Looking in, Looking out: agriculture and informatics, seeing and yielding the potential

A CSIRO Cutting Edge Science Symposium

Petra Kuhnert\textsuperscript{1}, Michael Battaglia\textsuperscript{2}, Bronwyn Harch\textsuperscript{3}, Mike Grundy\textsuperscript{4}, Graham Bonnett\textsuperscript{4} and Paul Barnett\textsuperscript{1}.

\textsuperscript{1} CSIRO Digital Productivity
\textsuperscript{2} CSIRO Land and Water
\textsuperscript{3} Institute for Future Environments, QUT
\textsuperscript{4} CSIRO Agriculture

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We wish to acknowledge the funding support from the Office of the Chief Executive and the Sustainable Agriculture Flagship that allowed us to run the symposium. We would also like to acknowledge the support from Louise Burton, who assisted with the preparation for the symposium and her assistance during the 2 days when the symposium was being held. Finally, we would like to acknowledge the participation of Andrew Zerger from the Bureau of Meteorology and Rochelle Christian from the Department of Environment.
Executive summary

Agriculture is data, technology and network rich. However, when this information is used to improve decisions on farm or at planning or policy scales it can be made difficult by failures of engagement, data integration or data uncertainty specification. The CSIRO Sustainable Agriculture Flagship (SAF) together with the CSIRO Computational Informatics Division hosted a Cutting Edge Science symposium on the 28-29 May 2014 at the Waite Campus in Adelaide.

The Symposium discussed experiences, challenges, and future opportunities for cross-disciplinary research. It brought together science leaders in:

- agriculture: forecasting and systems modelling, precision agriculture, science into society, impact assessment
- computational informatics: space-time modelling, data assimilation and visualisation, elicitation, network analysis, risk and uncertainty.

The symposium also provided opportunities for early career researchers to learn, develop and extend ideas beyond the conference so that new opportunities become integral to CSIRO’s core capability.

Key recommendations from the two day Symposium are:

<table>
<thead>
<tr>
<th>No.</th>
<th>Recommendation</th>
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<tbody>
<tr>
<td>1</td>
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<td>4</td>
<td>Build external partnerships to support CSIRO needs and aspirations in Agri-Informatics and build national capability at scale.</td>
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1 Introduction

Major factors are shaping agriculture:

- There is an increasing demand for food as populations and economies grow, thus increasing pressure further on production and productivity. (Laurance et al. 2014, Neufeldt et al. 2013, FAO 2013, Beddington et al. 2012a,b).
- Agriculture is confronted in many parts of the developed world with declining terms of trade and rising labour and input costs.
- Increasing environmental consideration, urban encroachment, population pressure and competing or new land uses (such as non-conventional gas or biofuel production) are increasing the complexity of land use decision making.
- Reduced stock holding by retailers to reduce costs and be more responsive to consumer demand are leading to changes in the supply chain logistics that require better information on commodity supply and risks to that supply.
- Consumer pressure, and access by producers to particular markets, may require trace-back of products to point of origin and environmental footprint.
- Genetic technologies are offering transformative potential for agriculture but their full realization in the field is dependent of the understanding and capture of genotype by environment on management interactions.

In each case, these challenges have key aspects that involve informatics: the analysis of complex and large data in time and space; decision making in the face of uncertainty; sensing and capturing information in real time for diagnosis of land or product condition and trend; integrating outcomes of decisions across non-commensurate indicators that may include economic, environmental and social values. Informatics will not address these challenges alone, and indeed it is not sensible, when taking this problem-centric view, to think of informatics or agri-informatics as separate from agriculture: the reality is that agriculture is (as always) the nexus of information and its use (aka informatics), practice and society.

