# Agricultural Innovation System in Australia

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## Abstract

*The aim of this paper is to document agricultural innovation systems (AIS) in Australia. We identified eleven broad categories (actors) in terms of their activities, namely: policy, education, finance and credit, marketing, input supply, research, extension and information, logistics, processing and storage, farmers and farm organisations and consumers. Survey results reveal that 11 kinds of innovation-related activities of research and education organisations with corresponding percentage weight are directly involved in innovation diffusion. Twelve pre-identified goals of innovation related activities of the above organisations surveyed with their corresponding percentage weight have also been revealed. The study reveals that the majority of funding (more than 80%) for innovation activities comes from the Federal Government and funding bodies. Finally survey results indicate that the main constrains/incentives are other issues such as funding, lack of qualified staff, equipment, environmental and Government policy issues etc.*

**Keywords**: *Agricultural innovation, Innovation systems approach, AIS in Australia*

## Introduction

Agriculture can be defined as the science and practice of cultivating the soil and rearing farm animals (Moore, 2002). Innovation is crucial to the development of agricultural production in order to stay competitive in world markets and to meet from the challenge of globalisation. Many innovations have come about by sharing knowledge, information and resources among stakeholders, with agriculture unusual in the extent of its traditional dependence upon public research.

## Innovation in Agribusiness

Agricultural innovation can be differentiated into three categories as follows:

- Product innovation – such as pesticides, new seed varieties, new types of animal feed, treatments and veterinary medicines etc. For these sorts of products, the commercialisation of science is done by industry (mainly in industries like chemicals), and typically involves large multinational firms. As a result information about the new product is driven by the firms in the form of product marketing. It is not transferred directly from the researcher to the farmer. The driver is the producer (e.g. Monsanto etc.), and the link is more likely to be the local distributor/retailer agricultural supplier.
- Process innovation – activities relating to new/improved ways of tilling and planting, new breeding and feeding practices, and new ways of tending (e.g. application of pesticides or animal feed etc.). These may be related to the use of new products. The links between research and farming practices in these processes are more direct. The links are also more diffuse, learning based and involve family, community

and extension/information. It will also be localised and conditional.

- Event responses – there may be a third area of innovation relating to responses to occasional unusual events, so there is less knowledge about what to do from experience at the farm level. Examples might be plagues (mice, locusts etc.), diseases (avian flu, foot and mouth etc.), fire, flood etc. Again the links between research and farming practices in these processes are likely to be more direct. However, they are also diffuse and involve family and community, though possibly with more reliance on extension/information (i.e. drawing on wider experience). The existence of some mandatory regulatory actions that might by themselves bring about innovation, for example in a situation where a new animal husbandry regime is to be followed in response/prevention to a disease to threat of disease. In itself this may force "innovation".

All play a part in the ongoing development of agricultural production.

## The Innovation Systems Approach

The innovation systems approach is a holistic approach that has emerged during the past decade and has become well established. It is widely used in the academic context and as a conceptual framework for innovation studies. It is also a useful tool to study industrial and agricultural innovations in the economy. In fact, the systems approach is crucial in identifying economic, social, political, organisational, institutional activities and functions of the innovation system. These activities are conducted by sets of agents that interact to achieve a common goal through exchange of information and by learning from each other.

The reality of agricultural innovation is that it involves a more diverse set of agents than is conventionally acknowledged by the linear approach. As a result, innovation requires different sets of functions, the most important ones being technological invention, communication and the adaptation of new ideas for current practice. Every function is equally important, and actors or stakeholders need to collaborate in order to achieve innovation. Termel et al (2001) define the agricultural innovation system (AIS) as a:

> *set of agents that jointly and/or individually contribute to the development, diffusion, and use of agriculture-related new technologies, and that directly and/or indirectly influence the process of technological change in agriculture (p. 6)*

The innovation system approach also provides a useful framework to explore the linkages between stakeholders in agricultural innovation diffusion. Those actors belong to various companies, organisations, institutes, corporations, universities or research centres. They can be classified as private, public and NGO/semi-public depending on size, nature of funding sources and whether they operate as a service or profit-oriented enterprise. These actors can be local, regional, national or international in their scope.

