PNAS RESEARCH ARTICLE | SUSTAINABILITY SCIENCE OPEN ACCESS

The global human day

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Edited by B. Turner, Arizona State University, Tempe, AZ; received November 21, 2022; accepted April 18, 2023

The daily activities of ≈8 billion people occupy exactly 24 h per day, placing a strict physical limit on what changes can be achieved in the world. These activities form the basis of human behavior, and because of the global integration of societies and economies, many of these activities interact across national borders. Yet, there is no comprehensive overview of how the finite resource of time is allocated at the global scale. Here, we estimate how all humans spend their time using a generalized, physical outcome–based categorization that facilitates the integration of data from hundreds of diverse datasets. Our compilation shows that most waking hours are spent on activities intended to achieve direct outcomes for human minds and bodies (9.4 h/d), while 3.4 h/d are spent modifying our inhabited environments and the world beyond. The remaining 2.1 h/d are devoted to organizing social processes and transportation. We distinguish activities that vary strongly with GDP per capita, including the time allocated to food provision and infrastructure, vs. those that do not vary consistently, such as meals and transportation time. Globally, the time spent directly extracting materials and energy from the Earth system is small, on the order of 5 min per average human day, while the time directly dealing with waste is on the order of 1 min per day, suggesting a large potential scope to modify the allocation of time to these activities. Our results provide a baseline quantification of the temporal composition of global human life that can be expanded and applied to multiple fields of research.

time use | sustainability | global | sociology | economics

Significance

Understanding how the global human system functions is crucial if we are to sustainably navigate planetary boundaries, adapt to rapid technological change such as artificial intelligence, and achieve global development goals. But, the vast scope and diversity of human endeavors presents a major challenge for holistic assessment. Here, we address this problem by providing a global estimate of time use by all humans, integrating economic and noneconomic data within a consistent framework. Our findings provide a bird's eye perspective on what our species does, including how economic activities fit into the backdrop of life, and reveal activities for which there is significant potential for change.

At present, we lack a coherent global understanding of human activities. This is not to say that the study of human activities has been overlooked. On the contrary, activities comprise the core of our species' behavior, and for decades they have been documented by diverse fields including economics (1–3), sociology (4, 5), history (6, 7), and anthropology (8–10). However, economists have focused primarily on paid work activities, relegating other activities to leisure or unpaid work, while sociologists, historians, and anthropologists have often focused their attention on the activities that take place outside the formal economy. Because of deep methodological differences, these studies are very rarely combined, and they have not been previously integrated at the global scale.

A coherent interdisciplinary understanding of activities is important at present because, although the motivations for people to act are couched within the contexts of their own lives, activities are coordinated through economic and societal links to generate a globally integrated human system (11). The food we consume, the clothes we wear, and the material objects we use are largely produced by others in distant parts of the world. Similarly, threats to planetary boundaries, like climate change and biodiversity loss, are the collective outcomes of human activities across the planet (12, 13). Although the consequences of any human undertaking vary greatly with the available technology and other contextual features, the time spent on tasks is a key factor in determining outcomes, whether producing food, constructing buildings, or tackling environmental problems (14, 15). Because global outcomes emerge from the sum of individual actions, it is crucial to understand how global activities influence local changes and vice versa.

Compounding the disciplinary divisions is a geographic fragmentation of activity data. The collection and analysis of activity data have tended to be carried out at the national scale, tailored to the specific needs and objectives of individual countries, and most analyses have focused on wealthy populations. Although there have been some efforts to compare sociological time use data for adults across countries (16–20), they have not previously been used to characterize the global human system in a broader sense. Economic activities are more often captured in global databases (21), yet where global economic analyses have been carried out, they have typically focused on individual sectors of the economy, or relied heavily on monetary valuations to combine activities among countries. Because wages and capital valuations can vary dramatically between countries, a monetary perspective does not provide a clear picture of the ends to which humanity's global supply of labor is directed.

Author contributions: W.F. and E.D.G. designed research; W.F., E.D.G., J.C., E.F., P.L.M., K.M., V.X., X.W., and S.X. performed research; W.F., E.D.G., C.B.-L., I.H., and R.M. analyzed data; and W.F., and E.D.G. wrote the paper.

The authors declare no competing interest.

This article is a PNAS Direct Submission.

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This article contains supporting information online at https://www.pnas.org/lookup/suppl/doi:10.1073/pnas.2219564120/-/DCSupplemental.

Published June 12, 2023.

Table 1. Categories used to harmonize data, according to the Motivating-Outcome-Oriented General Activity Lexicon (MOOGAL)

Group	Category	Description
External outcomes	Food provision	Providing food to humans, including agriculture and fishing, the processing of food items, cooking, serving, and cleanup
	Nonfood provision	Providing raw materials and energy to the technosphere, including mining, lumber, fossil fuels, and renewable energy
	Technosphere modification	The construction and maintenance of buildings, infrastructure, and movable artifacts
	Maintenance of surroundings	Cleaning surfaces and arranging the spaces that humans inhabit, taking care of accompanying plants and animals, disposing of wastes
Direct human outcomes	Somatic maintenance	Caring for the cleanliness, appearance, and health of human bodies, including medical care and childcare
	Deliberate neural restructuring	Education, both formal and informal, research in the academic and private sector, and religious activities
	Experience oriented	Engaging in activities to provide desired experiences, including through use of media, interactive hobbies and sports, socializing, and meals
Organizational outcomes	Organization	Activities that do not directly support any of the above outcomes, but instead serve to change the locations of entities, or allocate the time and access rights of humans, including through commerce, finance, real estate, law, and governance

