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How can *you* save the world? Empowering sustainable diet change with a serious game

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Abstract—Presently, one of the greatest challenges of humankind is climate change. It is usually assumed that its mitigation will require an extensive adaptation in many human habits. As every fourth ton of carbon dioxide emitted can be attributed to the food chain, it is argued that one of the most effective actions an individual can take is changing towards a more sustainable diet, like a plant-based one. Serious games have proved to be a successful means for achieving behavior change. We present *Veganity, your journey*, a mobile serious game aimed at assisting players in their transition towards a more plant-based diet. The game combines the characteristics of the idle game genre with diet tracking: in the game, as you progress in adapting your personal diet, you spare energy that can be spent in making the game world more sustainable. Personal factors, like changing your ecological or social norms, your habits and your behavioral costs and benefits, are targeted by different game mechanics. These include, among others, a currency mechanism for stimulating habit change, in-game actions building up self-efficacy, and tips raising problem awareness. Besides describing our game design, we also present the main features of the game implementation. From a preliminary evaluation, we conclude that *Veganity, your journey* successfully engages players in pursuing their own diet goals, and increases their reflection on, and acquaintance with, sustainable diet behaviors.

Index Terms—Serious games, Personal diet, Behavior change, Sustainability, Climate change mitigation

I. INTRODUCTION

In 2019, more than 11,000 scientists from 150 countries warned about the drastic effects of continuous greenhouse gas emissions on the earth's climate [1]. Despite many attempts to reach social and political consensus on lowering carbon emissions, global movements like "Fridays for Future" are emerging, demanding political action and pressing towards more individual responsibility as well. In order to mitigate climate change, widespread societal change seems necessary, and the more people take part in it, the easier and faster the transition will be [2].

Standing out among all economic sectors, the global food chain contributes around 26% of the yearly global greenhouse gas emissions, from which 81% can be attributed to the farming stage [3]. The majority of the farmland can be ascribed to the production of animal products such as meat and dairy [1]. Some studies estimate that if the world population would

collectively pursue a plant-based diet, global warming could be limited to 1.5°C [4], [5]. Therefore, from an individual's viewpoint, one of the most effective actions one can take is to change their diet to a plant-based one.

Today, many signs point towards an increasing awareness and interest in becoming vegetarian or vegan in many sectors of Western societies. Google Trends shows an ever increasing interest in the search term "vegan", and the plant-based market in the US has been growing with double digit numbers for the past years [6]. However, transitioning to a plant-based diet poses many personal challenges on those attempting to change [7], at both organizational, intellectual, motivational, and social levels.

Serious games have proven to be an effective means to facilitate behavior change in various dimensions [8], [9]. In this paper, we first look into the theoretical foundations of serious games for behavior change, within the context of the relation between one's diet and climate change. Our research question boils down to: "How can a serious game empower players to shift towards a more plant-based diet and sustainable behavior?"

As a result of this research, we designed and developed *Veganity, your journey*, a mobile serious game that answers this question by applying those principles to motivate the transition towards a more sustainable diet, within a climate change mitigation context. Due to the long term of such a behavior change project, game evaluation is currently still underway; in this paper we discuss preliminary results so far.

II. RELATED WORK

A. Diet and Climate Change

Modern food production has far-reaching impacts on the environment in general and on climate change in particular. The livestock sector alone, including the feed crop agriculture, contributes around 18% to global emissions of CO₂ equivalents [10]. Hence, emissions stemming from global livestock and feed crop agriculture surpass emissions from the transportation, housing or leisure sector [11]. Furthermore, livestock farming heavily impacts global fresh water usage, land use change and public health [10].

However, the public is mostly unaware of these facts. While people tend to link their dietary choices to personal health, the connection to the planetary health is largely neglected [4]. Thus, public authorities have started considering environmental aspects in their official dietary suggestions [12]. Interestingly, both environmental and health aspects overlap: in general, the more healthy the food consumed, the less impacts there are on the environment [13] [14]. From both angles, a plant-based diet can be seen as the most healthy and environmentally friendly, hence the most sustainable diet [15]. The term *plant-based* focuses on the health effects of the diet [16], and - contrary to *vegan* - is connoted more with Nature and less with ideology.