## Methodology and Data Sources

To document the innovation system in agriculture in Australia the following data collection tools were used:

**1**. Desk-based research identified the stakeholders who play a role in the agricultural innovation system in Australia.

**2.** A structured survey questionnaire was sent to a sample of stakeholders (identified by step number 1) by mail to gather information regarding the role of stakeholders in agricultural innovation activities and to analyse stakeholders' interaction in the innovation process (N=50). The questionnaire was similar in format to Temels' (2001) questionnaire for an agricultural innovation study in Azerbaijan.

In order to develop a picture of the agricultural sector, data were sourced from the Australian Bureau of Statistics (ABS) and Australian Food Statistics (AFS).

## Australian Agriculture

Australia has advanced in 200 years from a land largely without widespread, systematic agriculture to one of the world's leading producers and exporters of food, livestock and natural fibres (Reid, 1990). This achievement has taken place in the face of harsh climatic and environmental conditions, which necessitated the development of highly specialised agricultural systems, skills and technology.

The gross value of Australia's farm production in 2004 is $25 billion (4-6 per cent of GDP) with an export value of $29.5 billion. Around 375,000 (4 per cent of the national labour force) are employed in the rural farm sector. In 2003-4, agriculture accounted for around 5 per cent of Australia's investment effort and employed a similar proportion of Australian's net stock of capital. In 2003-04, it directly accounted for around 22 % of Australia's total goods and service exports (Trends in Australian Agriculture, 2005).

Australian farms range in size from small hobby and horticultural properties to large grazing and cropping farms. In 2003-4 farms under 50 hectares accounted for around 20 per cent of all farms (25,400). Thirty-three per cent of farms were sized between 100 and 499 hectares while farms over 2500 hectares accounted for 11 per cent of all farms. The median estimated value of operations of all Australian farms was $109,000, around 17 per cent of farms (21,600) had an income below $22,500, while around 11 per cent (14,100) had an median estimated value of operations of more than $500 000. Ninety-nine per cent of Australian farms are family owned and operated (Trends in Australian Agriculture, 2005).

Australian agriculture has undergone much change over the last few decades. Key drivers have been shifts in consumer demand, changes in government policies, technological advances and innovation, emerging environmental concerns and an unrelenting decline in the sector's terms of trade. Australian agriculture has become increasingly export oriented over the last two decades, with around two-thirds of production now exported. Exports have also become more diverse, with less reliance on traditional commodities such as wool and more on processed products such as wine, cheese and seafood (Trends in Australian Agriculture, 2005).

The agricultural workforce has a number of distinctive features, including: a high proportion of self-employed, family and casual workers; long job tenure; and a relatively old workforce with relatively low education levels and employee wages. Performance within the sector has been mixed. Over the last three decades the cropping industry recorded the highest productivity gains, and the sheep and sheep-beef industries recorded the lowest (Trends in Australian Agriculture, 2005).

| **SECTOR** | **GDP %** |
|---|---|
| Agriculture | 3.6 |
| Industry | 26.4 |
| Services | 70.0 |

**Table 1**: Sectoral Comparison of GDP% (Source: ABS (2005))

The agricultural sector contributed only 3.6 per cent of GDP in Australia in 2005. This is quite small compared to other sectors, such as manufacturing and services. However it contributes a diverse set of food production activities ranging from grape-growing to cotton-farming. Table 2 shows the number of farming enterprises engaged in agricultural food production activities in Australia from 1999 to 2004. It shows that reduction of number of activities listed during 1999 to 2004. However according to Australian farming brief (2006) the total land use on farms (769.2million hectares per year) unchanged during the same period. As a result there has been a consolidation of activities during the above period, with larger units emerging in many areas of agricultural production.