The last revolution in agriculture was driven by a combination of breeding and increased resource use. We are in the midst of a biotechnology changing the production frontiers of agriculture. Information sciences and especially informatics are transforming many service and production areas: they will continue to have an increasing role in agriculture.
The information and decision-making value chain (Figure 1) provides a framework for cutting across the agricultural and informatics science platforms that we believe could lead to better impact, delivery and sustainability (Basford and Harch 2014). The information and decision making value chain allows for collaboration, integration, delivery and assessment. Beginning with the formal design for data generation and capture, the chain moves through to the acquisition, storage, integration and modeling of different data sources from measurements, to modelled output and expert knowledge and elicitation. As we develop the science that assists in providing insights and understanding of the data, there is a need to bring in uncertainty to provide some realism about the predictions and forecasts we are proposing in space and across time (Kuhnert 2014, Cressie and Wikle 2011). There is a cultural change needed, which showcases informatics as a science and not just a tool that is used at the final stages of an investigation. It is an integral component of the information and decision making value chain that knits the design and data capture with the modeling to provide insights and understanding required to deliver the messages to policy makers in a clear, concise and unbiased manner (Laurance et al. 2014, McInerny et al. 2014). There is a clear need to ensure productivity meets demand, where the science being delivered is cutting edge and provides value to the global market (Basford and Harch 2014, McInerny et al. 2014). This framework is all about collaboration – bringing together scientists from agriculture and informatics to address agricultural challenges.

In a two day symposium, we explored how the Information and Decision-Making Value chain fits in with the current suite of agricultural challenges we are faced with. What components work well? Where do the transformation changes need to occur within this framework and where are the
incremental improvements that are needed to address the agricultural challenges of today? We heard from speakers within CSIRO about their agricultural research and some of the challenges they are currently faced with. We also explored the role of informatics in solving some of these big ticket items and heard from a broad range of speakers about the cutting edge informatics being applied to these problems.

We ran two workshop sessions across the two days with the aim of getting a broad cross-sectional view from attendees about the use of cutting edge informatics technologies to address the complex agricultural challenges. Specifically, we asked a series of thought provoking questions to stimulate some discussion in the area. These questions are summarised in Table 1. The responses to these questions are summarized in the following sections of this report.

Table 1: Summary of Questions posed throughout the 2 day workshop.

<table>
<thead>
<tr>
<th>Question No.</th>
<th>Question</th>
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<tr>
<td>Workshop Activity – Day 1</td>
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<tr>
<td>1</td>
<td>How does the “Information and Decision Making Value Chain” framework fit in with the current suite of agricultural challenges?</td>
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<tr>
<td>2</td>
<td>What components work well? What components are implemented well? Are there any components missing? What is the world doing that we aren’t?</td>
</tr>
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<td>3</td>
<td>Where do the transformational changes need to occur within this framework?</td>
</tr>
<tr>
<td>4</td>
<td>What are the incremental improvements in the decision making value chain required to address the Agricultural challenges needed?</td>
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<tr>
<td>5</td>
<td>How do you see informatics playing a role in solving some of the key agricultural problems of today? What should we be focusing on and where in the decision making value chain does this fit in?</td>
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<tr>
<td>6</td>
<td>What form of outputs and communication/engagement strategy is needed to ensure understanding and uptake by policy makers?</td>
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<tr>
<td>Workshop Activity – Day 2</td>
<td></td>
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<tr>
<td>1</td>
<td>What did you get out of the symposium that you DID expect?</td>
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<tr>
<td>2</td>
<td>What did you get out of the symposium that you DID NOT expect?</td>
</tr>
<tr>
<td>3</td>
<td>If you were a Flagship Director, what would your response be to investing in “agri-informatics”?</td>
</tr>
<tr>
<td>4</td>
<td>You sat and listened, participated, networked ... what are you going to do when you get back to your desk?</td>
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2 Agricultural challenges of the 21st century

Day 1 of the symposium showcased a range of agricultural challenges from projects that have been funded through the Sustainable Agriculture Flagship. The day opened with a presentation by Brian Keating that painted a global picture of agriculture in the 21st century. This was followed by a plenary talk by Bronwyn Harch and Petra Kuhnert that summarised the theme of the conference – two revolutions that CSIRO is aiming to mobilise. The first is a research culture revolution that focuses on the innovation in informatics to address the agricultural challenges. The second is a business model revolution, where the focus is towards the implementation of cutting edge informatics and uptake by stakeholders. A key element that is missing from our scientific research to enable this to happen is communication. There is a need for visualisation through specialised graphics, a common use of language and some sense of repeatability to ensure uptake. While this is implicit in the Information and Decision Making Value Chain (Figure 1), it is not something we readily do. The second plenary talk by Steve Hatfield-Dodds focussed on how we should engage with “the nexus”, where there are multiple audiences and multiple domains, namely energy, food, water, agriculture and land use. The National Outlook project was used as an example, highlighting that an integrated analysis is crucial to understanding Australian’s future risks and opportunities. These presentations were followed by several short talks that provided a snapshot of the agricultural challenges CSIRO is currently involved in. The abstracts for these presentations are available in a supplement to this report and a link to the presentations will be made available on the intranet (web page to be finalised).

