructing ecosupportive residential, commercial, administrative, medical, and educational facilities for the population; and (5) a communication system capable of providing emergency support to all residents in the event cell phone and internet service is disrupted (Hirschman 2022). An additional requirement put forward in the present research is that the area surrounding each CCH community be developed as an agricultural resource. In Appalachia, for example, future CCH sites are already located in agricultural areas. These locales currently produce a wide variety of fruits and vegetables, as well as having farms devoted to livestock such as dairy and beef cattle, sheep, goats, chickens, turkeys, and geese (Appalachian Regional Commission 2022) Thus, efforts will need to be made to not only preserve the current agricultural productivity, but to actively expand it to meet the needs of the incoming residents.

In addition, a social communication program must be undertaken from the outset to tell current residents about the advantages of creating a Climate Change Haven community in their area (see Hirschman and Toomer 2023). These advantages include increased economic tax revenue; affordable ecological housing options; increased employment opportunities; lower electrical costs; and enlarged and improved educational, recreational, medical, and entertainment facilities. These benefits will be provided as a result of the incoming population, which will include businesses engaged in information technology, pharmaceuticals, agriculture, and financial service industries. It is anticipated that entire companies and their employees will decide to relocate in the Climate Change Haven communities in Appalachia—most will likely be arriving from the states of Arizona, Texas, Florida, California and Georgia, which are already facing extreme climate change threats.

Financial and Time Estimates for Constructing Climate Change Haven Communities

Using three sites in Appalachia as our models, we present estimates of the various financial commitments and time periods required to create Climate Change Haven communities. After discussing these sites as models, the focus then turns to establishing Climate

Change Havens globally across the Northern Hemisphere with consideration given to the sociocultural aspects of international migration.

The three initial Appalachian locations were chosen because they have varying degrees of surface-mining damage that will require remediation before Climate Change Haven communities can be established on the sites. As discussed below and depicted in Figure 2, surface coal mining is often found across the globe in areas that will become or remain habitable in the year 2035. This is due to the geological co-occurrence of ancient coal deposits within mountainous regions as the continents were formed (Manger 2023) Thus, one of the major challenges facing migrating human populations globally is to remediate these surface-mined areas prior to establishing Climate Change Haven communities on them.