| Main activity | 1999-00 | 2000-01 | 2001-02 | 2002-03 | 2003-04 |
|---|---|---|---|---|---|
| Grape growing | 5924 | 6115 | 6081 | 5714 | 5836 |
| Apple and pear growing | 1145 | 969 | 860 | 836 | 897 |
| Stone fruit growing | 993 | 1000 | 984 | 1096 | 1030 |
| Other fruit | 4499 | 4495 | 4344 | 4382 | 4098 |
| Vegetables | 4557 | 4480 | 4303 | 3930 | 3819 |
| Grain growing | 15578 | 15682 | 15297 | 11411 | 14189 |
| Grain-sheep/beef cattle farming | 17492 | 15384 | 15197 | 16662 | 15856 |
| Sheep-beef cattle farming | 8014 | 7993 | 7421 | 9009 | 7803 |
| Sheep farming | 10853 | 9925 | 10767 | 10803 | 9981 |
| Beef cattle farming | 19582 | 21169 | 19245 | 24195 | 23769 |
| Dairy cattle farming | 13566 | 12605 | 10999 | 10709 | 10178 |
| Poultry farming (meat) | 845 | 782 | 773 | 717 | 709 |
| Poultry farming (eggs) | 454 | 463 | 481 | 457 | 344 |
| Pig farming | 1040 | 1052 | 1061 | 921 | 808 |
| Deer farming | 85 | 88 | 49 | 194 | 5 |
| Sugar cane farming | 4909 | 4743 | 4747 | 4762 | 4538 |
| Cotton farming | 974 | 996 | 697 | 520 | 562 |
| **Total** | **110510** | **107941** | **103306** | **106278** | **104422** |

**Table 2**: Number of enterprises engaged in agricultural food production in Australia (Source: Australian Food Statistics (2005))

Jayasuriya (2003) identified and categorized 13 major farming systems in Australia (Table 3). Those farming systems consist not only of crop farming but also of animal husbandry and forestry. Jayasuriya (2003) also explored major farming systems in Australia in order to quantify the percentage of each farming system, the number of farm families employed and what they grow.

| Farming system | Land area / % of country | Farm families / people employed | Enterprises |
|---|---|---|---|
| Dryland | 15% of the country | 33,200 families | Wheat, sorghum, sunflower, wool meat, beef |
| Pastoral | 45% of the country | Not available | Beef, sheep meat, wool |
| Irrigated and dryland Mixed | Not available | Not available | Maize, sorghum, soybeans, canola, wheat, barley, oats, pastures, sheep and cattle |
| Irrigated Rice | 155,000 ha | 2,000 families | Paddy rice, cereals, sheep |
| Irrigated Cotton | 459,300 ha | 1,300 families | Cotton lint and seed, other crops, sheep, cattle grazing |
| Irrigated Sugarcane | 419,000 ha | 6,900 growers. 23,000 employed | Sugarcane, raw sugar and by products molasses, bagasse and fibre |
| Horticulture | Annual vegetables & perennial fruit 136,500 ha each and wine grapes 128,000 ha | 93,000 employed across 13,865 properties 4,500 wine grape growers | Annual vegetables and perennial citrus, nuts, pome fruit, stone fruit, tropical fruit, berry fruit, banana, wine and table grapes, cut flowers |
| Dairy | 305 million ha | 13,900 farms employ 50,000 directly, another 50,000 provide related services | Fresh milk and manufactured dairy products |
| Poultry, Swine and Goat | Not available | Poultry 1850 farms, swine 3600 farms and goat 2400 farms | Broiler meat, eggs, pig meat, milk and skin |

**Table 3**: Major farming systems in Australia (Source: Jayasuriya (2005))

## The supply network

Australian agricultural producers consumed $8.9 billion in inputs during 1998-9, of which $8.1 billion were supplied domestically and $778 million were imported. Table 4 provides the overview of who are the main suppliers and who are the main customers of agricultural industry in Australia. Services to agriculture were largest individual category of domestically produced input supplies, costing 1,226million in 1998-9.

Other significant inputs to agricultural producers included medicinal and pharmaceutical products (1.3 billion), Road and rail transport (835 million) and basic chemicals (800 million).

