Apertures in Agriculture Seeking Attention

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Abstract

Agriculture is arguably one economic activity that serves as the backbone of human civilization—It is the provider of the most essential lifeline for human survival, namely, food. Today, we stand at a juncture where world over, all key stakeholders involved in this activity, i.e., producers (farmers), consumers, and the planet are facing grave concerns. Formulating these concerns concretely and leveraging AI methods in developing solution strategies can potentially help alleviate major risks to food systems. However, local contexts such as cultural practices, physical terrains, and socio-economic status pose unique challenges in being able to directly employ existing AI techniques across geographies. In this position paper, we highlight some such key challenges, specifically focusing on India and the developing world. We outline the problems of key stakeholders, and identify some gaps that need to be filled in addressing these problems.

1 Producers' Problems

Globally, one third of the food that we eat comes from smallholder farmers [1]. Low output from small farms and seasonal incomes are some of the key problems of such farmers. Uncertain yields, lack of market access, imperfections in price discovery, inadequate timely knowledge and advisory on crop selection, lack of production and monitoring best practices, and access to good quality storage facilities at affordable prices are other challenges facing these farmers.

Understanding the broader contexts behind small farm-holdings is essential in addressing the associated issues. In developing countries, particularly India, such fragmented landholdings is a stark characteristic of agricultural lands [2]. This is largely due to inheritance of arable family farmland and its fragmentation across successive generations, thereby dwindling their income potential. This is unlike developed countries which have larger swathes of vertically integrated farms [3].

Policy proposals have attempted to address the small farm holding issue [4] by introducing taxes on inheritance to discourage multiple inheritors of one land parcel. Designing AI algorithms to select the rightful heirs of land in a family with the objective of maximizing inter generational utility of farmland-parcels could be another approach. A motivation for such an approach stems from a recent work [5], that has attempted to optimally allocate opportunities in a dynamic model of inter generational mobility. However, there are multiple challenges in rolling out such algorithms/policies in the real world. Agriculture is the only source of livelihood for most small-holder farmer families and denying land to future generations can mean depriving them of their only viable source of income. Leveraging AI to upskill farming families in other sunrise areas of occupation can be beneficial in creating viable employment opportunities. An aspirational policy towards this end would be one that encourages families to voluntarily consider inheritance of land by only one or few members in the successive generations while others pursue alternate occupations. However, apart from raising ethical concerns associated with inheritance, such policies come with the challenge of maximizing alternate employment opportunities while also ensuring thriving farming populations. Universal Basic Income (UBI) is a popularly discussed mechanisms for pulling people out of a poverty trap caused by low-productivity employment [6]. The authors in [7, 8] mention that UBI could be reframed as a base wage in exchange for the basic data a person creates. In our context, this means data

NeurIPS 2021 AI for Science Workshop.

generated by farmers/farming assets has potential monetary value, the feasibility of which remains to be investigated given concerns related to data privacy and security. Thus, ensuring consistent incomes for farmers while also ensuring agro-ecologically sustainable crop choices remains a challenge.

2 Consumers' Problems

Evidence over the last two decades has shown that we produce enough to cater to the 'hunger' (calorific demand) of people, however distribution challenges prevent the food from reaching every corner of the world[9]. Nutrition needs of most people, however, across the spectrum of income levels are far from being met. Yet, food security programs of governments continue to invest in grains and ignore specific micro-nutrition needs of people [10]. Food choices of people are also skewed towards under-nutrition across all income groups. Lack of understanding on nutrition benefits is a major reason for these choices. Poor people do not want to just survive, they also want to live a pleasurable life [11]. So efforts around healthier and nutritious food offerings have to be complemented with efficient ways of encouraging people to eat the food offered [10].

Advances in AI based Food Science (involving expertise from chemistry, biology, nutrition, public health using data) is one emerging area where scientists are exploring various mixtures of plant based nutrients to obtain desired nutrition intake target [12]. This is an important step towards enabling wholesome nutrition with locally available ingredients produced across the world. Another line of research has focused on development of AI based food recommendation apps to educate consumers [13]. That said, recent research has also pointed at several issues related to the ethical, societal, and legal implications of relying on AI based nutrition recommendation applications [14]. A mechanism for sustained consumption of diverse, nutritionally rich food baskets, that is accessible, available, affordable by all sections of the society thus remains a challenge. Further, a regulatory setup that enables fair and transparent markets for farmers and consumers alike, and smart strategies to combat risks like bad weather or a global market crash are essential requirements, largely unmet.

3 Planet's Problems

The planet is at the receiving end of our food production and consumption status quo [15]. Lack of ecological sensitivity in crop selection puts major breadbaskets of the world at risk of catastrophic environmental damages such as ground-water depletion, greenhouse emissions, and global warming. India's example is pertinent in this regard. Rice and wheat are the most widely grown crops among cereals. Price structure of different competing crops has been tilted in favor of rice and wheat because of the procurement needs of the country. The alternative crops have been put on a disadvantage both in terms of competitive price and market uncertainty. One reason for the widespread cultivation of rice and wheat was 'Green Revolution' [16], aiming at self-reliance of production within India. It ushered in high yielding variety of seeds (of rice and wheat), which when used in agro-ecologically unsuitable climate belts of Punjab and Haryana, caused a drastic reduction in water tables [17].