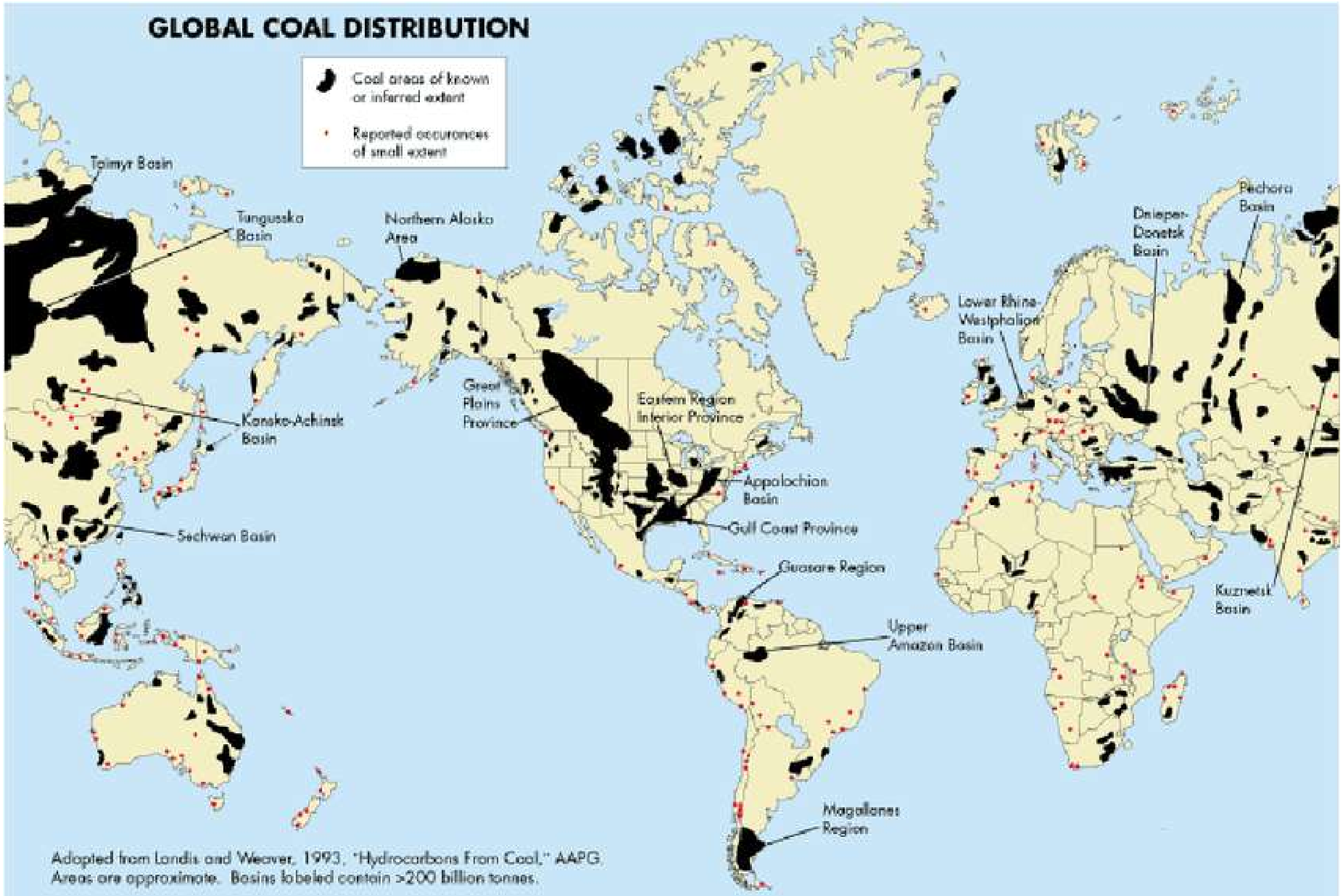

Figure 2. The map shows where coal mining activities have occurred and remediation will be required prior to the construction of Climate change Haven communities.

We first turn to a discussion of surface-mining remediation in order to prepare Northern Hemisphere Climate Change Haven sites for migrant arrival. Recent studies have documented that the most rapid and cost-effective means for remediating surface-mined land is by planting panicum virgatum, commonly called 'switchgrass' (Schmidt 2017; University of Arkansas 2023; World Economic Forum 2023) on the damaged land surface.

3. Switchgrass and Surface-Mining Remediation

A simple and widely available plant species, panicum virgatum, commonly known as switchgrass or prairie grass can serve as an inexpensive means for remediating areas that have previously been subjected to surface mining (Langton 2023; PBS 2023). In surface mining, the top layers of soil are usually removed from a hillside or plateau in order to gain access to the layers of coal lying underneath. This method of mining has been in widespread global use since the 1970s (American Mine Services 2023; Farm-Energy Extension 2023).

Mining companies across the globe often leave the scraped surface bare once the underlying coal has been removed, which leads to flooding during rainstorms. This in turn often causes landslides in the valleys below (U.S. Department of Energy 2023). These same valleys are often where villages, towns, and factories are located. As a result, residents are forced to flee their homes and farms, and businesses are damaged or destroyed. This phenomenon has become more commonplace now that climate change has exacerbated the frequency and severity of rainstorms across much of the planet (Piguet 2022). Because many of the global areas that have been surface mined and left unremediated are among the places where Climate Change Haven communities can be located, quickly and effectively resurfacing these landscapes is of critical importance.

Environmental researchers have recently identified several species of switchgrass as effective covers for these surface-mined areas of terrain (Bryce 2023). A photo of typical switchgrass is shown in Figure 3.

Figure 3. Root system of switchgrass grown at the Land Institute. Note the dense root system that can effectively hold surface soil in place.

Much of North America, especially the prairies of the Midwestern United States, was once prime habitat to vast swaths of native grasses, including switchgrass. As settlers began spreading west across the continent, these native grasses often were plowed under and the land converted to crops. Removal of the native ground cover in the Midwest contributed to the disastrous 10-year period (1930 to 1940) known as the Dust Bowl Decade in the Central and Great Plains regions of the United States. Indeed, the Dust Bowl was perhaps the first modern example of climate change destruction due to human activity (Land Institute Organization 2023).

Switchgrass has two distinct forms: the lowland type tends to produce more biomass, while the upland grass is more cold-tolerant; these are shown in Figure 4, along with a subvariant The lowland types of switchgrass will likely become more common in northern regions across the globe as temperatures increase due to climate change. This will produce an energy bonus for higher elevation areas such as Appalachia, Canada, and Northern Europe, because lowland switchgrass can be harvested two to three times a year and used as a cellulose-rich biofuel (Barth and Farmer 2017; University of Arkansas 2023). Using switchgrass as a biofuel, together with the use of hydropower generators which are discussed below, will permit residents in Northern Europe, Canada, and Appalachia to shift away from their current reliance on oil and coal-burning furnaces.

Fortunately, the areas in which switchgrass will need to be grown to remediate surface-mined land are often located adjacent to existing coal-fired furnaces; this will greatly reduce the transportation time and cost in retasking these coal furnaces to biofuel (Kumar et al. 2022).

An even more efficient source of noncarbon electricity production is utilization of the abundant natural water resources in many of the global Climate Change Haven areas. Flowing water can supply electricity using hydropower generators. As discussed below, hydropower generators are among the most cost-efficient and nonpolluting means of providing electricity (US Geological Survey 2023).