| Suppliers & supplies | Agricultural producers | Markets & consumers |
|---|---|---|
| Supply $8,911m | Agriculture $30,428m | Consumption $30,428m |
| | | |
| Domestic supply $8,133m | Domestic production $28,900m | Intermediate (business) uses $18,428m |
| Medicinal and pharmaceutical products,<br>pesticides $1,275<br>Services to agriculture, hunting and trapping $1,226m<br>Other food products $654m<br><br>Basic chemicals $799m<br>Agricultural machinery $126m<br><br>Wholesale trade $733m<br><br>Road and rail transport $835m<br><br>Banking $496m<br><br>Legal, accounting, and business Management services $461m<br>Water supply; sewerage and drainage services $395m<br>Services to transport and storage $340m<br>Petroleum and coal products $362m<br>Other $431m | | Meat and meat products $5,720m<br><br>Dairy products $2,871m<br>Other food products $1,715m<br><br>Services to agriculture, hunting and trapping $1,201m<br>Wine and sprits $988m<br>Textile fibres, yarns and woven fabrics $886m<br>Flour mill products and cereal foods $684m<br>Fruit and vegetable products $549m<br>Accommodation, cafes and restaurants $472m<br>Sport, gambling and recreational Services $427m<br>Beer and malt $250m<br><br>Retail trade $176m<br><br>Bakery products $36m<br>Other $1,715m |
| Imported Inputs | Imports | Final Demand |
| $778m | $1,527m | $12,000m |
| | | Household consumption $3,803m<br>Private capital expenditure $1,287m<br>Inventories $368m<br>Exports $6,542m |

**Table 4**: Australia's agricultural producers supply chain, 1998-9 (Source: ABS (2006))

## The Agricultural Innovation System (AIS) in Australia

The Agricultural Innovation System involves the collaboration of various actors who perform specific roles in the innovation-dissemination process. They can be categorised depending on the role they perform in the innovation system as policy makers, education providers, finance/credit providers, research organisations, input suppliers, extension and information providers, farmers and farm organizations, logistics providers, processing companies, storage facilities providers, marketing

companies and consumers. Major actors in the AIS and the way they link with farmers (or farm organisations) are shown in Figure 1.