Diet change towards a more plant-based diet can thus be seen as an important means for climate change mitigation. In particular, devoting the land currently used for livestock and feed crop farming to reforestation could reduce climate change mitigation costs up to 50% [5]. The European Union lists the change towards a vegetarian diet as the largest potential of climate change mitigation, possibly reducing greenhouse gas emissions by more than 260 megatons CO₂ solely in 2020 [17]. This large societal change, however, requires deep and challenging individual behavior change.

B. Behavior Change for Sustainability

Individual behavior change has gotten academic attention for a long time. Both psychological and sociological research fields have developed concepts to explain the difficulties in changing behavior, even when there is a general problem awareness. Stimulating and fostering individual behavior change should thus never be seen as a one-dimensional activity [7].

Regarding a change towards a plant-based diet, the European Union lists the lack of knowledge, cultural norms and “strong habitual components” as the biggest barriers to climate change mitigation in the food sector [17]. These factors perfectly align with the sustainable behavior change framework of Hamann et al. [18], who identify six main factors determining one’s behavior change: personal ecological norms, social norms, behavioral costs and benefits, weighing processes, habits and emotions. Other frameworks, such as the behavior change wheel of Michie et al. [19] cluster three different sources of behavior, namely *capability*, *opportunity* and *motivation*, which also overlap with the sustainable behavior change framework of Hamann et al. [18]. In essence, current research agrees in that sustainable behavior change needs a multi-dimensional approach.

Taking the work of Hamann et al. [18] as a basis, personal ecological norms provide a first approach to changing one’s diet towards a more plant-based one. If people are aware of the impacts of their diet, have a feeling of self-efficacy and perceive their own responsibility, they are much more likely to substitute animal products with plant-based products. Secondly, social or cultural norms can either inhibit or accelerate the change towards a plant-based diet, depending on one’s personal social network. Thirdly, costs and benefits

of switching to a plant-based diet can additionally determine the success of such an attempt; if there are no low-threshold offers to plant-based diets, one might consider the costs too high. Fourthly, all the previous factors are differently weighed per individual, when considering change towards a plant-based diet. Lastly, habits and emotions also touch upon this process and will likely need to be steered for achieving sustainable change. It is hereby crucial to keep in mind that behavior change is not simply habit change; on the contrary, habit formation is only one of many aspects of an individual’s behavior change process.

C. Serious Gaming

In line with the previous section, it has often been posited that a promising means to incorporate multiple dimensions of sustainable behavior change is by means of serious games. Essentially, these “let players gain an experiential understanding of real world issues through play” [8], and are, therefore, able to both convey problem awareness and encourage individual action [9]. Multiple serious games for behavior change have already been examined by research, some of which have failed, and some of which seem promising [20]. Generally spoken, games solely based on educational activities without active game play seem to work less well than games which allow players to make their own decisions and conclusions [21].

Presently, there is a limited pool of serious games which concern climate change mitigation [22]–[24]. There is however a growing number of games assisting in behavior change, such as games to quit smoking [25] or reduce alcohol and drug abuse [26]. Moreover, there exist games that encourage a healthier diet for young adults [27], [28] and children [29], [30]. However, to the best of our knowledge, there seems to be so far no serious game explicitly pursuing individual diet change motivated by climate change mitigation.

III. GAME DESIGN

The game *Veganity, your journey* aims at empowering players to change their eating habits towards a more sustainable diet. Here we describe the main design choices and gameplay elements that support this goal.

A. General game description

Veganity, your journey is a so-called *idle game*, a particular genre in which the player can perform simple actions that earn in-game currency, which can be spent on improving aspects in the game. In this case, the player alternates between *sparing energy*, by achieving their sustainable diet goals, and *applying that energy*, by choosing where in the world to invest it in a sustainable way. This choice is fitting for the goal of changing a diet behavior, which typically takes quite some effort over a long period. In addition, the above cycle also justifies the choice for a mobile game, which makes taking such actions very accessible for players.

First and foremost, *Veganity, your journey* allows for players to set their dietary personal goals in terms of animal-based products they would like to replace by plant-based food for a

chosen period of time. Personal goals play an essential role in the gameplay because they allow the player to freely decide on a personal diet plan, which they are comfortable with and wish to follow. This design choice follows Hamann et al.'s [18] tailored approach to behavior change.