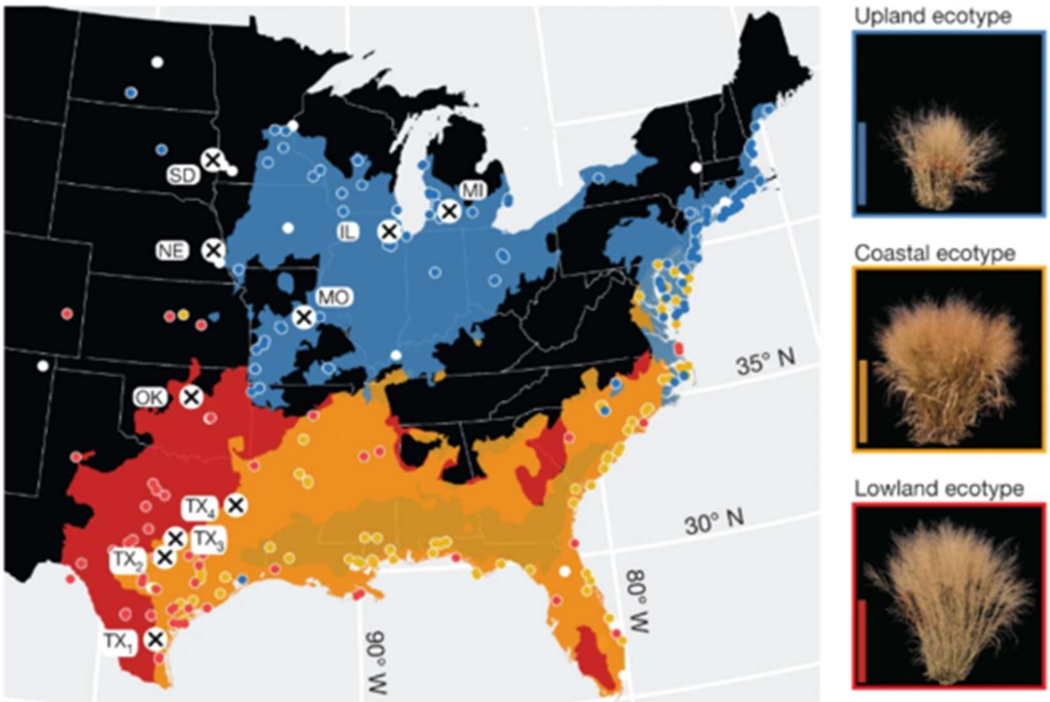

Figure 4. *Panicum virgatum* ecotypes and their distribution in the United States.

4. Hydropower Electric Generators

Hydropower, or hydroelectric power, is a renewable source of energy that generates electricity by using the natural flow of a river or other body of water (Abbasi et al. 2022a; US Geological Survey 2023; US EPA 2023; Water Power Technologies Office n.d.). Utilizing turbines, flowing water is transformed into electricity that is then channeled into the local power grid, providing energy to the community. In the Climate Change Haven model, hydropower is used to provide electricity for communities up to 30,000 persons; this will include administrative services, schools, hospitals, recreational venues and businesses, as well as residences (Hirschman 2022).

Because hydropower uses water energy to generate electricity, the facilities are usually located on or near a water source (US Geological Survey 2023). This can be a river, lake, or reservoir. The energy produced depends on both the volume of the water flow and the degree of elevation entering the turbine system. The greater the water flow and the higher the elevation, the more electricity can be generated. Once inside the hydropower generator, water flow is directed through a pipe that spins the blades of a turbine, producing electricity (US Geological Survey 2023). Importantly, the global areas that will be able to serve as Climate Change Havens have an abundance of rivers, lakes, and reservoirs, which can readily be equipped with hydropower generators. The cost for their installation will be between USD 6,000,000 and 10,000,000 to produce enough power to supply a town of up to 30,000 residents and supporting services (US EPA 2023).

The US Energy Information Administration (EIA) estimates the average construction cost for hydropower to be 1415 USD per kilowatt, which is less expensive than either wind or solar power energy (Energy Information Administration 2020). At present, hydropower is underutilized in the United States; however, the states of Idaho, Washington, and Oregon produce most their electricity from this energy source and as a result have lower energy costs than the rest of the United States (US Water Power Technologies Office 2021).

A further advantage of hydropower energy systems is that they are able to respond quickly and efficiently to shifts in demand and can also provide seasonal energy storage (US Geological Survey 2023; The Office of Energy Efficiency & Renewable Energy n.d.). They are also superior to other energy sources in being able to ramp up and down as demand varies hourly and daily (The Office of Energy Efficiency & Renewable Energy 2021). But perhaps one of the most important features of hydropower is that installations can operate for 10 to 20 years with very minimal maintenance expenses (The NREL Annual Technology Baseline 2023). Thus, once they are installed in Climate Change Haven communities globally, the cost of providing electricity to the inhabitants will be minimal.

Hydropower generators also can be installed on existing traditional spillway dams, including those constructed decades earlier throughout Appalachia by the Tennessee Valley Authority (TVA) and which are also widespread globally (Zhang and Gu 2023). These are depicted in Figure 5 below; the maps depict both the dam sites and the water catchment areas that feed the dams. Doing so will not only open the natural flow of these waterways, but also reduce the cost of maintenance and cleaning required for a traditional spillway dam. Removing the spillway system also helps reinvigorate the ecology of the surrounding environment (US Geological Survey 2023).