Figure 2: Summary of discussions around the Information and Decision Making Value Chain.
The following sections summarise the discussions around the presentations delivered on the first day. Figure 2 aims to capture many of the summaries provided from the group discussions.

2.1 Agricultural Challenge: Scale

- Scale does matter – but how do you get Monsanto to understand in what way it matters? They are marrying their own genetics and crop information to general soil resource information on a scale of 1:25000. We know they need it at a finer scale of 1:5000. Is this the right answer for the right reason? What will be CSIRO’s role in this domain in the future? Advancing methodology frontiers, public interest in transparency and clarity, we cannot deliver to Australia on our own. Is Monsanto creating a data market more than anything else? This represents a priority topic going forward in new Flagship.
- Scale was also highlighted as a big challenge in the National Outlook work.
- The agri-informatics challenge is a space-time problem. Scale matters and time lags are lengthy. We require a digital revolution to bring together biology with the sustainable sciences.
- Are we sensing the right things? – at the right scale, the right way to “experience” the data?

2.2 Agricultural Challenge: Food Production & Food Security

- The estimates around food production in urban environments are not well understood. Urban issue is important in connecting city people to food systems but the footprint is not big enough to make a big difference.
- There is a focus on food production and yield. Where is the balance in food production and lowering cost? The world has to increase food production. The Australian farmer could choose to produce less but still be more profitable. Both lenses are important. However, if whole worlds choose to produce less, then the fundamental law is being broken. Food would then become very expensive. The framing of decisions therefore becomes important in these contexts.

2.3 Agricultural Challenge: Engaging with Informatics

- No strong community of practice in this space. What is the big issue for the ag/science sector that forces it to come together?
- We require a definition of “agri-informatics”. The informatics component is occurring in all types of fields, not just agriculture. To ensure it works well, it is important to “get the marriage going well” – be interactive and connected with those coming at it from an agricultural perspective.
- There are two big challenges for Australian agriculture: (1) Big data/analytics and modelling, and (2) Decision-making workflows e.g. working through the “horrendograms”. How do we capture the magic that goes on between the inputs and the outputs? This is where the Information and Decision Making Value Chain fits in. To address these
challenges, we need to be smart and have the capability, infrastructure and networks in place.

- It seems we are on the cusp of an informatics revolution in the agri-informatics area – what is the tipping point where there is so much inertia in the system that it almost becomes self-fulfilling? Is there a sense of where that tipping point is and what does it look like? There are platforms where all the information is coming together. The challenge is for people to realise that there is a platform. A few consortiums in Australia are starting to get this right. For example, Circa are currently doing this in the financial sector.
- How can we do real time analysis effectively?
- Where do you set the boundaries of what you are trying to achieve? How can we obtain confidence around the measurements we take? How can we relate the variability around time and space going forward?
- The informatics challenge is across 3 dimensions – (1) knowing why soil carbon varies, (2) on farm consequences, and (3) what’s your transaction cost under different management regimes. Do you want a subsidy, lock down, donation etc? There is a need to have multiple dimensions to solve the problem.
- The “career making horrendogram”: Making sure that the code, computer model, does what we think it does. Because these models are so complex, it is difficult to determine whether an effect is real or not. There is a need to make the model robust and bug free and be confident in the outputs.
- We need to be better accustomed to dealing with uncertainty in a probabilistic way to help inform management. This should be part of robust science. Many current implementations are not probability based.
- Where is management having an impact across the landscape given the amount of variability?
- The challenge is around biodiversity and how we measure it. We have more confidence in the carbon captured by trees through remote sensing and other measurement technologies.

