



R&D Plan for
**Integrated
Agri-Aquaculture
Systems
1999-2004**

**A report for the Rural Industries Research
and Development Corporation**

by Geoff Gooley

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Foreword

Of recent years, the concept of integrating aquaculture with irrigated farming systems to enhance farm productivity and water-use efficiency has been evaluated in a project funded by the Rural Industries Research and Development Corporation (Project DCM-1A *Agriculture/aquaculture systems integration to enhance farm productivity and water use efficiency*) and the Victorian Department of Natural Resources and Environment (Fisheries Victoria). This project was undertaken from 1994/95 to 1997/98 in the Goulburn-Murray Irrigation District (GMID) of Victoria by the Marine and Freshwater Resources Institute (MAFRI) in collaboration with Goulburn-Murray Water, Deakin University and irrigation farmers in the GMID. More recently, several other state and federal agencies have also been actively involved in facilitating industry development in this area and in conducting relevant R&D and pilot, commercial scale trials, including activities in Western Australia, South Australia, new South Wales and Queensland.

Based partly on these initiatives, and in recognition of the current global trends towards the integration of aquaculture and irrigated agriculture, the opportunity now exists for Australia to formally establish an Integrated Agri-Aquaculture Systems (IAAS) industry sector at a national level. Such an initiative, however, needs to be underpinned by a comprehensive and well coordinated, nationally prioritised R&D plan, which synthesises the needs of all key stakeholders. Consistent, therefore, with RIRDC's Five Year Strategic Plan (1997-2002), the development of a national five-year IAAS R&D Plan, as part of the Corporation's Resilient Agricultural Systems sub-program, is seen as an appropriate means to ensure that future Australian R&D be outcome focused and relevant to key industry needs.

Additionally, it is intended that the Plan will provide a strategic, "overarching" framework for related initiatives linked to IAAS, that may have a more specific and detailed focus, such as aquaculture use of inland saline groundwater. Accordingly, a complementary project being conducted by the Fisheries Research and Development Corporation (FRDC), designed primarily to establish a national R&D Plan for inland saline aquaculture, will effectively address a number of imperatives relevant to IAAS, but in a much more comprehensive and detailed manner than is intended in the present Plan.

Where appropriate, therefore, in order to achieve operational synergies related to consistency of objectives, efficient use of available resources and timeliness of outcomes, it will be necessary for funding agencies and research providers alike to be cognisant of IAAS industry R&D needs at all levels.

This project was funded from RIRDC Core Funds which are provided by the Federal Government.

This report, a new addition to RIRDC's diverse range of over 450 research publications, forms part of our Resilient Agricultural Systems R&D program, which aims to foster agri-industry systems that have sufficient diversity, flexibility and robustness to be resilient and respond to challenges and opportunities..

Most of our publications are available for viewing, downloading or purchasing online through our website:

- downloads at www.rirdc.gov.au/reports/Index.htm
- purchases at www.rirdc.gov.au/pub/cat/contents.html

Peter Core
Managing Director
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1. Purpose of the Plan

Objectives

- To facilitate the establishment of an Australian *Integrated Agri-Aquaculture Systems (IAAS)* primary industry sector at a national level.
- To identify and engage key stakeholders including peak agriculture and aquaculture industry bodies, regional communities, primary producers, investors and the R&D community.
- To identify, synthesise and nationally prioritise the R&D needs of the developing IAAS sector and to consolidate such needs into a comprehensive, nationally co-ordinated program over an appropriate time frame.
- To provide a strategic IAAS R&D focus for all relevant fisheries and aquaculture, agriculture, water and associated primary industries management and research agencies, industry bodies, fish farmers and other primary producers.
- To encourage the utilisation and industry ownership of IAAS R&D as a fundamental means of achieving longer-term environmental and economic sustainability within the developing IAAS industry sector.

The Plan is based on the outcomes of the *Farmer-Operated Integrated Aquaculture, National R&D Planning Strategy Workshop* (FOIA R&D Workshop), conducted by the Rural Industries Research and Development Corporation and held at Trawool, Victoria, from 15-16 September, 1998. The Workshop was attended by 16 delegates representing twelve key primary industry stakeholder groups across the Australian aquaculture, irrigated agriculture and land and water industry sectors. The composition of delegates at the Workshop also consciously emphasised the participation of state and federal policy makers, resource managers and major/national industry peak body representatives within these stakeholder groups. Delegates to the workshop are listed in Appendix 10.1. Professor Sam Appelbaum, Head – The Bengis Centre for Desert Aquaculture, Ben Gurion University, Israel, delivered a keynote address based on an Israeli perspective of commercially significant IAAS application (see Appendix 10.2). IAAS farmer opportunities and a preliminary listing of potential candidate IAAS species identified by workshop delegates are summarised in Appendices 10.3 and 10.4 respectively.

Definition of IAAS

IAAS can be variously defined as:

- Aquaculture undertaken as part of an integrated agricultural production system; more specifically incorporating aquaculture practices and operations with other commercial farm enterprises, infrastructure usage and management objectives as an integral, but not necessarily primary, component of an agricultural (typically irrigated) production system.
- Irrigation farming, agricultural water storage utilisation and aquaculture as part of integrated systems which are based on the multiple and more efficacious use of the same water; typically first for fish production and then for irrigation (modified after Cohen 1997).

- Integration of aquaculture with terrestrial farming systems to achieve sustainable management and utilisation of natural and “waste” resources (after Edwards 1998).
- The linking of aquaculture with other human activity systems to capitalise on use of their by-products; more specifically concurrent or sequential linkages between two or more human activity systems (one or more of which is aquaculture), directly on-site (farm), or indirectly through off-site needs and opportunities or both (after Edwards 1998).