In contrast to monetary metrics, which are not strictly physical, all humans exist for exactly 24 h per day and spend each minute doing something (22, 23). This 24-h time budget constraint is applicable at any scale, as well as over the history of human development. A complete and holistic quantification of how global humanity allocates its ~190 billion hours per day could therefore provide a firm grounding from which to assess how human behavior is changing over time, as well as the scope and plausibility of strategies to simultaneously achieve multiple goals, such as the 17 internationally agreed upon Sustainable Development Goals (SDGs) (24, 25). For example, time provides a simple basis for assessing the overall feasibility of reallocating labor to constructing nonfossil fuel energy systems (advancing SDGs 7 and 9) or dealing with plastic pollution (SDGs 12, 14, and 15) while maintaining meaningful employment in a globalized economy (SDGs 8 and 9). It also represents an important, human-centered perspective on development and the evolution of human experience in the face of social and technological shifts, including the accelerated transformation of labor markets through urbanization, automation, and artificial intelligence (26–28).

Making use of the 24-h constraint requires a holistic assessment of activities. The disciplinary division between paid and unpaid activities can be resolved by combining observations from economic and sociological time use data with a harmonized set of activity categories. Given that global economic networks exchange vast quantities of materials and goods across national borders, understanding how the time budget constraint relates to physical outcomes also requires assessing activities for the complete population of the world. Combining national data requires taking into account discrepancies in the subsets of the populations surveyed (e.g., labor force and legal adults), as well as addressing numerous variations in reporting conventions and activity categorizations. These methodological hurdles have impeded the development of a unified global perspective on activities.

A Holistic Estimate of Global Time Use

Here, we assemble a complete estimate of what humans are doing, averaged over time and across the entire population, to provide an aggregated high-level view that we refer to as the global human day. We combined available data collected by national statistics agencies, international organizations, and researchers from over 140 countries, wherever available during the period 2000 to 2019 to avoid the economic and social disruption of the COVID-19 pandemic (*SI Appendix*, Tables S1 and S2). We interpolated within geographical regions to countries with incomplete or missing data in order to account for undersampled populations. We assessed the full human lifespan by weighting population-specific time use estimates using age-structured demographic data (*Methods*).

Our approach is enabled by a generalized categorization of activities (29), the Motivating-Outcome-Oriented Generalized Activity Lexicon (MOOGAL), which allows for the integration of data originally collected for diverse sociological, economic, and anthropological purposes. The lexicon is comprised of eight categories (Table 1), which are subdivided into 24 subcategories (Table 2). The subcategories are described in physical, rather than colloquial, terms to limit ambiguity in their application across cultures. Since the MOOGAL lexicon is designed to combine economic and noneconomic data, it differentiates based on the motivating outcome that causes the activity to be undertaken, rather than whether or not the activity is undertaken for pay. For example, both paid daycare work and unpaid care of young children by parents are classified under physical childcare, while food preparation includes both cooking at home and working at a restaurant. Similarly, the time invested by humans as both bus passengers and bus drivers would be included together within human transportation, since changing the locations of humans is the intended outcome for both activities. We produced concordance matrices for crossmapping all time use survey and economic activities to the MOOGAL subcategories, resulting in 3,956 MOOGAL subcategory definitions. Although it is not common to report uncertainty estimates for time use data, we endeavored to provide a partial estimate of the uncertainty range for each global average value. This uncertainty range aims to represent uncertainty in the initial data, the association to MOOGAL subcategories, and from interpolation to countries with missing data, and should be seen as approximate (see *SI Appendix* for a detailed description of the full method).

Table 2. Subcategories of the MOOGAL

Category	Subcategory	Definition	Examples
Food provision	Food growth & collection	All activities related to the growth of edible organic matter, its collection, and initial storage	Crop and animal production. Fishing, hunting, and trapping. Ploughing, clearing of land, sowing, planting, transplanting. Kitchen gardening. Collecting, storing, and stocking of products. Fish farming. Gathering wild products
	Food processing	Transformation of food to prevent spoilage and detoxification, or to create storable beverage and food products	Food manufacturing. Milling, husking, pounding. Beverage manufacturing. Food processing and preservation. Jarring and canning
	Food preparation	Transformation within days or hours of eating. Includes cleanup of preparatory surfaces, serving, and washing of dishes	Cooking. Preparing meals for the home. Washing dishes. Catering. Food and beverage preparation and serving. Parboiling. Bread baking. Serving meals/snacks. Clearing table
Nonfood provision	Materials	The extraction of substances from the Earth system to be used for artifacts, buildings, and infrastructure	Mining and quarrying. Digging out clay, gravel, and sand. Mining of metal ores. Forestry and logging. Nonferrous metal mining. Stone cutting
	Energy	Extraction and provision of energy	Oil and gas extraction. Electric power generation, transmission, and distribution. Gas production and supply industry. Petroleum processing. Mining of uranium and thorium ores. Gathering firewood and other natural products used as fuel
Technosphere modification	Buildings	Construction and maintenance of residential, commercial, and industrial buildings	Home maintenance. DIY home improvement. Construction work. Building and extension of dwelling. Construction activities for own home
	Infrastructure	Construction and maintenance of structures to facilitate the transport of people, materials, and information	Civil engineering. Telecommunications. Construction of roads, railways, and bridges
	Artifacts	Creation and maintenance of movable objects	Manufacturing of base goods. Manufacturing of textiles. Manufacturing of pharmaceuticals. Manufacturing of computer, electronic, and optical products. Making handicrafts, pottery, printing, and other crafts. Assembling machines, equipment, and other products. Vehicle maintenance and repairs. Production of goods for own household use
Maintenance of surroundings	Inhabited environment	Maintaining the cleanliness and order of inhabited spaces and materials, including home, workspace interiors, and grounds	Laundry. Indoor cleaning. Washing clothes and shoes. Ironing. Cleaning dwelling. Care of house plants. Ground maintenance. Pet care. Care of textiles
	Waste management	Dealing with waste and unintended by-products outside of inhabited buildings and their immediate environment	Waste management and remediation services. Sewerage. Recycling. Sewage and refuse disposal, sanitation, and similar activities. Waste disposal. Removing trash
Somatic maintenance	Hygiene & grooming	Maintaining the cleanliness and appearance of the body	Washing yourself, getting dressed. Bathing. Personal care. Grooming. Private activities. Personal hygiene
	Physical childcare	Physical and practical care of young people, including cleaning, feeding, and minding young children to ensure safety	Physical care of children: washing, dressing, and feeding. Supervising children needing care. Minding children. Physical care of preschool children
	Health care	Medical care and physical support to persons in need	Medical care for family members. Health care to oneself. Medical examination or treatment. Physical care of sick or disabled adult. Receiving medical/personal care from professionals. Mental health