Once a plan has been chosen, the game helps players to track their upcoming dietary goals. While they do this, the game showcases the impacts of their present diet on the planet, represented by the game world. For eating plant-based according to their plan, players receive in-game rewards in the form of (spared) energy, which they can invest in their choice of sustainable actions (e.g. plant trees or collect plastics) that have a direct effect on the global parameters of the game world; see Section III-B3. In this way, players are empowered to locally make incremental improvements in the world, and encouraged by seeing the corresponding effect on the game world as a whole. Making the impact clear to the player also fits within Hamann et al.'s [18] framework. Finally, the game provides useful tips and tricks that improve players' knowledge about sustainable diets.

B. Core game loop

The core game loop consists of the four main steps depicted in Figure 1: the player inputs their dietary data, receives rewards, improves their game world and acquires knowledge. These four activities combine to empower the player towards a more sustainable diet, whilst deepening their knowledge on this topic.

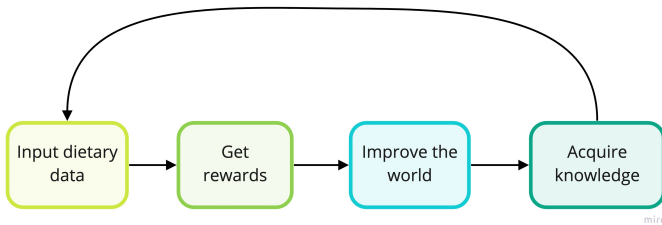


Fig. 1: Core game loop

1) *Input dietary data*: Inputting dietary data involves the player checking boxes daily for different types of animal-based products they did not consume during that day (supposedly according to their set goals). These types are *red meat, poultry, fish, dairy, eggs or any other* (this category includes smaller animal-based products). These types of animal-based products were chosen because they are part of a normal animal-based diet and have a significant impact on the environment. Daily inputs encourage players to keep up with their diet goal, because by having to check boxes in a list, they become explicitly aware of their concrete meal choices. Moreover, players receive immediate insights on the effect small changes can have on the world.

2) *Get rewards*: When players earn rewards in games, they tend to have a more fun and fulfilling experience. Furthermore, game reward systems can even motivate the player in the real world [31]. In *Veganity, your journey*, the player receives a

reward, in the form of energy, for every goal achieved, as shown in Figure 2. The dietary data tracked by the player also yields energy, based on the estimated environmental harm caused by each animal-based product that was avoided. For example, the CO_2 equivalent necessary to produce one serving of beef is 6.61 pounds [32]. Then, in a sense, a person not eating that serving of beef is 'saving' that amount of CO_2 equivalent; thus, in the game, that player gains 7 'energy' points to express that action can be used to improve the player's game world. In addition, the player can earn badges by reaching certain milestones.

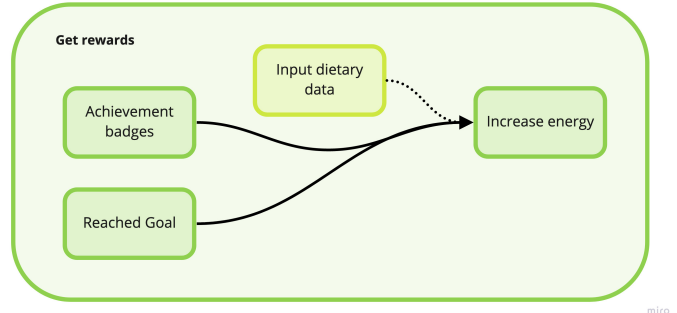


Fig. 2: Get rewards game arc

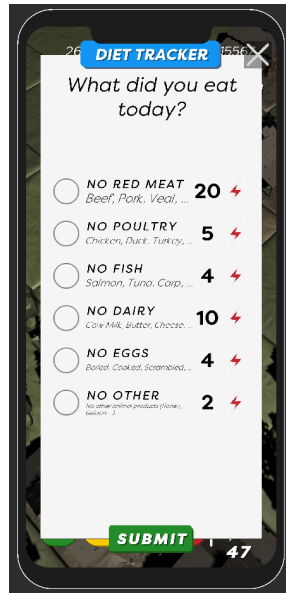
3) *Improve the world*: The state of the game world is described by three global parameters, corresponding to the three main human footprints: carbon, water and land. Their values are expressed in units that the player can easily relate to: kilometers driven by car, Olympic pools and soccer fields, respectively.