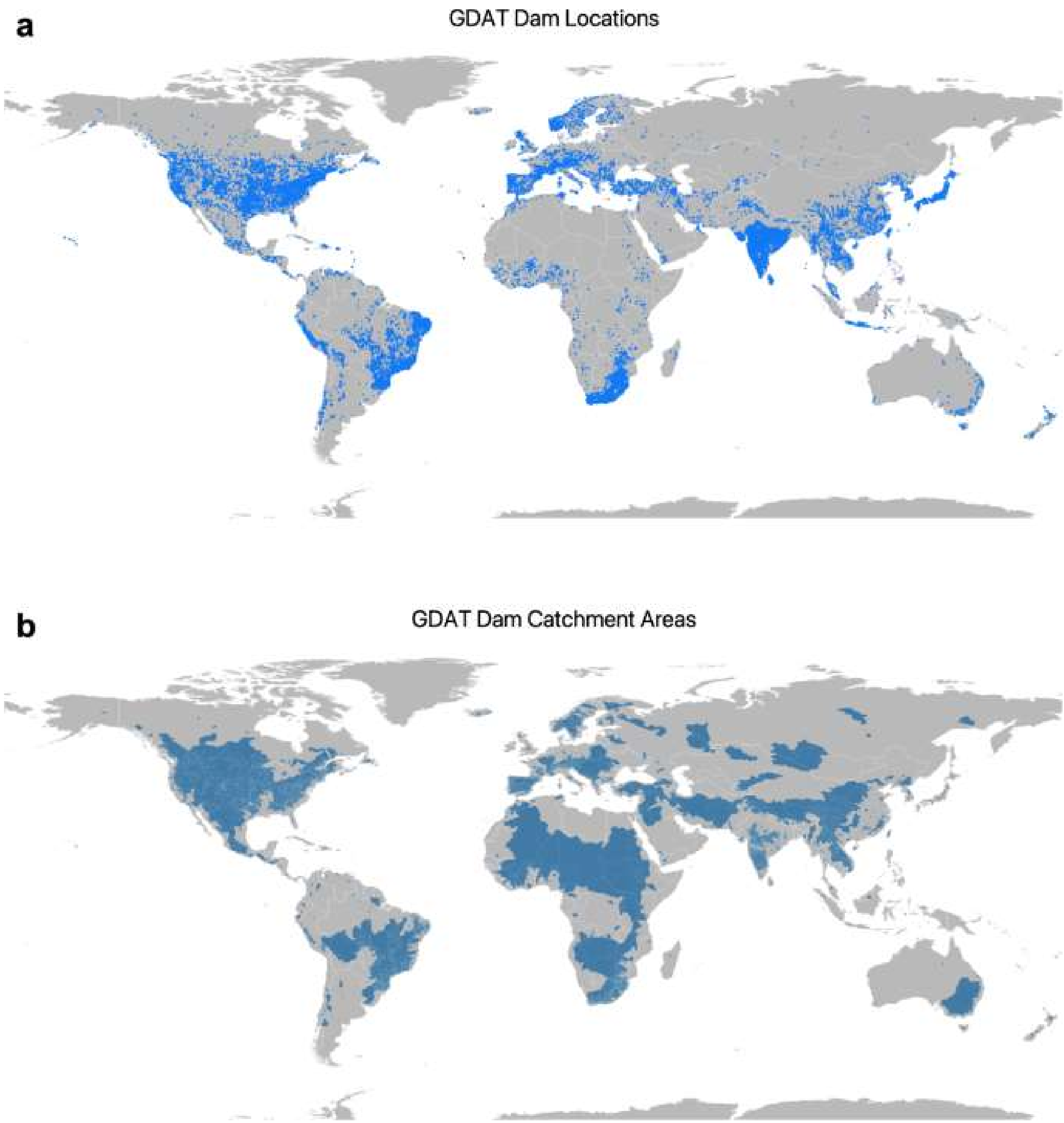

Figure 5. Global Dam Tracker: A database of more than 35,000 dams. Available online: www.nature.com/articles/s41597-023-02008-2 (accessed on 5 April 2023).

It is estimated that hydropower generator systems could ultimately be installed at over 230,000 sites across the United States—all of which would be run-of-river facilities that would not create environmental issues in the surrounding areas (US Geological Survey 2023). These hydropower 'drop-in' systems can be positioned in a river or waterway, where they cause little environmental disruption, and have very low construction and maintenance costs compared to other energy-producing alternatives. The estimated costs for these systems are 2400 to 14,000 USD per kilowatt hour (The NREL Annual Technology Baseline 2022) depending upon the size of the waterway and the surrounding terrain (U.S. Department of Energy 2023).

5. Flood Control Systems for Climate Change Havens

Global locations appropriate for Climate Change Havens are forecast to experience increased rainfall over the coming decades (United Nations Climate Report 2023). This rainfall will occur in heavier amounts and over shorter periods of time than is now normal for these regions (United Nations Climate Report 2023). While this is useful for hydropower generation, it will be quite problematic for existing flood control systems globally. Already, severe flooding is being experienced throughout Pakistan, Western Europe, and other areas (United Nations Climate Report 2023). Thus, it will be necessary to create comprehensive and effective flood control systems in places being developed as Climate Change Haven communities prior to the arrival of incoming migrants.

The hydroelectric power systems discussed above can often serve as flood control barriers, but it is likely that additional water-control efforts will be needed in river valleys and along streams that may not be suitable (or too costly) for installing hydropower electricity systems. For these locations, the most suitable option will likely be flow-through/perforated dams (FEMA 2023).