2.4 Agricultural Challenge: Communication and Uptake

- Could Apps be useful for communicating our science better? There is a user’s appetite for just another report versus information obtained through Aps. A lot of us do not move towards Apps because they are time consuming and we do not have the capability to implement them quickly. There is also the fear of releasing “data” or “modelling results” that might lead to an interpretation that is not what was intended.
- We need to move beyond the science communication paradigm. It needs to be collaborative all the way.
- How much do you think our problem is lack of information and making wise decisions from that information? Throwing more information at something does not solve it. Sometimes we over-generalise and forget that the local details have more impact. Obtaining the information at a fine scale is important. This needs to be filtered and fed back to the decision makers.
- If we refer back to Figure 1, the opportunity is not just to interpret the results but how do we use informatics to engage those through the process of discovery. This is a trans-disciplinary activity.
There needs to be due diligence in what we publish and we need to be careful with how we describe results, while being as transparent as we can. There will be people who read our reports with a political lens and will want to mis-use the data.

A very large user of the reports we write and numbers we publish are voters, since many of the policies are derived from the report. A large proportion of voters would not understand what is written in the report and why should voters believe what is written in the report as often, their interpretation is dependent on expert opinion rather than hard numbers. People come to every problem with suppositions and with preconceived ideas and beliefs. We need to write papers in high impact journals like Nature to make a difference. It is often difficult communicating our findings as there are a spectrum of political views. We do not need to be politically polarised. We should be presenting our research findings as risks and opportunities in the global economy.

How do we turn complex modelling into simplicity? How complex do we need to go?
If land holders are going to make dollars out of biodiversity, how can you measure it? We could model a variety of budgets which harness the carbon price and then we have a targeted payment fund which pays the difference between return and the next best land use.

2.5 Agricultural Challenge: Competitors

There are other people interested in informatics but the big issue is what is the obligation going forward? Do farmers pay on practice or are they given a subsidy. The market does not have the confidence to buy carbon into the future. Everyone seems to be avoiding the issue.
We are lagging behind in the use of pesticide understanding. Other countries are doing a better job at this but we can’t just translate their technologies to Australian conditions.
3 Using Informatics to make sense of data

The second day of the symposium focussed on how innovative informatics methodologies could be used to address some of the agricultural challenges Australia has been presented with.

Mike Grundy provided an opening to the second day that summarised some of the primary themes from the first day and what should be the focus for future research in the agriculture space. There needs to be a narrative around plausible futures in this space that assists decision makers in making decisions around the types of futures that can be achieved. “Without effective monitoring and learning systems, the future is that much further away and further unknown”.

A plenary session given by Prof. Chris Wikle, presented statistical methods that facilitated several aspects of the “Information and Decision Making Value Chain”, namely

- Integration of data and modelling
- Gaining insights and understanding
- Decision making under uncertainty
- Designing for data generation and capture.

Prof Wikle showed through a proximal soil sensor example how information can be modelled in a way such that the outputs can be used to inform management. He presented a Bayesian Hierarchical model for analysing spatially dependent functions responses, where the application was focussed on estimating electrical conductivity in soils. He followed on with a spatial design of sample locations of soil cation exchange capacity. Prof Wikle highlighted throughout his presentation a danger in model fitting. “As complexity increases, the level of ad hoc modelling increases!” In these situations “we seek more probabilistically coherent modelling approaches”. To cope with some of the big data issues, Prof Wikle suggested the use of dimension reduction techniques. He then went on to highlight the strengths of a Bayesian analysis to accommodate complex processes and measurements and the uncertainty inherent in each. An interesting component of Prof Wikle’s presentation was around spatial adaptive design. He showed that there is a trade-off between complexity and measurements. How complex does your model need to be to ensure efficiency? Can we adopt a simpler model to obtain the same type of predictions and outcomes?

These presentations were followed by several short presentations that outlined some of the cutting edge informatics developments being developed and applied to agricultural problems in Australia. A summary of the discussions around these presentations appear below.

3.1 Informatics Challenges: Storage, Discovery, Communication and Access.

There needs to be provenance, transparency, collaboration and a common language amongst the group. Informatics is its “own language” which needs to be better defined. There is a need for integration. Some examples of integrated modelling are eReefs and the Bioregional Assessment work.