The game world state parameters can be incrementally improved by local player actions. For this reason, the game world has a tile-based structure. Tapping on a tile reveals its available action(s) and the respective energy cost; see example in Figure 3e. Each game action represents a real-world environmentally friendly measure that can be taken not only locally, but also at the food industry level. The opportunity to improve the world gives the player a feeling of self-efficacy, as the player sees the progress of their diet tied with the improvement of their world. This sense of self-efficacy is important because it contributes to change one's behavior, as mentioned earlier (Section II-B). Furthermore, acting on the game world increases players' problem awareness, as they are actively involved in improving the world.

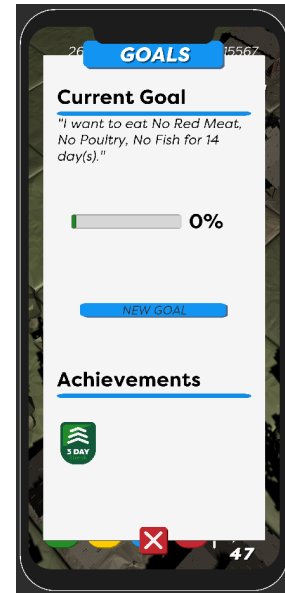
4) *Acquire knowledge*: Players acquire knowledge through feedback messages, with information on how and why the world global parameters evolve as a result of their diet and action choices. A player can also interact with a character present in the game world, who provides information about plant-based diets and their effects on the environment. This element plays a key role in informing about the topic addressed by the game, increasing problem awareness by the players, so that they can take more informed decisions in changing their diet.



(a) Main menu



(b) Diet tracker



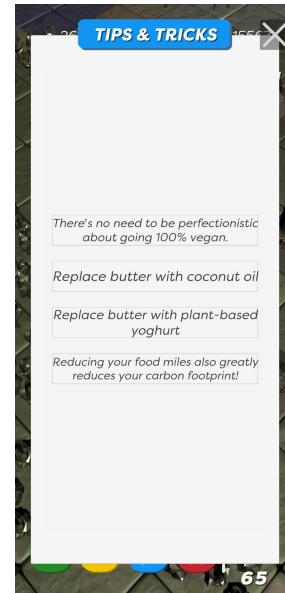
(c) Goal progress



(d) Game world



(e) Tile Action



(f) Tips given

Fig. 3: Game interface for various purposes

IV. PLAYER INTERACTION

Because *Veganity, your journey* makes use of various interaction panels, the game consistently uses portrait mode: besides making it easier to play casually, transitioning between panels is often more efficient in this mode. This section gives a brief overview of the player interaction facilities; see Figure 3.

a) Diet tracker: The diet tracker, as depicted in Figure 3b, is used by the player to fill in their diet everyday. The dietary data input by the player is stored in the player's profile data together with the corresponding energy received.

The progress towards the player's goal is recalculated when submitting this data.

b) Goal system: In the goal panel, as depicted in Figure 3c, the player can assess at any point in time their current goal progress and possibly set a new goal. When the user confirms the goal, the list of selected products and the target number of days are stored in the player's profile data.

c) Game world: The game world consists of square tiles, each representing a different type of land use, e.g. forest, grassland, urban, water, industrial, etc.; see Figure 3d. By panning, the player can easily navigate the game world; by

tapping, the player can choose on which tile to focus their next action. Currently, the possible actions available are: *planting a tree* (see Figure 3e), *grabbing plastic waste*, *increasing meat taxes* and *installing solar panels*. Each action has its own energy cost, as well as its specific effects on the world global parameters.

d) *Information*: There is a character wandering around in the game world who offers tips and tricks. When the player receives tips and tricks, these are stored in the player's profile data as well. All the tips and tricks the player has received can be retrieved on the tips panel; see Figure 3f. Moreover, the amounts by which the player improved the world parameters through their diet and actions can be seen in parameter pop-ups.

V. PRELIMINARY EVALUATION

In order to assess whether *Veganity, your journey* succeeds in empowering players to change their behavior, a rather long-term evaluation process is needed, that requires tracking to which extent players succeeded in changing their diet habits. Unfortunately, finding participants to collaborate in that process was strongly hindered and slowed down by the present pandemic restrictions. Therefore, we opted to setup and process first the data from a shorter evaluation which, rather than focusing on prolonged behavior change, assesses the game key features that can be directly linked to the framework inspired by Hamann et al. [18], which drove the design of the game.