Flow-through dams are constructed across waterways whose normal flow levels are not usually problematic. However, when rainfall is intense, these waterways can fill rapidly and carry-off buildings, roads, homes, and crops along their banks. To prevent this, a flow-through dam uses a low structure across the bottom of the water flow which does not restrict the normal current and permits moderate-sized debris to pass.

Either a raised blocking structure or low-level spillways are then built across the river above the normal water flow. In case of a flash flood event, these will slow the water sufficiently to prevent washout below the dam. However, they will also temporarily back-up the water behind the dam, so a reservoir or pond area needs to be prepared for this possibility. No buildings, crops, or livestock should be permanently kept in the reservoir area (FEMA 2023).

There are several commercial companies available that specialize in building this type of dam and the cost is low—especially compared to the damage that will be avoided. The cost should be in the range 20,000 to 50,000 USD per dam (United Nations Climate Technology Center & Network).

6. Emergency Communication Systems

Although Climate Change Haven communities will have their own electrical systems, be located in climatically safe areas, and have safeguards against flooding due to increased rainfall, they will still be susceptible to external threats such as cyberattacks and terrorist activities that disrupt internet and cell phone systems. Cloud-based data is also susceptible to these same forms of attack. To insure residents' safety during such events, a local/community-based communication system is desirable. After examining various alternatives, the best option appears to be for community members who are age 16 and over to be provided with two-way radio receiver/transmitters (Beren 2023). Residents would carry these receiver/transmitters to work, school, shopping, and recreational activities much as they now do with their cell phones. Each Climate Change Haven community will be equipped with an AM radio station, so that residents can be notified if a serious event, e.g., a flood or fire, is occurring and local cell phone/internet reception is not functioning. Additionally, by having their own radio receiver/transmitter, residents can also immediately report any dangers they encounter in the community to the appropriate authorities.

The need for such an emergency communication system has become readily apparent during the past few years in the Appalachian region. Flash flooding in Kentucky, West Virginia, Virginia, North Carolina, and Western Pennsylvania has knocked out both cell phone and internet service for several days (Harvey and E&E News 2022). This leaves residents stranded, unable to report missing persons, and unable to reach emergency service personnel. This dangerous situation can be avoided in the future if residents, businesses, schools, and first responders are able to communicate quickly and securely.

7. Equipping Three Counties in Appalachia with Climate Change Haven Communities

Thus far, discussion about Climate Change Haven communities has been focused primarily at a global level. We now turn to a specific set of plans created for three counties in Appalachia that can serve as prototypes for Climate Change Haven planning and construction. The counties were chosen because they are 'typical' of other Climate Change Haven options internationally: Wise County has been heavily surface mined with little remediation, Dickenson County has a moderate level of nonremediated surface mining, and Russell County has experienced only a small amount of surface mining and requires no remediation. The counties also vary in their levels of mountain inclines, with Wise County having the highest level of precipitous terrain, while Russell County's terrain consists of rolling hills and grassy fields. Since across the globe several of the regions that would be able to serve as Climate Change Havens have also experienced surface mining, e.g., China, India, and Scotland, and have varied levels of mountainous terrain, the discussion below should be widely applicable.

7.1. Initial Land Preparation Using Switchgrass

The first task was to generate initial estimates of the time and expense for remediating surface-mined land using switchgrass. We estimated the costs as follows. For Dickenson County, which is moderately surface mined, approximately 15% of the land area will need to be seeded—a total of roughly 132 square miles. The county will need sufficient seed to cover this area. If volunteer labor (e.g., schools, church groups, scouting groups, local sports teams) is used, the cost should come to around USD 4,000,000 to 5,000,000 for the entire project.

If local garden store chains, e.g., Lowes, Home Depot, are willing to provide the grass seed to the county at their corporate cost, this amount would even be less. Once seeded, the grassed areas will require two to three years to produce root systems capable of holding the surface soil in place during heavy rain events. They then can be safely built upon with Climate Change Haven housing, businesses, schools, hospitals, and entertainment venues. Importantly, this will also make a larger land area available for growing crops, raising cattle, sheep, and other meat animals, and planting additional orchards. This will enable the Climate Change Haven communities to source the majority of their needed food within the county. Additionally, having community members contribute some of their leisure time to tending these agricultural projects will help reinforce community cohesion and increase their health levels.

In Wise County, where approximately 30 to 35% of the land area of 405 square miles requires surface remediation, the estimated cost using volunteer labor would be USD 11,000,000; again, this could be lessened if corporate donations of switchgrass seed are available. For Russell County, the cost is estimated to be USD 2,000,000 using volunteer labor, since only 10% of the land has been surface mined. As with Dickenson County, both these counties will be able to plant crops and raise animals on their newly reclaimed land, lowering food costs and increasing county cohesion and health.

As alluded to above, an additional social benefit of using the volunteer labor of current local residents to resurface their county's land and to contribute to its food supply is that this will provide them with a stronger sense ownership and personal commitment to the success of the Climate Change Haven community. They and their families will be among those living in the new community. From a social psychological perspective this will create a sense of community solidarity and personal commitment to its success. As discussed later, it is vital that these same local residents have a strong voice in choosing which in-coming migrant populations will be allowed to settle there.