Table 2. (Continued)

Category	Subcategory	Definition	Examples
	Sleep & bedrest	Time spent in bed and/or sleeping	Sleeping, naps, sick in bed. Incidental sleeps and naps. Bedridden due to disease
Deliberate neural restructuring	Schooling & research	Deliberate education and research activities	Education. Attending class. Homework and research. Studying and learning. Remote education learning activities. School, technikon, college, university attendance
	Religious practice	Religious practice and ceremonial, social, or cultural events	Ritual ceremonies. Praying. Religious activities. Private prayer, meditation, and other spiritual activities
Organization	Material transportation	Transport undertaken to move artifacts, raw materials, and food	Road freight transport. Shipping. Loading, unloading, handling, and other transportation services. Postal service, couriers, and messengers. Warehousing industry. Transporting in vehicles. Fetching of water
	Human transportation	Transport of persons for the purpose of changing their location	Travel to/from work. Travel for social and cultural activities. Travel to or from school. Commuting, job, and study-related travel. Public transport. Transport of passenger by motorized and nonmotorized transports. Journeying
	Allocation	Activities that are not directly motivated by a specific outcome for humans or the external world, but instead contribute to determining the allocation of time and access rights to humans	Wholesale and commission trade. Retail. Banking. Financial and insurance industry. Public administration and defense. Local government services. Extraterritorial organizations and bodies. Accessing government services. Real estate industry. Legal and accounting activities. Petty trading, street and door-to-door vending, hawking. Grocery shopping. Purchasing goods. Shop online stores. Paying household bills. Household management. Job search
Experience oriented	Meals	Activities centred on eating and drinking, including associated socializing	Eating and drinking. Eating meals/snacks. Pubs and restaurants. Coffee, refreshments. Meals associated with work. Visit to restaurant, café, bar
	Active recreation	Recreation that involves an elevated metabolic activity, whether purely for the experience or including a fitness motivation	Active sports. Ball games. Walks. Wushu and Qigong. Hiking. Walks in forest and on land. Walking the dog. Water sports
	Passive, interactive, and social	Activities undertaken for the purpose of producing a desired experience, including passive observation of media or surroundings, interactive engagement with devices or other people, and socializing	Watching TV. Listening to radio, personal media device, or other audio. Reading. Using computer to read and watch/listen to programs. Doing nothing, rest, and relaxation. Arts and hobbies. Computer games. Visual, literal, and performing arts. Museum/exhibition. Spectator to sports, exhibitions, concerts. Socializing. Attending or hosting social events. Telephone calls. Discussing, gossiping. Family and socializing. Visiting relatives and friends

The Global Human Day. Our resulting estimate of the global human day is shown in Fig. 1, reported as the number of hours per day engaged in each activity, averaged across all humans, where the area of each colored cell is proportional to the amount of time. Sleep and bedrest, the largest category (9.1 ± 0.4 h), is shown as the adjacent crescent. This sleep estimate is significantly larger than the global average of 7.5 h of sleep per day recorded among adults by wearable devices (30), a difference we attribute to the inclusion of children in our estimate and to the time spent in bed but not sleeping (*Methods*).