Complying with the current social restrictions, the whole evaluation process was done online, via a website¹ especially set up for this purpose. The method used consists of (i) filling in a pre-survey, (ii) playing the game for (at least) 5 days, and (iii) filling in a post-survey. Both surveys were designed to assess knowledge acquisition, engagement with the game, and reflection induced by the game. Engagement is a good indicator of whether the game is fun to play. The knowledge acquisition and reflection are evaluated because they are important factors for behavior change. Additionally, in-game data is saved to complement the information acquired through the surveys. All the data is collected anonymously through a unique in-game generated ID which helps linking the game data to the anonymous survey answers.

Initially, the evaluation site was disseminated over several dozens of adults, both acquaintances and general public on social networks. Unfortunately, due to the above-mentioned constraints, and to the demanding time requirements, so far only 10 answers were received comprising both the pre- and post-playing surveys. Out of the 10 participants, four are vegan for several months per year, and one of them wants to become fully vegan.

In this preliminary evaluation we chose to simulate the behavior change process, by asking the participants to set a goal for the duration of five days and play the game daily in order to reach it. Moreover, they were encouraged to perform

actions, find tips and tricks in the game and keep an eye on how their diet and actions affect the game world.

The graphs in Figure 4 show the main results of this preliminary evaluation. Overall, it can be observed that people did reflect on the knowledge acquired in the game and became more aware of the effects an animal-based diet has on the planet (Figure 4a). Goal setting is the most preferred game mechanic (Figure 4b) because, according to the open answers provided, goals allow people to set their own pace and strive for an attainable objective in the near future. The energy spending and goal attainment proved to be engaging aspects of the game (Figure 4c).

It is clear that, in order to thoroughly assess the extent of behavior change as well as of habit creation, further evaluation over a longer period of time and with a larger group of participants is required. Unfortunately, due to the present restrictions, the pace of enrollment and the adherence of participants in the evaluation is much lower than desirable. We therefore decided to keep the evaluation website up, and continue the effort on recruiting participants over the coming months, to enable the collection of more evaluation data. However, despite being preliminary, we believe the results obtained so far are significantly positive and encouraging.

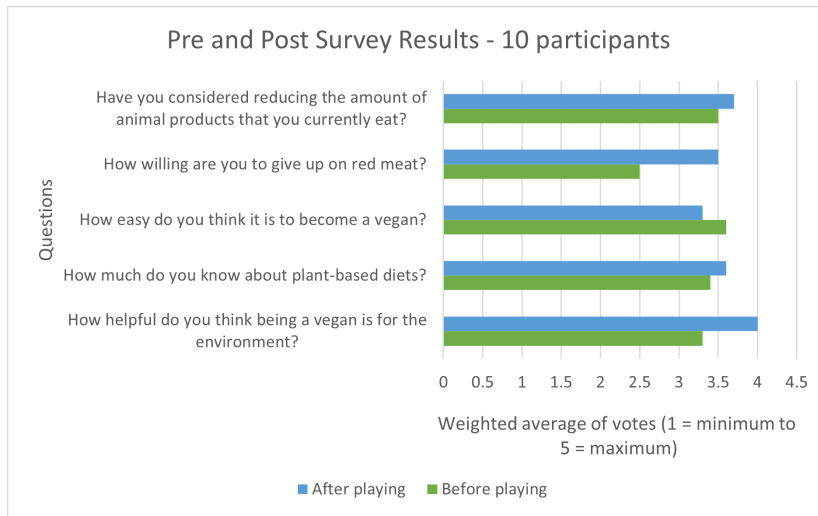
VI. DISCUSSION AND CONCLUSION

We presented *Veganity, your journey*, a carefully designed serious game with tailored game mechanics, following an innovative approach to empower players in achieving their self-proposed sustainable diet goals, within a climate change mitigation context.