We now turn to a more detailed discussion of the social, political, and ethnic aspects of constructing Climate Change Havens in these Appalachian counties. These same issues will be need to be considered in Climate Change Haven communities across the globe (Adger et al. 2020; Ahmed and Eklund 2021; Ceglar et al. 2019; Nabong et al. 2023; Parrish et al. 2020; Vinke et al. 2020; Zhang et al. 2022).

7.2. Wise County, Virginia

Wise County has a current population of 40,000 residents, most of whom are white and Protestant (Wise County Government 2021). The political orientation of the population is conservative and consistently votes for conservative candidates in local, state, and national elections (Adams 2020). Current residents' political orientation is a salient factor for all potential Climate Change Haven communities, and it will be essential to also take into account the ethnic and religious composition of the existing population in order to ease the acceptance of migrant populations (Atapattu 2020). For this reason, the majority of sites in Appalachia would be most compatible for white Protestant migrants coming from the Southeastern or Southwestern United States (Hirschman 2022).

However, it is also important to note that Black, Latino, Muslim, and East Asian persons do currently live within the present Wise County population and new arrivals in family groups would likely be welcomed as well, especially if the current residents are asked about this ahead of time and given time to consider and approve it. In Appalachia, as in the rest of the world, current inhabitants want to feel that they have a voice in their own future. As discussed below, there will be large benefits for communities who accept these newcomers, including expanded medical, educational, recreational, and employment opportunities.

Two towns in Wise County were selected as sites for constructing potential Climate Change Haven communities—Wise and Norton. The town of Wise has approximately 4000 residents and the University of Virginia—Wise campus is located nearby with a faculty, staff, and student population of 4000 (Wise County Government 2021). A second town, Norton, was also selected as a potential Climate Change Haven community due to its more progressive political attitudes. It also has a population of around 4000 persons (Norton Virginia Government n.d.).

Wise County has ample water resources located within its boundaries, including reservoirs, rivers, and lakes. Once these are equipped with hydropower generators (estimated to cost approximately USD 6,000,000 each), they will be able to provide enough carbon-neutral electricity to power the expansion of both towns to 20,000 to 30,000 persons, together with providing a revenue source to the county and the towns. In the United States, Climate Change Haven communities that have excess electrical power after meeting the needs of their own residents will be able to sell that power to neighboring states, likely at a lower cost than what those states are now paying for carbon-based electricity.

7.3. The Town of Wise

A team of six researchers trained in qualitative methods (participant observation, informal interviews, projective techniques) made several trips to the town of Wise and talked in public areas with current residents about the possibility of additional people arriving there and what new community amenities, transportation options, medical services, housing options, businesses, and professional services they would like to see added, if they chose to become a Climate Change Haven community. The researchers were college students recruited from among inhabitants of the Appalachian Region. This was to insure their dialect, apparel, and social customs were compatible with those of the local population. The research was conducted over a three-month period in spring 2023.

The residents reported that they were generally open to expanding their town, especially if new, high-paying technology and professional jobs became available, and health care, public transportation, educational, and housing options were expanded. The idea of having their own county electrical service was especially attractive to the residents, since the cost of their current coal-fired electrical service has been rapidly increasing. They believed that remediation of existing surface-mined areas in their town and around the county would be a positive step, especially since flooding (due to increased rainfall) has been present over the past few years. Notably, however, a few of the residents expressed concern about losing 'the way things are now'. These residents tended to be older and often operated farms in the county.

These desires and concerns were taken into consideration in planning the types and locations of new housing and business development and also the locations for hydropower generators and flood control dams. Special attention was paid to maintaining current agricultural activities and expanding the amount of acreage devoted to food production. Some of the construction requirements are discussed below. These served as models, with some alterations for local conditions, for the other locations that are discussed subsequently.

7.4. Environmentally Sound Apartment and Condominium Housing

Most new residents arriving in Climate Change Haven communities globally likely will not be bringing large amounts of home furnishings and equipment with them; many of their possessions may have been lost in floods, tornadoes, hurricanes, and other natural disasters due to climate change. Thus, their best initial housing options will likely be apartments and condominiums, which are already furnished and located near public transportation.

Ecosustainable housing complexes suitable for families, married couples, and single individuals will be constructed in the center of the town of Wise (EcoFriend 2021) and electric bus service (Cummins Inc. 2021) will be provided to transport the new arrivals to their workplaces, administration buildings, recreational facilities, entertainment facilities, grocery shopping, medical service providers, and schools for children from kindergarten through high school. These facilities will be located in ways that minimize distance and encourage walking and bicycling to and from each venue. For persons who are not mobile or who have young children, a circulating electric bus service will be provided (ideally free of charge) in which residents can hop on and off at regular stops.

Several European and Asian countries have already installed such transportation services in their central cities and have greatly reduced air pollution and traffic accidents, and improved the physical health of their inhabitants as a result (electrek.co/guides/electric-buses). We propose that a similar model be implemented not only in the town of Wise, but within all Climate Change Haven communities (Herriges 2020).