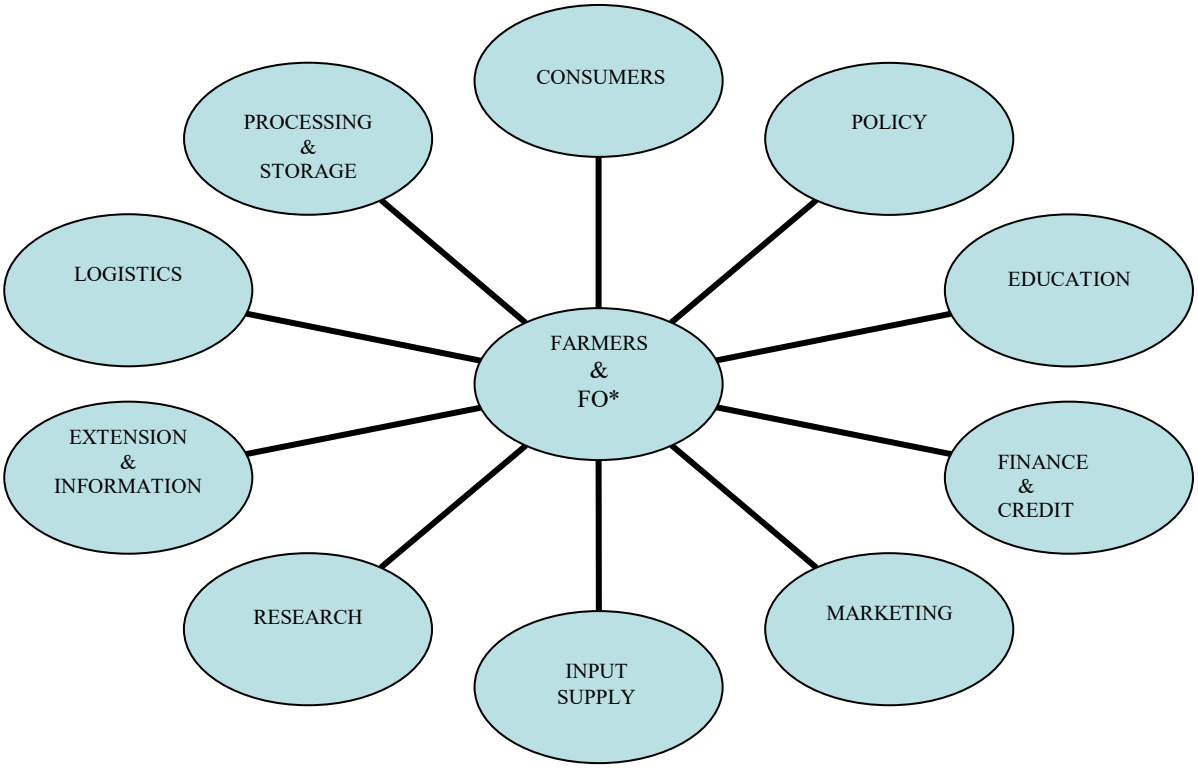


**Figure 1**: Agricultural Innovation System (AIS) in Australia (FO* = Farmer Organisations)

However, there are not only linkages with farmers but also among the other actors. Linkages can exist between any stakeholders of the system. They can be pictured as a cobweb where the above actors are linked with each other through nodes. Examples of public and private organisations/companies who perform a specific role in agricultural innovation in Australia are listed in Figure 2.

Figure 2 (below) depicts the systematic nature of major players in AIS in Australia. It also helps to identify major contributors of the each broad category. Left-Right arrow indicated that both way of information and resources flows, also described as inflows and feedback loops.

## The Empirical Results

This study has undertaken an empirical investigation into identified research organisations/institutes and University research centres in Australia. A survey of 50 research organisations/centres, including a number of universities, was conducted during 2005 to determine the: (a) type of innovation related activities of the organisation; (b) goals of innovation related activities of the organisation; (c) how the behaviour of an organisation is shaped by organisational/institutional constrains and/or incentives for innovation; and (d) funding sources for their innovation activities.

Using a sample of organisations/centres identified via web-search in 2005, an explanatory letter and questionnaire was distributed by post. Fifteen organisations (7 Government departments, 4 Universities and 4 Research and Development Corporations) responded to the survey. This represents a response rate of 30 per cent.