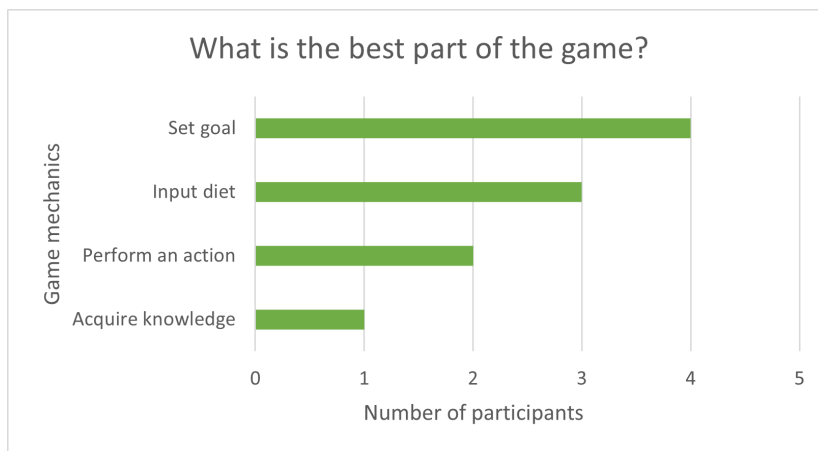
The preliminary results of the game evaluation already allow us to conclude that *Veganity, your journey* shows promising outcomes for bringing about sustainable behavior change. Notably, it confirms that the game mechanics chosen has direct effects on several aspects of the sustainable behavior change framework of Hamann et al. [18], including ecological norms and personal habits. In particular, being able to accurately set your personal goals was very much appreciated, confirming the importance of a voluntary commitment to motivate your behavior change. Moreover, players report that taking actions to improve the game world, as well as sparing energy by tracking their own diet, results in a more positive attitude towards a plant-based diet. More importantly, over 60% of the players reached the goal they set for themselves, while 70% said they would even have set a more ambitious goal, which seems to indicate that the game promotes progress. Additionally, the information provided in the game led to an increased problem awareness. The large-scale, long-term game evaluation, however, is still ongoing and more conclusive results can be expected in the future. In any case, we can already conclude that the idle game genre is an ideal design choice for the purpose of empowering players to shift their food choices towards a more sustainable diet.

We also envision various possible improvements on the present design of *Veganity, your journey*. Among them, the game could provide incentives for players to continue playing

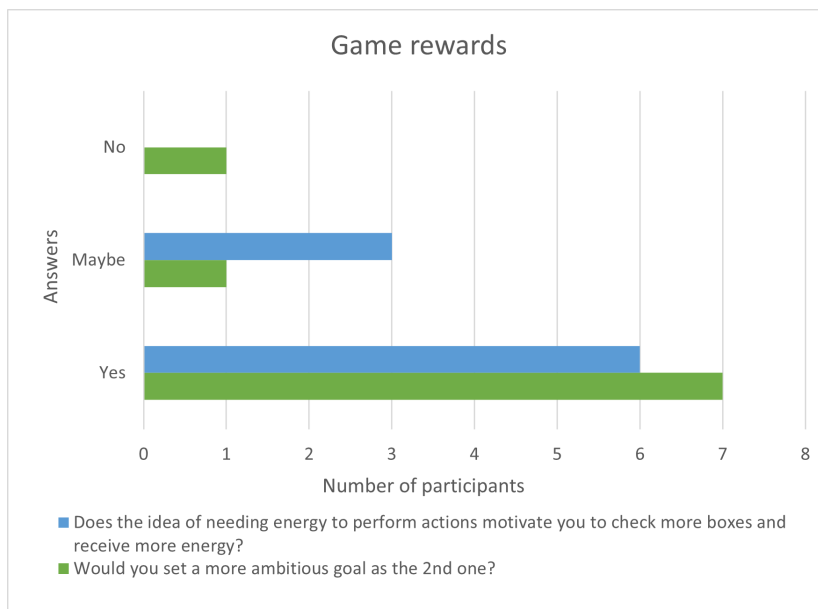
¹<http://serious-gaming.tech/veganity/>



(a) Reflection chart



(b) Best game feature chart



(c) Engagement chart

Fig. 4: Summary of preliminary survey results

over a longer period of time, including e.g. unlocking new areas of the game world, or making new player actions available, depending on the player progression or on current world parameters. Moreover, daily reminders for playing could be strategically provided to encourage players to abide by their established plan. In addition, integration with players' social networks would likely help both boast about their achieved goals and receive encouragement for their ongoing efforts. Finally, we believe providing practical, personalized advice regarding specific plant-based diets should also be explored as players progress in their chosen diet plans [33].

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