Some incoming new residents may be affluent, for example, executives who decide to move their entire company to the Climate Change Haven community or persons with successful medical, technical, or pharmaceutical enterprises. To accommodate these new residents, ecologically sound upscale housing developments near the town of Wise will be constructed and linked to the electric bus route in order to provide transportation into and out of Wise. All personal transportation vehicles in the county will be required to be electrically powered in order to eliminate the need for petroleum fueling stations. This should not prove burdensome to residents, as county-produced hydropower electricity will be readily available at low cost for recharging their vehicles.

Nationally and regionally, there are several qualified construction companies with experience in building 'walkable towns' such as those proposed for Wise and the Appalachian Climate Haven Region (see Engineering News Record 2019; FortuneBuilders 2022; Project Drawdown 2023). Globally, towns that find this model is appropriate for their own expansion should contact builders as soon as possible. By 2030, climate change will create rapid deterioration of living quality across the globe and a large inflow of climate migrants; it is critical that Climate Change Haven communities be either completed or under advanced stages of construction prior to 2030. Countries having the potential to establish Climate Change Havens, e.g., Scotland, Sweden, and Austria, should begin to identify and contact appropriate builders as soon as possible, in anticipation of the arrival of large numbers of incoming climate migrants. Figure 6 below shows a proto-type walkable town housing project.

7.5. Norton, Virginia

A second site suitable for use as a Climate Change Haven community in Wise County is the city of Norton (www.nortonVA.org). Norton has a current population of around 4000 persons and has its own governing board. This city is more politically progressive than much of Appalachia and may, therefore, be receptive to migrants from other countries, as well as those from the Southeastern and Southwestern US.

Figure 6. Ecological housing such as this in Climate Change Haven communities can accommodate single persons, couples, and families.

Both Norton and Wise can place hydropower generators on the nearby Wise Reservoir and/or the Guest River to support populations of up to 30,000 persons in each town at a cost of 6,000,000 USD per generator. Future expansion of Climate Change Haven towns in the county could be extended to the town of Pound, VA, in the northern part of Wise County, using a hydropower generator on the Pound River, and also in the town of Big Stone Gap in the southern portion of the county using the Powell River. These installations would enable approximately 100,000 new residents to be placed in Wise County, while still maintaining the natural environment. The cost of the hydropower generators is estimated to be USD 6,000,000 to 8,000,000 for run-of-river placements.

7.6. Dickenson County

Dickenson County is adjacent to Wise County. It comprises 334 square miles and has a current population of around 14,000 persons (Dickenson County Government 2019).

As discussed earlier, approximately 15% of the county's surface has been mined and will require remediation using switchgrass prior to becoming a Climate Change Haven. The largest town, Clintwood, has a resident population of around 1000 persons. Clintwood would make a desirable location for a Climate Change Haven community of 25,000 to 30,000 residents using the same design features described earlier for the towns of Wise and Norton.

Dickenson County has a large variety of water sources capable of producing hydroelectric power. Most important among these is the John Flanagan Dam and Reservoir that is already outfitted with a traditional spillway dam to produce electricity.

The existing spillway dam can be converted to a large-scale hydropower generator facility at a cost of around USD 10,000,000. Once modified, the new generator will be able to supply electric power to over 100,000 persons. This would provide substantial tax revenue to Dickenson County, because the excess electric power could be sold to neighboring Kentucky communities that are currently using expensive coal-fired plants to produce electricity.

The small, nearby town of Haysi (current population around 500 persons) can also be developed into a Climate Change Haven community of 20,000 persons. Both Clintwood and Haysi would be equipped for incoming residents in much the same manner as described for Wise County with ecological multiunit housing, business parks, recreational areas, hospitals, educational buildings, and administrative services all positioned in a compact arrangement. Because this county will have excess electricity available, it would also be feasible for major corporations and manufacturing facilities now in climate-threatened areas to relocate here, thereby providing their employees with an environmentally safe community in which to live and work.

7.7. Russell County

Russell County is adjacent to Wise and Dickenson counties. Its current population is approximately 25,000 persons. The county seat, Lebanon, has a population of around 3400 residents. The Clinch River flows through the center of Russell County and can be outfitted with two or more hydropower generators at a cost of around USD 6,000,000 each. This would provide the county with sufficient electrical resources to service up to four Climate Change Haven communities of 20,000 to 30,000 persons.

This plan is made even more feasible by the fact that very few areas of the county have unremediated surface-mine damage (less than 10% of the total land area) and much of the terrain is rolling hills with few steep inclines. Therefore, construction on the CCH communities could begin immediately. It would likely be most appropriate to begin building these communities near the county seat of Lebanon, which could then serve as a model for developing the rest of the county.

8. Social and Cultural Strategies for Building Global Climate Change Haven Communities

Thus far, we have described the environmental and financial feasibility of locating Climate Change Haven communities in Appalachia. It is assumed that the majority of migrant population in-flow will be from climate change threatened regions of the United States, especially the Southwestern and Southeastern states. This leaves unaddressed the larger global problem of resettling climate change migrants across national borders, especially the inflow of migrants from Africa, the Middle East, and Southeast Asia who may be seeking to reach Northern Europe.