For the ≈15 h per day of human life not devoted to sleeping and bedrest, the activity subcategories can be summarized according to three large groups. Direct human outcomes (9.4 h), comprising the largest group, are motivated by the immediate consequences they have on humans. These activities include taking care of the appearance, cleanliness and health of human bodies, the deliberate restructuring of human neural pathways, and the generation of desired experiences. The most time-consuming subcategory is passive, interactive, and social activity which includes reading, watching screens, playing games, going for walks, socializing, and sitting doing nothing, and occupies an average of 4.6 ± 0.3 h or ≈31% of the average waking day. The second large group includes activities motivated by external outcomes (3.4 h), i.e., intended to produce physical changes in the world outside humans themselves. These changes

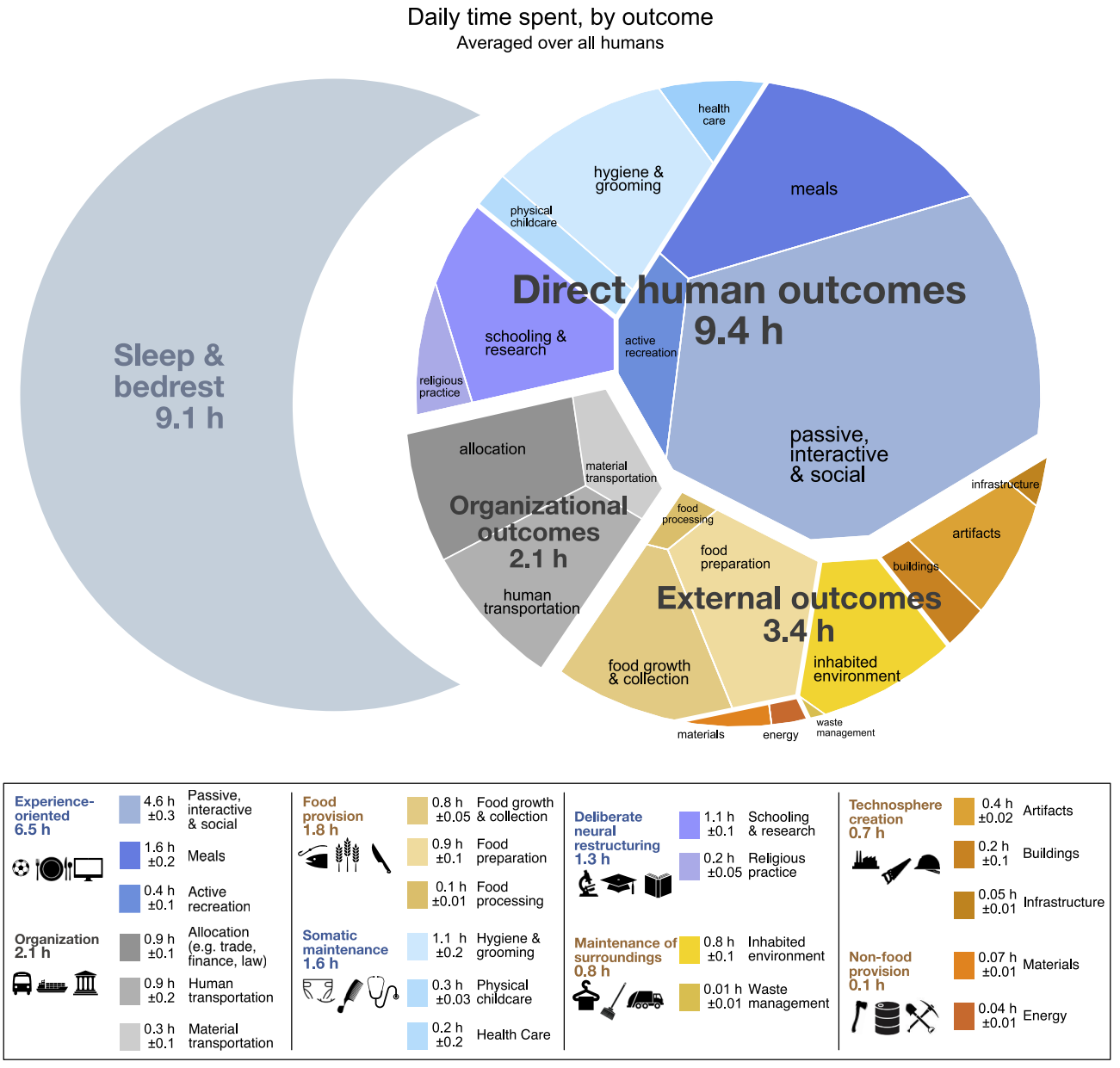

Fig. 1. The global human day, including both work and nonwork activities. The time devoted to each activity, averaged across the entire human population of ≈8 billion people, is indicated by the area of each colored shape in the Voronoi diagram. Direct human outcome activities aim to modify the bodies, neural structures, and experiences of humans. Activities with external outcomes are intended to modify the immediate surroundings of humans, including construction and maintenance of the technosphere, and the provision of food, energy, and materials from the Earth system. Activities with organizational outcomes include moving humans and cargo, as well as activities that allocate labor and access rights such as trade, finance, law, and governance. The time spent in each subcategory is listed below the diagram, in hours per day, with approximate confidence intervals that reflect contributions from the original data sources, interlexicon associations, and interpolation.

include extracting materials and energy from the natural environment, producing food, creating and maintaining movable objects and immovable constructions, and maintaining the cleanliness and tidiness of the spaces humans inhabit. Activities in the third large group are motivated by organizational outcomes (2.1 h), including activities that modify the locations of humans and materials, and an array of activities that are not directly motivated by particular physical outcomes, but instead serve to allocate the time use and access rights of humans (29). Allocation is achieved by mechanisms that vary between cultures and economic systems, including legal and political systems, finance, policing, and shopping.