We never design our data for re-use. We need better ways (or better tools/process) for storing the different sources of data that we collect to enable it to be re-used. Datasets could be made “citable” to make it more attractive for people to store it. Farmers could be potentially paid if their data has contributed to the data market.
3.2 Informatics Challenges: Integration of Data and Modelling

There is a challenge in integrating measurements with models. How do you represent the system processes and how complex do you go? The carbon modelling work has demonstrated a proof of concept in relation to blending measurements with a process but the challenge is to extend the model to incorporate more complex processes (multi-pool) and gain user support for the methodology.

There is a need to develop methods for mapping, modelling and monitoring soil at the right spatial and temporal scales, while accounting for uncertainty.

3.3 Informatics Challenges: Decision Making and Implementation

We need to demonstrate how informatics can assist in addressing policy questions.

How do you know that a data/information product is good enough? How can you then use that to drive investment in other areas e.g. sensing or monitoring that may need to improve that product to a point of being good enough?

There needs to be an investment in sensing technologies. We do not have the tools yet.
4 Conclusions

The cutting edge science symposium was an excellent forum for showcasing the research we have currently been involved in. It has also provided valuable discussions with a broad range of scientists working in the Agriculture space and how we might work towards developing future projects and research strategies. This report will be sent to the flagship director and program directors of the Agriculture Flagship in the hope that the outcomes from the symposium may assist with future planning for agriculture research work in this space.
5 Recommendations

1. That the Agriculture Flagship should create a cross-cutting initiative in Agri-Informatics to catalyse activity internal to that Flagship and create pan Flagship activities with DPAS and L&W Flagship.
2. The L&W, DPAS and Agriculture Flagships should seek collectively to support a community of practice in the area of Agri-Informatics and seek to hold annual science meetings in the area.
3. That the community of practice in (2) seek to establish guidelines and practices for archiving and data provenance and data and software repository to enable archive, discovery and access to make such data discoverable for reuse.
4. Build external partnerships to support CSIRO needs and aspirations in Agri-Informatics and build national capability at scale.
References


Appendix A Workshop Activity 1 - Summary

A.1 The “Information and Decision-Making Value Chain” Framework

- The framework is useful but it can be interpreted differently by some. There can be multiple interpretations from each bubble in the chain.
- What is missing is a participatory process. This needs to be front and centre in the process and it needs to be adaptive.
- A major omission is that there is nowhere for external validation of the question. Are we asking the right question at the right time? Are we in tune with social expectations and perceptions?
- How do lags fit into the information and decision-making value chain?
- Planning and delivery is often under-cooked. There is ongoing engagement required. There needs to be a “translation of knowledge” product at the end and to do this you need to understand the system.
- There is an implied logic within this framework that you always start at the “data collection” phase. Getting the question right is probably a good starting point.
- Should there be “wheels within wheels” where some nodes appear more than once.
- Research is supposed to be done to benefit industry and farmers but where and how do they access this?
- There is a focus on integration of data and modelling. People position themselves on the wheel. There cannot be this divide and we need to be talking to groups.
- How does socio-economic and biophysical process come together? How do we create linkages with separate areas of research?
- There needs to be a participatory process to ensure the components of the value chain follow through.
- A major omission here is that there is no external validation of the question. Are we in tune with social expectations?
- The level of innovation required will vary depending on the challenge being addressed. To address most agricultural issues, there is a need for good climate, soils and land management data. Climate data is reasonably good, while soils is more problematic and land management data does not exist.
- Scale and integrating at different scales is a big issue. There is a great opportunity to collaborate on a range of areas in the agricultural space.
- There is a real need to do a better job at communicating uncertainty. How do we communicate this with farmers? Is it about having some trust in models or information we present? Monitoring and evaluation seems missing from what we do at the moment.
- The efficient integration of data and modelling is a key challenge.
- We need better descriptions of the process. We need to use stakeholder knowledge and have a learning system which constantly re-evaluates what we are doing. We need to include citizen level science, where we have data capture through portable hand-held devices. In a world where there is massive amounts of information, we need to be able to tell a valid story. So what level of information do we require?
• Although the accessibility to data is improving, we need better ways to access it. Sharing of data needs to happen at the beginning and not at the end. There needs to be a cross-discipline approach. No-one thinks about data re-use.
• We need to be aware of the different types of uncertainty and where it might be. How do we quantify and analyse this to bring around change? How do we communicate this or make decisions differently.
• Government and institutional arrangements need to be factored in as well.
• There should be rewards for paper output or the development of new projects. There is a feeling that there is no incentive for moving through the value chain to ensure uptake and delivery. There should also be a shared understanding of issues and why things are happening.
Appendix B  Workshop Activity 2 - Summary

B.1  What did you get out of the symposium that you DID expect?