Shrinking land holdings have also put additional pressure on water resources as each farmer wants their own water source [18]. Smart methods for efficient water use have been explored, like soil sensor based monitoring [19]. However, the ground-water table continues to deplete at an alarming rate and recharge at a much slower rate. Crop-selection that is agro-ecologically sensitive hence becomes a very important decision for sustainable water-use [20].

4 Concluding Remarks

Innovations such as mobile based advisory to farmers for production and crop monitoring, credit offerings based on yield prediction models, efficient land and water use using remote and soil sensors, address pieces of the problems. However, integrating these solutions to co-ordinate useful end-to-end solutions for highest priority problems of each agricultural stakeholder—consistent income for farmers, healthy and accessible nutrition plans for consumers, and ecologically sensitive crop choices for the planet— continue to be pressing concerns. Consulting domain experts like agricultural scientists and economists, understanding the local geographical-socio-economic contexts, and hearing from farmers to get a real world view of the situation might be some promising steps forward.

References

[1] Hannah Ritchie. Smallholders produce one-third of the world's food, less than half of what many headlines claim. *https://ourworldindata.org/smallholder-food-production*, accessed: September 2021.

[2] Deepa Maggo. Impact of covid-19 on smallholder farmers – insights from india. *https://www.wbcsd.org/Overview/News-Insights/WBCSD-insights/Impact-of-COVID-19-on-smallholder-farmers-in-India*, accessed: September 2021.

[3] Ted Nordhaus and Dan Blaustein-Rejto. Big agriculture is best. *https://foreignpolicy.com/2021/04/18/big-agriculture-is-best/*, accessed: September 2021.

[4] Kiyohiko G. Nishimura, Fukujyu Yamazaki, Takako Idee, and Toshiaki Watanabe. Distortionary Taxation, Excessive Price Sensitivity, and Japanese Land Prices. *NBER*, 1999.

[5] Hoda Heidari and John Kleinberg. Allocating Opportunities in a Dynamic Model of Intergenerational Mobility. *ACM FAccT*, 2021.

[6] Rebecca Hasdell. What we know about universal basic income: A cross synthesis of reviews. *https://basicincome.stanford.edu/research/papers/what-we-know-about-universal-basic-income/*, 2020.

[7] Jaron Lanier and E. Glen Weyl. A blueprint for a better digital society. *Harvard Business Review*, 2018.

[8] Vi Hart. Changing my mind about ai, universal basic income, and the value of data. *Data Dignity*, 2015.

[9] Paolo D'Odorico, Joel A Carr, Kyle F Davis, Jampel Dell'Angelo, and David A Seekell. Food inequality, injustice, and rights. *BioScience*, 2019.

[10] Abhijit V. Banerjee and Esther Duflo. Poor Economics: A Radical Rethinking of the Way to Fight Global Poverty. *PublicAffairs ISBN 978-1-58648-798-0*, 2011.

[11] Jenny Lei Ravelo. Abhijit banerjee: Poor people do not live on eggs and bananas. *https://www.devex.com/news/abhijit-banerjee-poor-people-do-not-live-on-eggs-and-bananas-77875*, accessed: September 2021.

[12] Anupam Jain, NK Rakhi, and Ganesh Bagler. Analysis of food pairing in regional cuisines of india. *PLoS One*, 2015.

[13] Thomas Theodoridis, Vassilios Solachidis, Kosmas Dimitropoulos, Lazaros Gymnopoulos, and Petros Daras. A survey on ai nutrition recommender systems. *ACM International Conference on Pervasive Technologies Related to Assistive Environments*, 2019.

[14] Daniel Karpati, Amro Najjar, and Diego Agustin Ambrossio. Ethics of food recommender applications. *AIES*, 2020.

[15] Thomas Nemecek, Niels Jungbluth, Llorenc Mila i Canals, and Rita Schenck. Environmental impacts of food consumption and nutrition: where are we and what is next? *International Journal of Life Cycle Assessment*, 2016.

[16] Prabhu L. Pingali. Green revolution: Impacts, limits, and the path ahead. *PNAS*, 2012.

[17] Balsher Singh Sidhu. Groundwater depletion in punjab: Time for a major policy overhaul.

[18] Dharminder-Sharma. Increasing Irrigation Water Use Efficiency: Challenges and Way Forward for Punjab. *UN SDG*, 2021.

[19] Jian Ding and Ranveer Chandra. Towards low cost soil sensing using wi-fi. *MobiCom, ACM*, 2019.

[20] Bridget R. Scanlon, Claudia C. Faunt, Laurent Longuevergne, Robert C. Reedy, William M. Alley, Virginia L. McGuire, and Peter B. McMahon. Groundwater depletion and sustainability of irrigation in the us high plains and central valley. *PNAS*, 2012.