Time Devoted to the Global Economy. Because our analysis includes both economic and noneconomic data at the global scale, it enables a unique perspective on how economic activities fit into the overall distribution of human activities. Economic activities are defined here as those within the scope of what the International Labor Organization considers "employment," including work for pay or profit as well as the production of nonmarket goods within households. These economic activities account for ≈2.6 h (158 min), roughly 11% of the global human day, or one-sixth of waking hours over the average lifetime. Although this may appear small, it is equivalent to a 41-h work week among the global labor force (which is approximately 66% of the working-age population, those aged 15 to 64 y).

When the global economic activity is viewed on its own (Fig. 2), we see that almost one-third involves the growth and collection of food (44 ± 3 min), mainly in the form of agriculture. Roughly one quarter of economic activity is dedicated to allocation (37 ± 2 min), which includes retail, wholesale, real estate, insurance, finance, law,

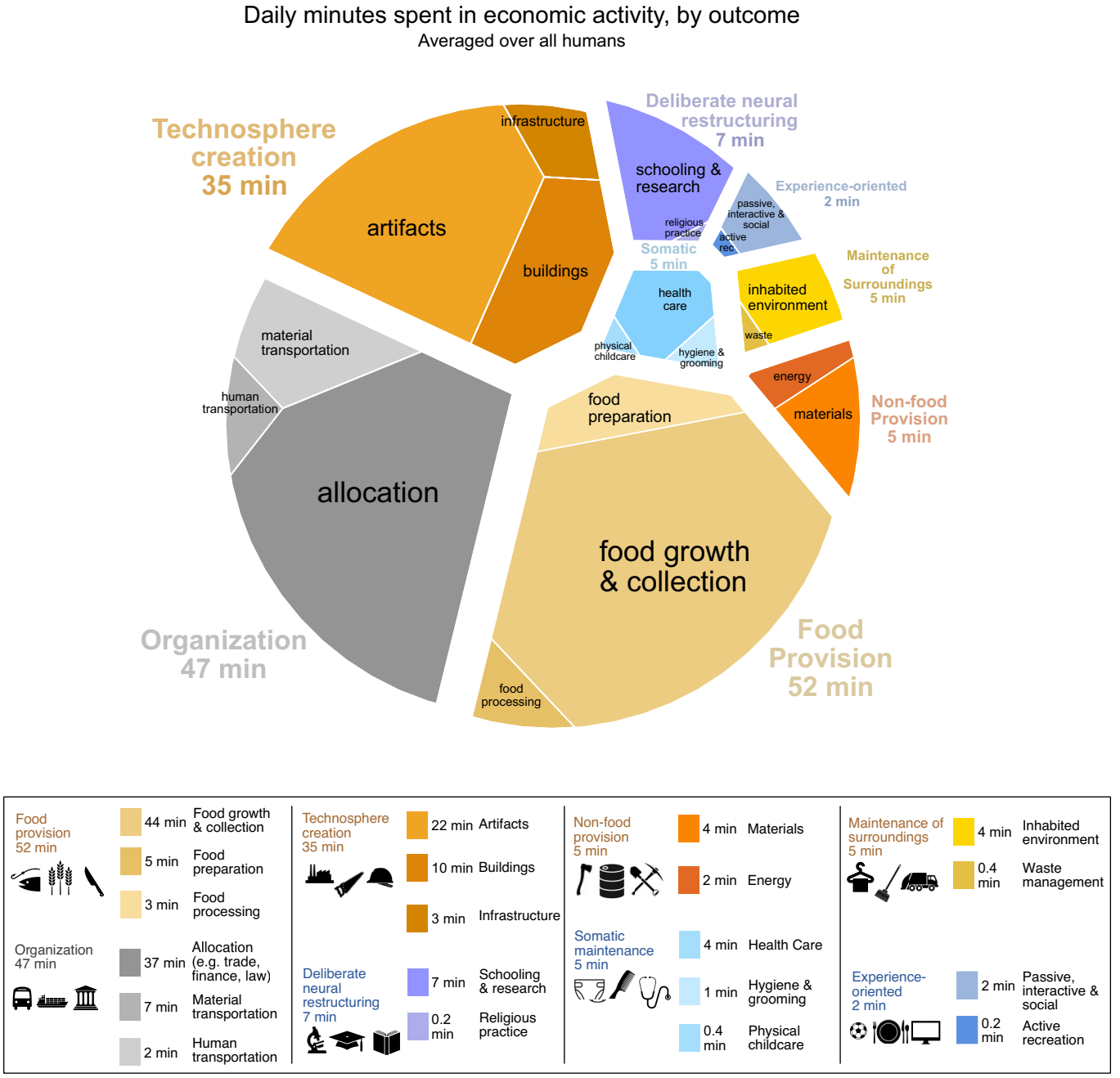

Fig. 2. The global economic day. Voronoi tree is calculated as in Fig. 1, for the average time spent in paid employment and unpaid or other own-use/household production of goods, averaged across the global population. Average times per subcategory are shown at the bottom of the figure, in minutes per day. The sum of all economic activities is ≈2.6 h per day, equivalent to a 41-h work week among ≈66% of the working-age population.

and governance. The production of artifacts, which includes the manufacture of vehicles, machinery, electronics, domestic appliances, and all other movable goods as well as their intermediate components, accounts for roughly one-seventh of the total economic activity (22 ± 2 min). The remaining economic time is mostly partitioned among the construction and maintenance of buildings, freight and other material transportation, food preparation, and schooling and research.