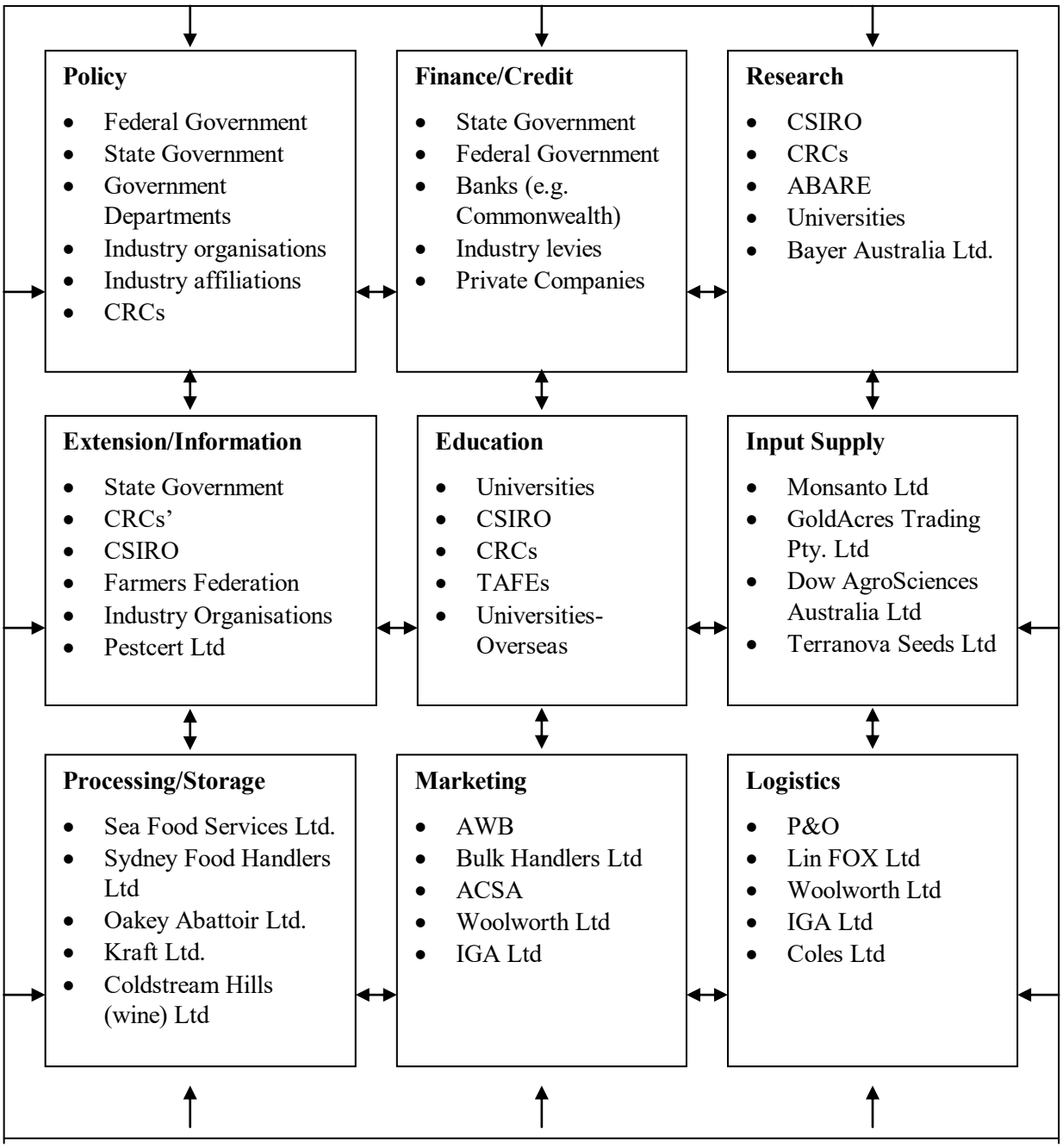


**Figure 2**: System diagram of selected actors of AIS in Australia

## Types of innovation-related activities

Table 5 indicates responses regarding types of innovation-related activities. Respondents could select more than one option. Most organisations conducted more than one innovation-related activity. As a result responses do not add to 100 per cent. Organisations that participated in the survey have conducted all (11) types of innovation-related activities in Australia in varying degrees.

Table 5 indicates those activities in chronological order. Almost all organisations surveyed were involved in technology development (93%). And more than 50 per cent of organisations involved technology diffusion (67 per cent), training (60 per cent) and demonstration (53 per cent) respectively. Further, survey revelled that technology evaluation, integration, use, policy, introduction/selling, acquisition and financing represented less than 50% of innovation-related activities of the organisations.

This shows that these activities are conducted by other organisations such as state government and private companies.

| No | Kind of Innovation | Number | Percentage (%) |
|---|---|---|---|
| 1 | Technology development | 14 | 93 |
| 2 | Technology dissemination | 10 | 67 |
| 3 | Technology training | 9 | 60 |
| 4 | Technology demonstration | 8 | 53 |
| 5 | Technology evaluation | 7 | 47 |
| 6 | Technology integration | 5 | 33 |
| 7 | Technology use | 4 | 27 |
| 8 | Technology policy | 4 | 27 |
| 9 | Technology introduction/selling | 3 | 20 |
| 10 | Technology acquisition (local/international) | 3 | 20 |
| 11 | Technology financing | 2 | 13 |

**Table 5**: Types of innovation related activities of the organization

## Goals of innovation related activities

Table 6 reveals the responses relating to the goals of innovation related activities. Most organisations conducted more than one innovation-related activity. As a result responses do not add to 100 per cent.

More than 50 per cent of organisations indicated that their goals for innovation-related activities were to provide knowledge and information (87 per cent), introduce new products and services (80 per cent), increase commodity quality (80 per cent) and production (73 per cent), reduce environmental damage (67 per cent) and increase market opportunities (60 per cent). Table 6 presents the detail.

| No | Goals of innovation related activities | Number | Percentage (%) |
|---|---|---|---|
| 1 | Provide knowledge and information | 13 | 87 |
| 2 | Introduce new products or processes | 12 | 80 |
| 3 | Increase commodity quality | 12 | 80 |
| 4 | Increase commodity production | 11 | 73 |
| 5 | Reduced environmental damage | 10 | 67 |
| 6 | Increase market opportunities | 9 | 60 |
| 7 | Improve production flexibility | 7 | 47 |
| 8 | Reduced labour costs | 5 | 33 |
| 9 | Generate own income | 5 | 33 |
| 10 | Fulfil regulation or standards | 5 | 33 |
| 11 | Reduced material costs | 4 | 27 |
| 12 | Reduced energy consumption | 4 | 27 |

**Table 6**: Goals of innovation related activities of the organization

## Funding sources

Table 7 shows responses relating to funding sources for the innovation activities in research organisation in Australia. Most organisations conducted more than one innovation-related activity. As a result responses do not add to 100 per cent.

