# Applications of Precision Agriculture in Rural Communities

Amy Kaleita, Iowa State University

Precision agriculture (PA), or site-specific farming, is a term used to describe a suite of technologies and management strategies to tailor the treatment of crop land to the small-scale, local conditions. The PA trend began in the mid 1990s, with the full deployment of Global Positioning Systems (GPS). In 2000, the highest quality GPS signal, which was previously only available for US military use, was made available to the public. Combined with yield monitors that allowed farmers to track and record crop yields across the field as they harvested, the positional information allowed farmers to generate repeated maps of crop yield on their land. With relatively accurate yield maps, farmers are able to see spatial and temporal trends in crop production, which has stimulated an interest in managing and responding to those trends. Should low-yielding areas be given special attention to try to improve their performance? Should high-yielding areas be given a different type of special attention to try to take full advantage of their productivity? And what kind of attention should that be, and how should it be done? Those questions and their answers make up a lot of the current focus of precision agriculture.

In the US, PA has been particularly utilized in grain farming, where a large number of acres would, in the absence of a PA strategy, be treated uniformly in terms of seedbed preparation, pest management, planting, and harvest. In its most basic implementation, simply mapping the crop yield has become a part of many producers standard operating procedures – by 2010, some 60% of corn acres in the US are yield monitored. But it's the next level of PA implementation (response and management) that is the most exciting frontier of agricultural production systems, in my opinion. What can and should be done to manage different areas of a field differently, according to their needs and potential? This relatively basic question spins off a host of complicated technical and engineering issues in terms of monitoring, tracking, and controls. It also presents an opportunity to think about how these technologies can help us create **a comprehensive optimization framework for production agriculture** that as a matter of course includes objectives of not only of maximizing net returns for the farmer, and maximizing yields to feed a growing population, but also minimizing environmental impacts by enabling a more sensitive treatment of the landscape without compromising productivity.

At the moment, if a farmer is using higher-level PA technologies, it is probably limited to variable rate fertilization – adding more fertilizer to areas with higher yield potential as demonstrated by a history of yield maps, and perhaps adding less to areas with lower yield potential due to soils and/or topography. Even that single site-specific management change, though, is not all that straightforward (which largely accounts for the considerably lower adoption rate compared to yield monitoring). Ideally, a fertilizer prescription would be based on a rigorous assessment of not only past yields, but a consideration of those yields in the context of the climate and weather patterns in those seasons, which requires high quality data about local weather conditions; the soil variability, which requires high density spatial and temporal data about the quality and condition of the soil; and finally the ability to estimate the yield impact of those conditions.

None of that is particularly easy to achieve, and that challenge holds true for essentially all of the potentially high-impact PA operations: data collection and decision support are the biggest bottlenecks. Sensing and information technologies are beginning to making inroads into agriculture in a big way, but adapting or developing these technologies for the natural (or nature-based) environment is a significant challenge – environmental conditions are dirty and generally hostile to wires and chips; variability in space and time is huge, and the systems are highly non-linear and interconnected.

Below are some of the major needs for the maturation of precision agriculture.

- *Tiny, robust, inexpensive, smart sensors:* How can we monitor, with as little interference of the agricultural operations as possible, all of the myriad things that affect productivity and environmental impact? Given that it is not possible to monitor everything everywhere all the time, how can we deploy sensing systems that give the highest return for the investment?
- *The last mile of communication:* How does data flow from the sensor to the first central hub of data and vice versa? Rather than an information superhighway, the “last mile” is usually more like an information back road. The communication systems must be wireless, and probably fully buriable. They must be secure and private. They must consume very little power. They must probably self-localizing and self-correcting. This is especially critical for PA applications, because the spatial and temporal variability of the natural environment is high, so the number of data collection points required in order to fully characterize the farm may also be high.
- *Internet of Things (IoT) for agriculture:* To what extent can we catalog and track all of the data that we do collect? And to what extent can we embed value-added data transforms to make to convert raw data into actionable information?
- *Both overt and invisible applications*: Ten years ago the word “app” did not even exist, but it is rapidly becoming the most common way that many people interact with data today. Furthermore, if PA is to be adopted by a large number of famers, data interaction frameworks have to be flexible to the wide and diverse variety of data that an individual farmer might chose to collect. What kinds of cross-platform apps can we develop that support this?
- *Nimble equipment*: Particularly in grain production, the trend in agriculture has been towards larger and larger equipment, many pieces of which are essentially single-function. In order to move towards a site-specific management framework, we probably need smaller, nimbler, more multifunctional equipment.
- *Options for the developing world*: A lot of what I have outlined above is most likely accessible to farmers in the developed world. What technologies and support are cost-effective in the developing world where the farms, the budgets, and the profit margins are often smaller, and the infrastructure is radically different? As farms in the developing world transition to more mechanized systems, how to we help those farmers maintain the familiarity with and responsiveness to site-specific productivity that they probably currently have?