Variation with Material Wealth. Because our data compilation includes formal, informal, subsistence, domestic and care work, as well as nonwork activities, normalized to total populations, it allows a comprehensive comparison of how activities vary between countries. To provide an overview, we show how activities vary in relation to material wealth, for which we use GDP per capita ($US PPP) as a proxy. Our data reveal particularly notable trends in four activities vs. GDP per capita, shown in Fig. 3. The time spent growing and collecting food is large in low-income countries (>1.0 h) but becomes very small in high-income countries (<5 min). This striking trend can be largely attributed to labor-saving technologies (27) that allow the same amount of food to be produced with an order of magnitude less time. The decrease of approximately 1.2 h in food growth and collection over the income range is roughly counterbalanced, perhaps unsurprisingly, by an increase in the time spent engaged in experience-oriented activities (passive, interactive, and social interactions plus meals and active recreation, a ~1.5 h increase). There are also significant increases of the time spent in allocation activities (~0.4 h) and on infrastructure construction and maintenance (~0.1 h) across the range of GDP per capita.

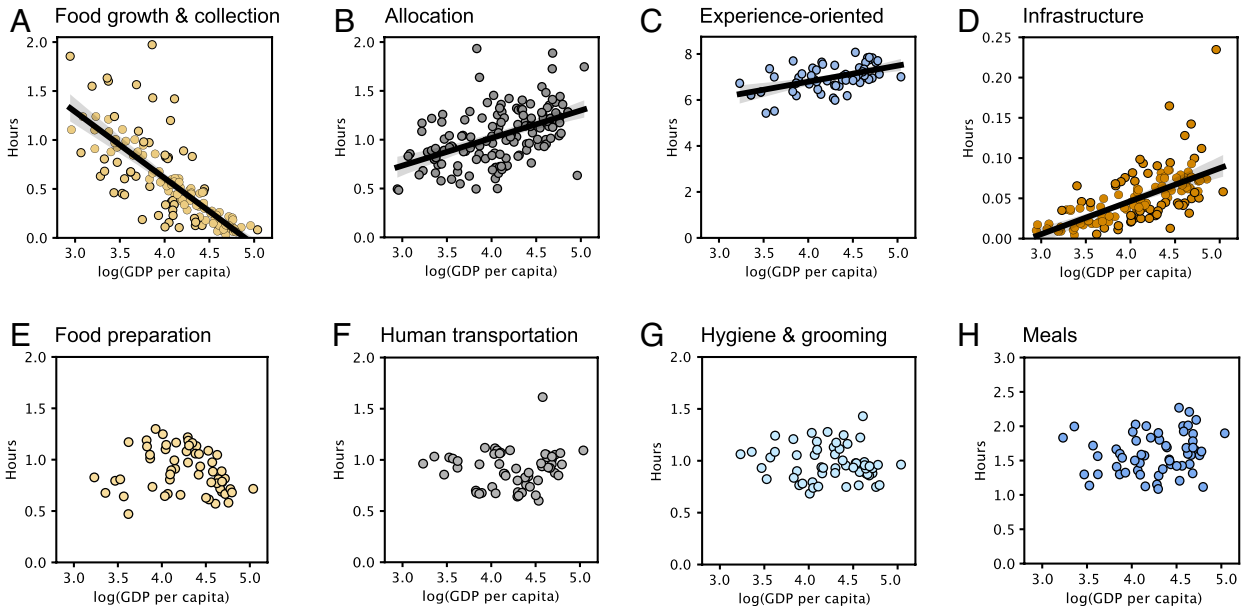

Fig. 3. Activities vs. GDP per capita at the country scale. Each circle represents the population-average time per day for one country. Panels *A*–*D* show subcategories with highly significant linear trends, while panels *E*–*H* do not show significant trends. Panels *A*, *B*, and *D* include only countries with economic data, while other panels include only countries with time use survey data.

In contrast, other activities are remarkably invariant vs. GDP per capita. Food preparation (0.9 ± 0.1 h), human transportation (0.9 ± 0.2 h), hygiene and grooming (1.1 ± 0.2 h), and meals (1.6 ± 0.2) show no detectable trends with GDP per capita (Fig. 3 *E*–*H*). This invariance does not imply that the portions of time devoted to these activities are universal across humans, as they certainly vary among individuals. Rather, our results do not show a consistent variation with GDP at the population level, suggesting that material wealth does not play a large role in determining the allocation of time to these activities. Together, these wealth-invariant activities comprise 4.5 ± 0.4 h or 30% of the waking day.

The relatively constant time spent in human transportation is particularly notable, given that travel is often thought of as a cost that might be alleviated with technology (31), analogous to the large effect of labor-saving technology on agriculture (27). Instead, our data imply that material wealth has a negligible effect on travel time at the population level (Fig. 3*F*). This supports long-standing speculation regarding an inherent travel time budget (32–34), which was originally based on more geographically limited data, and is consistent with the hypothesis that the built environment and transportation technology tend to coevolve to maintain a psychologically bounded average daily travel time (35, 36). This general observation has implications for the potential to reduce transport-related energy expenditure: If travel time is relatively invariant at the population scale, per capita energy consumption can only be reduced by decreasing the energy consumption per travel time. It follows that the energy cost per travel time is the key variable of interest, and that—on their own—reductions of the average energy cost per distance traveled are unlikely to reduce overall energy consumption in daily personal transport.