The question now becomes can we locate similar communities in Climate Change Haven Regions around the globe where there are larger issues of a political, economic and social nature that must be taken into account? In this section, we first focus on these issues within an Appalachian setting and then consider them within a global context. Because climate migrants to Appalachia will be arriving largely from the Southeastern and Southwestern areas of the United States, they will be speaking the same language, used to eating the same foods, and likely have much the same leisure activities and social behaviors as the native Appalachian residents. Even with all these sociocultural similarities, we still recommend that the residents of individual counties throughout Appalachia undertake the initial efforts to consider building Climate Change Haven communities by holding public meetings in which local preferences and concerns can be discussed (see Hirschman and Toomer 2023). It is vital that current residents feel that they have a voice in who is allowed to move into their county and what design, location, and amenities the new Climate Change Haven community will have.

To help promote this participative process, local newspapers and radio stations in each county will be requested to introduce the notion of Climate Change Haven communities to their residents using informational scripts prepared in advance. County newspaper articles and radio programs will reassure residents that their own county will remain very habitable despite climate change (e.g., Hirschman and Toomer 2023). Public meetings will also be held to ask county residents to consider the types of companies and agricultural activities they would like to have relocate to their county. A county website will provide additional details about the opportunities provided by building a Climate Change Haven community and also have a section for individual residents to voice their opinions pro and con regarding this new venture. County administrators will be able to respond to these comments and reassure residents of the viability of the project.

Concurrently, the estimated timeline and cost estimates for building Climate Change Haven communities in each county will be presented at public meetings organized by the county government. These meetings will describe the construction times involved in building these towns (three to five years) and installing the necessary hydroelectric generators, flood control dams, and surface remediation (if needed) efforts. Alternative locations for the new towns in their county, and the advantages—both economic and cultural—that creating these new towns will bring to their county will be discussed as well. Among the benefits are:

1. A much larger tax base due to an increased population and new businesses relocating to their county. (Many Appalachian counties have lost population in recent years, with a corresponding decline in tax revenues and public services).
2. Improved educational systems as new schools are built for the incoming residents and their children. (Several schools in Appalachian counties now are closing due to decreased student enrollment).
3. Improved medical and dental services, as skilled medical personnel relocate to their county.
4. County-owned and controlled hydropower electrical systems that will provide electricity at much lower rates than they are currently being charged by the coal-fired plants.
5. Expanded cultural and recreational opportunities created within each new town.
6. Increased housing options within the new towns.
7. Improved flood control systems across their entire county.
8. Expanded agricultural resources and fresh food options, providing lower cost and healthier groceries.

Upon gaining the support of their residents, county administrators can begin negotiating with certified ecobuilders to construct the towns, with hydropower generator companies to install the new electrical systems on county rivers, lakes, and reservoirs, and with flood control companies to construct appropriate flow-through dams on waterways. It is likely that the earliest counties to begin this process will have the greatest advantage in negotiating build-times and build-costs, because their county can be used as a promotional model by the companies they choose—much as 'model homes' are now built by real estate developers to attract potential buyers (Stern 2016).

Extending the Sociocultural Model to a Global Context

For potential Climate Change Haven community sites across the globe, however, this process will not be as simple or easy. A large advantage that the Appalachian locations have is that their incoming migrants will likely all be fluent in English, have familiarity with the US legal system, and possess US banking accounts, US driver's licenses, and US voter registration. In other words, they will be relocating geographically but not culturally.

In Britain, a similar set of conditions will also apply—persons from Wales and England may soon choose to 'migrate' northward to Scotland, as their southern regions become overly hot. Similarly, persons from southern and coastal France and from southern and coastal Spain and Portugal will likely choose to move to the Pyrenees Region, as their countries experience excessive heat and storm conditions due to climate change. However these in-country migrants will still be able to speak their native language and follow their familiar customs. In China and Brazil, persons now living along the coastal areas and in the southern portions of the country will soon need to migrate northward, but will remain in their own country (Oliveira and Pereda 2020; Zhang et al. 2022).

However, for the millions of persons now being displaced by climate change from the Middle East, Southeast Asia, Bangladesh, Pakistan, the Baltic Region, Africa, Central America, and Cuba, the prospects are not so bright (Cattaneo et al. 2019; Chowdhury et al. 2020, 2022; Ferris 2020; Nguyen et al. 2023; Smirnov et al. 2023). In order to survive, they will have to leave their home countries and travel to regions of the world where their native language is not spoken, their social and religious customs are deemed unusual, and their occupations may not be appropriate (Helbling 2020; McAdam 2020; Nabong et al. 2023; Vinke et al. 2020).

However, a hopeful possibility is that these same persons will bring with them agricultural experience with crops and livestock that are viable in their new Climate Change Haven countries. For example, as Scandinavia, Greenland, and Iceland become warmer due to climate change, they may be able to support crops and farm animals never before possible (Ward Jones et al. 2022; Unc et al. 2021; Raza et al. 2019). In these cases, the migrants originating from the Southern Hemisphere who wish to settle there would be able to immediately apply their knowledge and farming practices and prove to be a valuable addition to their new Climate Change Haven country.

Those of us who are fortunate enough to already live in Climate Change Haven regions must recognize that 'there but for fortune go I', and that our own personal climate safety is due to happenstance, not foresight. We ourselves could have been one of those who are now being displaced, who are forced to seek shelter in a strange land, and we must welcome them to live among us.

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