- A richness of diversity of views.
- How broad the research field is.
- Reinforcement of how critical informatics is in solving research challenges.
- Networking. Good opportunity to meet others outside the division and an opportunity to speak to others and know that groups exist within the organisation.
- Overwhelmed by the spectrum. We need to be diverse but respectful of others skills. Very inspired.
- Being inspired from the incredible new technologies and platforms being used.

B.2  What did you get out of the symposium that you DID NOT expect?

- The decision and information value chain is an engineering diagram and not a science diagram. A lot of what we are doing here is engineering and should be seen and valued as such.
- How to deal with big data and how can we incorporate all available information to facilitate better decision making.
- Very thoughtful and thought-provoking philosophical discussions.
- Definitions of agri-informatics/informatics not discussed until the second day. We need a clear definition of informatics. We need to make informatics transformational from the past.
- Make it simple. Use simple language when talking about informatics, Call it something to give it visibility. Make it clear what “value-add” you can have for problems and be involved early on to make it accessible.
- It is time to rethink modelling. Transformation is in the projects you write next. Time to embrace change? How do you get the capacity to deal with that?
- There are time lags to uptake. Methods presented were not developed in the last few weeks. There are data and computational challenges.
- We leverage one project off another. Is this standard business practice? We need to be on top of all issues in every project. We need to design projects with the capacity to build upon it if the opportunity presents itself. We also need to adapt to the operational environment.
- There is a need for a community of practice to find out what is available, what is being done and what will be done in the future.
- A lot of what we saw here was a stocktake of what we are doing. There was an expectation for benchmarking. We need to be more explicit.
B.3 If you were Flagship Director, what would your response be to investing in “agri-informatics”?

- Apart from providing time for researchers to deal with the research advances is the uptake in the community by those that do not have the mathematical skills. Amongst the end users (e.g. agribusiness, agronomist) they don’t understand the maths behind this work. We need to ensure the projects are delivering what someone wants and can use. Ensure the dialogue continues with key stakeholders to ensure uptake.
- Communication is very important. Flagship Directors should come down to the lower levels, business development and communications.
- We need to think in 3 buckets: (1) upstream investment in creativity (thinking, cross-fertilisation of informatics and agriculture), (2) what are the other domain areas doing in informatics and (3) downstream investment in terms of impact. There needs to be a community of practice.
- Update the website and make a list of all the projects in this flagship. This allows for communication. There might be similar projects being undertaken that you are not aware of. There needs to be a community of practice informing people.
- The information and decision making value chain is a really useful diagram to show all aspects of informatics. It is surprising that people are pigeon-holding themselves. There are 3 levels to invest in: (1) individuals, (2) teams and (3) institutional.
- We need to state very clearly the importance of informatics in solving research challenges. We heard that the opportunity around transformation is really significant and so the value and importance is very critical. The complexity of the problem space in agriculture and information sciences comprise very broad fields. This implies that you do need a critical mass of capability of people skilled up in different areas and point to these challenges in a systematic way. In some sense, a community of practice is not enough, we need a much more sophisticated awareness and co-ordination of capability against challenges.
- We need consistency and efficiency. The matrix is disappearing, so what will suffer? Very receptive to a plan where projects can be made more consistent and where there is no reinvention of the wheel.
- Putting together a list of people with different skill sets is difficult. A website is not the answer.
- How did the flagship directors fund the ANO? It is serious investment to maintain skills in the organisation. Invest in people, something stronger than a community of practice.
- DPAS statisticians are not put into the Agriculture flagship?
- Plant Industry projects would not be possible without two scientists from CCI who have been supporting the group. There is more interest in training in informatics tools around data analysis and visualisation. CSIRO Learning and Development courses are not scientific and are about being a good corporate citizen. Base tools should be available to all scientists.
- Informatics is disruptive. There are different ways of going about things. Get people to contribute to lots of data. Pitch around disruptive elements of this rather than making it a bit better. Think bigger and try and think about things differently.
- Putting together examples of where they can inspire our collaborators – imagine the potential future.
- What is in it for me/my flagship. The entire issue is more important when sitting in one flagship and working with one another.
• Flagships need a coherence of purpose and diversity of methods. What are we not doing and would it be useful? Can we use other data e.g. farmers phone calls. If we get the question right then we are 90% of the way there. Are we asking the right questions? We need to explore diversification methods. A structured process is required.
• It is about strategy and having a coherent vision. We need principles to take care of those absolute fundamental parts of the information world. We are an information product producer and we must recognise this.
• Invest in platforms and trainings of individuals so they can use it. There needs to be a multi-user aspect. Are there investments to be made in a general way to give access to the tools developed? How can we learn from where we have invested?
• How do we increase our whole capability in the area? There is investment in TCPs, who are trying to do this in some places.
• We need to disrupt some thinking and get people from other areas into these leadership roles. Disruptive placement of people need to be irritants to make way for new opportunities.