Time for Sustainable Action. Our analysis shows that the activities through which humans directly modify the state of our planet account for a relatively small portion of the global human day. For example, the extraction of all raw materials such as wood, minerals, and rock requires only 4 ± 1 min, while energy provision, including the extraction and refining of all fossil fuels, is achieved with 2 ± 1 min. This is not to say that these activities are minor in aggregate physical or economic terms: When summed over the global population, ≈780 million person-hours are dedicated to material extraction and energy provision daily, equivalent to ≈285 billion person-hours per year. On their own, these large sums might give the impression that material extraction and energy provision comprise a major component of human activity. But instead, when viewed as a relative fraction of the whole, they are found to be remarkably small compared to activities such as hygiene and grooming, which consume ≈3.2 trillion person-hours per year, roughly 12-fold more.

The concept of Energy Return On Investment (EROI) offers an interesting perspective on the human time invested in energy provision (37). An EROI ratio compares one form of usable energy with the energy investment required to provide it. Our results allow a unique assessment of the average return on human metabolic energy investment. Although the usable energy could be quantified at multiple points, for the sake of argument, we choose the final global energy supply, approximately 13 TW in 2019 (38), to compare with the human metabolic energy expenditure used in the activity of providing that energy supply. If we assume a typical adult human mass of 70 kg, with a basal rate of 1.1 W kg^{-1}, working at a typical rate of 2.5-fold the basal rate (39), our results imply that the average global rate of human metabolic energy invested in all forms of energy provision (2 min per day) is ~2 GW. This is equivalent to an EROI ratio for the human to final energy supply of more than 5,000-fold. This EROI ratio is a factor of 5 to 10 lower than values estimated previously for Italy and the United States by ref. 40, which we attribute to a combination of international exchange and the inclusion of low-efficiency energy forms such as firewood collection in our global estimate. We emphasize that this is a crude estimate, but it shows the extremely high average EROI, relative to metabolic energy, achieved by the global human system.

Because the global supply of energy and materials is currently provided with a small fraction of the total time (amounting to ≈ 3% of the global economic time), the time allocated to these activities could be altered to a relatively large degree without necessarily having a large impact on the time allocated to other activities. This assessment suggests that climate change solutions, such as shifting labor away from fossil fuel industries and into the

construction of global renewable power infrastructure, are highly feasible in terms of the global time budget, in that there exists a clear physical scope for humans to reallocate time among the relevant activities without significantly disrupting the overall distribution of time at the population level. The potential of labor-saving technologies to reduce the time required for food growth and collection, highlighted above, suggests that a synergy might exist between the mechanization and electrification of agriculture in low-income countries (41) and the construction of solar energy infrastructure. This does not speak to the policy and economic measures required to engineer such transitions, which are likely to be highly challenging. But, it does indicate that a future with quite different infrastructure and energy flows can be physically achieved without requiring a great disruption in the overall composition of human activities.

Meanwhile, the amount of time devoted to dealing with waste, outside of our dwellings and their immediate surroundings, appears to be very small (≈1 min). We caution that our assessment of waste management time may have been unable to capture time investment by some government agencies, consultants, and the informal economy, so the ~1 min per day may be an underestimate. Nonetheless, this small time investment stands in stark contrast to the time spent cleaning and arranging within our dwellings (≈40 min). It seems plausible that many waste problems, including the accumulation of ocean plastics and water contamination by toxins, could potentially be greatly alleviated through a relatively small reallocation of the total human time budget. Motivating such shifts of time allocation requires dedicated policy and economic strategies, but our analysis suggests that the time is available for the global human system to address 21st-century sustainability goals.

Outlook. The holistic approach to time use presented here can serve as a foundation for future work. Additional dimensions of global time use, beyond the physical outcomes focused upon here, can be resolved through the global application of complementary standardized lexicons (29). These additional dimensions might include social interactions, physical context, or technology use. The geographic distribution of activities can be directly linked to material, energetic, and monetary flows, as well as to subjective experiences, to enhance process understanding. Changes over time in the global human day, informed both by historical records and ongoing monitoring, can potentially provide further insight on long-term behavioral mechanisms and the roles that changes in time allocation play in societal transitions. Globally standardized time use patterns can be applied as human-focused alternatives to GDP (42), and calculations of potential changes in time use may help to chart pathways toward SDGs, applicable for planetary-scale governance (43). Time, it has been said, is the coin of life—and in a globally connected society, it is essential to have a thorough global understanding of how that coin is spent.

Methods

Our estimate of the global human day is constructed as part of the Human Chronome Project (https://humanchronome.org/), based on three primary components, namely nationally representative time use surveys, national statistics of employment and working time according to economic activity, and a multicomponent time use model for youth aged 0 to 17 y. We also include sleep data from wearable devices for comparison with time use survey data. The data sources are briefly described below, followed by the strategy used to interrelate activities through a common lexicon, and a brief discussion of uncertainty. A more thorough description of the method is provided in *SI Appendix*, including supplementary figures and tables.

Time Use Surveys. To provide a baseline for average daily time use, we obtained nationally representative time use surveys from 58 countries comprising approximately 60% of the world population. These surveys are conducted by national statistical agencies with the goal of providing a broad understanding of how the population allocates their time to a set of activities. Most of these surveys report any formal economic participation as a single activity, e.g., "work for employment" (with some exceptions). Survey data are collected via self-completed time diaries, telephone or in-person interviews, online questionnaires, or a combination of these methods. The measure we use is the population-weighted average daily time spent on each activity among all respondents, which is the product of the participant time (the average time spent on each activity only among those who engaged in the activity) and the participation rate (the percentage of all respondents engaging in the activity). When available, the aggregate survey data were downloaded from the respective national statistical agency database, and translated as necessary. If the aggregated datafile could not be located, the relevant table from the survey report was manually transcribed to a computer-readable format. The full list of countries, including the source location, is given in *SI Appendix*, Table S1.