It reveals mix of funding bodies. However, most of the funding (more than 80 per cent) derived from Federal government and related funding bodies/agencies. This suggests that most agricultural research and development funding for the surveyed organisations come from public sources. The reason was that almost all organisations surveyed own by Federal or State Government. State government funded relatively less (13 per cent) to agricultural research and development. This indicates that the Federal Government mainly responsible for research and development of agricultural activities.

| No | Funding Source | Number | Percentage (%) |
|---|---|---|---|
| 1 | From Federal government | 13 | 87 |
| 2 | Funding bodies/agencies | 12 | 80 |
| 3 | Collaborative contracts | 10 | 67 |
| 4 | Competitive grants | 9 | 60 |
| 5 | Non-competitive grants | 6 | 40 |
| 6 | Industry levies | 4 | 27 |
| 7 | Patents and copy rights | 3 | 20 |
| 8 | Awards and prices | 3 | 20 |
| 9 | Own resources | 3 | 20 |
| 10 | From State government | 2 | 13 |
| 11 | International donor assistance | 1 | 7 |
| 12 | Loans and credits | 0 | 0 |

**Table 7**: Funding source of innovation activities

## Constraints and incentives for innovation

Finally, table 8 indicates responses relating to how behaviours are shaped by organisational /institutional constraints and/or incentives for innovation. Most organisations conducted more than one innovation-related activity. As a result responses do not add to 100 per cent.

The majority of respondents (53 per cent) indicated that other issues, such as funding, staff, equipment, environment and government policy, affected innovation in their organisations more than kind of behaviour listed. The most commonly cited constraints (53 per cent) on innovation were the finding was difficult to obtain funding followed by a deficiency of skilled staff and equipment.

| **No** | **Behaviour of organisation** | **Number** | **Percentage (%)** |
|---|---|---|---|
| 1 | Other* | 8 | 53 |
| 2 | Cultural Norms | 5 | 33 |
| 3 | Laws | 3 | 20 |
| 4 | Health Regulations | 3 | 20 |
| 5 | Social Rules | 3 | 20 |
| 6 | Technical Standards | 2 | 13 |

**Table 8**: Which incentives/constraints have most affected the innovation behaviour of your organisation. Other issues* – funding, staff, equipment, environmental, government policy issues

# Summary and Conclusions

In this paper we identified 11 actors in terms of their function within the Australian Agricultural Innovation System. They are policy makers, education providers, finance/credit providers, research organisations, input suppliers, extension and information providers, farmers and farm organizations, logistics providers, processing companies, storage facilities providers, marketing companies and consumers. These actors are inter-linked with each other in order to share knowledge, information and resources to meet requirements to innovate. A systems approach was utilised to identify the systematic nature of the collaborative links of the above actors.

The study concludes that actors in the AIS in Australia are linked to each other in sharing knowledge, information and resources. Some organisations perform more than one role in the AIS in Australia, such as State Governments and universities.

Even though the Australian agricultural sector contributes a relatively small percentage (3.6 per cent in 2005) to its total economy, the AIS in Australia involves a significant portion of the manufacturing and services sectors. Analysing Australian agricultural producer's supply chain in 1998-9, it is possible to conclude that one-third of agricultural production was exported. On the supply side, most inputs were

produced by domestically. However, most important inputs for agriculture (machinery and chemicals) were imported.

Surveyed organisations indicated that the major types of innovation-related activities are technology development (93 per cent), technology diffusion (67 per cent), technology training (60 per cent) and technology demonstration (53 per cent). The survey also revealed that major goals (80 per cent or more) of innovation-related activities were: provide knowledge and information, introduce new products and processes and increase commodity quality, with most of the funding for the activities come from Federal Government and its funding bodies. Finally the survey indicated that the major constraints for innovation can be categorised under funding, staff, equipment, environmental and government policy issues. Therefore it is vital to address the above issues to enhance innovation-related activities in the AIS in Australia in general and in surveyed organisations in particular.

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