B.4 You sat and listened, participated, networked ... what are you going to do when you get back?

• Cross flagship participation – work out what the request for capability from other Flagships
• Making space available for people to “hot desk” to enable cross fertilisation of ideas.
• How do we encourage or facilitate interactions with CCI folk? What are the incentives?
• Opportunity to explore this space and connect in a more structured way.
• Having a better understanding around Bayesian statistics.
• Look to see what else is going on in the world. What are other fields doing to set the benchmark?
• Enormous opportunity and obligation as we shift from a formal matrix to the new risky flagship structure. Practice area networks are essential and have function of sharing knowledge and making it easier for non-practitioners to find the right person for advice. Magic happens when we move from tools to a value proposition.
• Interest in new opportunities and connections.
• Try and take stock of how expansive the thinking has been here. Review current suite of projects and elevate the level of science, change the questions and look for new clients on the capabilities that exist in the organisation.
• Develop some high impact papers around the symposium discussions.
• Construct a seamless Ag modelling data system.
• Develop real time information systems about our major Ag processes. People can see what is happening as it happens.
• Consider the simplification of the integrated network of models that are often used. What parts of the models can be simplified without compromising accuracy. What parts of that system is crucial.
• An investment of $100B in the system over 4 years and a one line brief from the government for that level of funding.
• Most flagship directors do not have the answer for everything. Be bold about what you want to do.
Appendix C  Working Group Notes

C.1  Group 1

C.2  Group 2
C.4  Group 4

C.5  Group 5
C.6 Group 6

Issues:
- User involvement and ownership
- Ability to work and impact
- Works well: data storage
- Not implemented well:
- Discovery
- Metadata

Changes:
- Interface between community processes (in value chain)
- Software for operation automation

C.7 Group 7

Notes:
1. Status may be written within steps.
2. Smart farmers can build harvest data.
3. Important steps:
   - Data collection
   - Analysis & understanding
   - Material & measures
   - Implementation
   - Evaluation

Questions:
- How do you get all the data?
- Are you ok with the world data?
- How is it important?

Purpose:
- Importance of data

Values:
- Capture and use ground farmer's data
- Transfer communication to public
- Identify and share appropriate data early in a project

Incentives:
- Shared understanding
- Definition of problems
- Improved interdisciplinary collaboration
Value chain represents all the key aspects of addressing food Ag challenges but not global ones

Chain should start sound insights/Decisions

Not necessary to have flow in that decide end

Information required per component will vary depending on the particular challenge

Management & Production data not well captured or managed. Little agromonic practice data

Implementation still poor. Possibly not enough social engagement/outreach.

Open-data model required. May need incentives to access

Validation/Verification compact? (before implementation)

Transparency component? (maybe around the whole)

Data access/outsourcing needs to be better

Needs to be designed into the cycle

Automation (in decision making and data collection, etc)

Better understanding of confident decisions

More useful description of uncertainty
Looking in, Looking out: agriculture and informatics, seeing and yielding the potential.

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FOR FURTHER INFORMATION
CSIRO Digital Productivity
Petra Kuhnert

w www.csiro.au