The quality of each survey is assessed according to several key characteristics, notably survey duration, data collection method, and lexicon length. Three quality levels (A, B, and C) are associated with a 5, 10, and 20% baseline uncertainty on the time values reported in the survey, respectively. For details regarding the quality assessment, see *SI Appendix*, section 6.

Economic Activity. The main source for economic data was ILOSTAT, the online repository of labor statistics managed by the International Labour Organization (ILO) Department of Statistics. Mean annual employment and mean weekly working time data, recorded under the International Standard Industrial Classification (ISIC) of economic activities, were used to calculate mean daily working time of the entire population. We also obtained the comparable economic activity data for Canada, China, Japan, and Russia, which did not archive data with the ILO. In total, economic data were available for 139 countries, representing 86% of the world population.

Youth Population. While the time use surveys are nationally representative, many do not include youth below a minimum age, which varies by country between 14 and 18 y. The absence of children from most time use surveys can be generally attributed to the view of time use as a metric of human capital, a context in which children are not considered useful (44). In order to correct for the consequent bias, while also providing a complete description of human time, we assembled a complementary dataset on the time use of youth aged 0 to 17 y and used this to construct an age-structured model of total youth time. Student enrollment data from the World Bank and UNICEF were paired with educational instruction time from the OECD to calculate average daily time spent in schooling for each age. Youth employment data were taken from the 2016 ILO Global Estimates of Child Labour report, which covers children between ages 5 and 17 y in 105 countries and provides child employment rates in agriculture, industry, and services. Youth working hours were obtained from the World Bank. The activities occupying the remainder of average daily time were estimated using data averaged from time use studies conducted in 10 countries, as well as a global youth sleep time study (see *SI Appendix*, section 4 for details). Sensitivity tests without the youth model are provided in *SI Appendix*, section 9.

Sleep. Sleep, as recorded by wearable devices among >18-y-old adults, consumes 7.5 h per day, while the self-reported estimates averaged over all ages result in an average of 9.1 ± 0.4 h of sleep plus resting in bed, or being in bed but not sleeping. The 1.6 h discrepancy is partly attributable to the well-characterized overestimation of total sleep time in time diaries (45, 46). Prior comparisons of sleep time have found this difference to exceed 1 h (45) due to the inclusion of sleep onset latency, offset, nighttime waking, and other activities in the self-reported sleep time. In addition, youth, who are included in our global estimate but not the wearables data, generally sleep longer hours.

Activity Categories. Given the diversity of our data sources, it was necessary to crossmap across a large number of activity categorization systems, known as lexicons. Activities were reclassified according to the motivating outcomes that cause the activities to be undertaken, using the MOOGAL as described in ref. 29. The MOOGAL subcategories are intended to apply to any human population and epoch and are generally well aligned with commonly used sociological and economic lexicons (HETUS, ICATUS, ISIC) for the majority of activities. Activities that are coordinated between multiple people, such as those carried out in economic activities organized

by firms, are categorized according to the motivating final output, consistent with standard economic practice. We apply a priority scheme such that Priority 1 subcategories are identified in preference to Priority 2 where both co-occur, and Priority 3 has the lowest priority. Thus, Priority 3 experience–oriented activities (e.g., reading) are only coded as such if they are not identified as contributing to a Priority 1 or Priority 2 outcome (e.g., schooling and research). Because activities are frequently reported in terms that include more than one MOOGAL outcome, our coding system allows fractional partitioning of an observed activity between MOOGAL subcategories. For a given lexicon of length n, each activity is associated to the 24 MOOGAL subcategories in an $n \times 24$ matrix by assigning a relative weight between 0 and 1 to each subcategory. These weightings indicate the portion of time from the original activity that is associated with the given subcategory, as estimated by human coders. A weighting of 1 indicates that the activity is uniquely associated with the single subcategory, while a weighting of 0 indicates that the activity is entirely excluded from that subcategory. An activity that cannot be entirely associated with a single subcategory is split fractionally among subcategories, that together sum to 1. All activity definitions were estimated independently by at least three coders, discrepancies were reviewed, and mean values were used wherever unequal but defensible estimates co-occurred.

Interpolation to Countries with Missing Data. Our dataset includes direct observations for 145 countries. Of these, both time use and economic data were available for 52 countries, time use data alone were available for 6 countries, and economic data alone were available for the remaining 87 countries. To assess the entire global human population, we group countries into 17 geographic regions based on the ILO subregions and separately interpolate both time use and economic data to the missing countries in each region. For each missing data type, countries are filled using the population-weighted average of the sampled countries in the same region, for each subcategory.

Data, Materials, and Software Availability. All data used in this work, as well as scripts to compile the results, are deposited in zenodo (10.5281/zenodo.7941615) (47).

ACKNOWLEDGMENTS. We thank Victoria Reyes-García, Jeroen Van Den Bergh, David Carozza, Dror Etzion, Majdi Hunter-Batal, Maxwell Kaye, Maria Pastor, Lior Greenspoon, Eric Kolaczyk and Brian Robinson for helpful comments and discussion.

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