It is not intended, nor is it deemed necessary, that this Plan provide a categorical definition of IAAS. By its very nature IAAS is and always will be a practical and relatively simple and broadly defined concept which embraces a diversity of practices, systems and operations. The above definitions are therefore not exhaustive and intended only to be indicative of the general principles which underpin IAAS.

Key Stakeholders

Key IAAS stakeholders can be summarised as:

- Existing (irrigation) farmers, including the National Farmers Federation and associated peak (representative) industry bodies
- Existing aquaculturists, including the Australian Aquaculture Forum and relevant state-based peak (representative) industry bodies
- New investors (be they aquaculture and/or agriculture based)
- Seafood industry, including buyers, processors, retailers and exporters
- Federal Government R&D Corporations and associated funding agencies/initiatives, including the Natural Heritage Trust
- Government-based fisheries, agriculture, land/catchment and water resource managers, including Standing Committee on Fisheries and Aquaculture
- Regional/rural communities, including local government authorities and regional economic development agencies
- Indigenous communities, including Aboriginal and Torres Strait Islander Commission and regional Koori communities
- Environmental agencies and associated peak bodies
- Catchment management and water resource authorities
- Research and development agencies, including centres for fisheries and aquaculture, aquatic sciences, land and water, and bio-economics R&D (including state-based agencies, universities and CSIRO)
- Service industries, including suppliers of feeds, systems, equipment, technical and training services etc

2. Vision and Mission Statements

A vision and mission for the future to be embraced by the developing *Australian Integrated Agri-Aquaculture Systems (IAAS)* primary industries sector:

Vision Statement

A diverse and innovative Australian primary industries sector which on a routine basis effectively and efficiently integrates aquaculture and agriculture practices into farming systems which are both profitable and ecologically sustainable.

Mission Statement

To develop, promote and coordinate Integrated Agri-Aquaculture Systems practice within Australia to enhance overall farm productivity and water use efficiency by:

- integrating aquaculture as part of routine farming operations
- optimising integrated systems through closer collaboration between relevant R&D service providers in all states
- facilitating strategic, cost-effective, market-driven R&D
- encouraging multiple use of water as part of such operations
- containing and utilising on-farm otherwise wasted resources such as inland saline and nutrient rich waste waters
- encouraging more diverse use of existing farming infrastructure such as irrigation channels, water storages, pumps and pipelines
- developing simple, low capital cost aquaculture infrastructure and associated technology to complement existing on-farm resources and routine practices
- within an appropriate framework achieving nett environmental and socio-economic benefits for the community, including both present and future generations

3. Background to the Industry

Rationale for IAAS

With a global emphasis on ecologically sustainable development of natural resources, it is logical to integrate where possible appropriate farming practices to enhance farm productivity and water-use efficiency. Water is currently under utilised in irrigated farming systems in Australia as a result of routine, single-use only. Long term sustainability factors and water management costs to the industry and community at large indicate that farmers will need to diversify and increase total farm productivity and profitability as well as conserve water.

With such increasing pressure on Australia's water resources, integration of water uses should be considered. In other parts of the world, in particular Israel and various Asian countries, integrated farming systems are highly developed and make considerable use of the available water resources for fish production on a sustainable and synergistic basis with various forms of agriculture. There has been no major commercial effort in this area by Australia to date, although interest from the farming community appears to be increasing rapidly.

Within a global context, aquaculture is the primary means by which the shortfall in world fisheries production is expected to be met in future generations. Indeed according to the most recent FAO statistics (1996), current world aquaculture production has grown at an average annual rate of almost 10% since 1984, compared with 3% for livestock meat and 1.6% for capture fisheries production. Specifically, the annual contribution of cultured finfish and shellfish to total finfish and shellfish production (120.3 million tonnes in 1996) has risen from 13% in 1990 to 22% in 1996. Overall global aquaculture production, including finfish, shellfish and aquatic plants, has now reached 34.12 million tonnes worth US\$46.5 billion, of which the majority of finfish and shellfish production is from inland waters (15.6 million tonnes; 59.1%)(FAO 1998).

Australian aquaculture production by comparison is relatively small (total of approximately 25,700 tonnes worth in excess of AUD\$444.2 million in 1996/97) and largely marine-based (O'Sullivan 1998), with the rate of development of inland aquaculture lagging behind other sectors of the industry, both nationally and internationally.

Agricultural production in Australia by comparison with aquaculture is relatively large. By some estimates, irrigated agriculture specifically accounts for over 25% of total production worth at least AUD\$5-6 billion annually. Existing irrigation resources include the use of > 13,000 GL of water per annum, some 2,000,000 ha of land, over 20,000 km of water supply channels, and myriad, relatively small, on-farm water storages. Additionally, associated with irrigated farming are extensive saline groundwater resources, estimated at about 2,875 GL across Australia.

Within the Goulburn-Murray Irrigation District (GMID) of Victoria alone there are approximately 490,000 ha of irrigated farmland in the GMID of Victoria which consumes on average about 2.6 million ML of water per annum, costing farmers about \$60 million annually. This represents almost 10% of the overall dollar value of the total annual agricultural produce from the GMID, the major food producing river basin in the country. For more information, a general summary of Australian and Murray-Darling irrigation resources and production is provided by Crabb (1997).

Furthermore, it is now generally agreed that water diversion from the Murray-Darling Basin is at, or in some cases has exceeded, maximum sustainable levels. Specifically, almost half of the mean annual runoff from the Basin has been diverted for urban, industrial and agricultural use, with about 95% of the water being diverted for the irrigation industry. This scenario seriously threatens not only the environmental integrity of the largest river basin in the country, draining catchments across four states, but also threatens the longer term viability of the dependent industries. Accordingly, from July 1997, the Murray-Darling Basin Ministerial Council has set an upper limit on the amount of water that can be taken from the river system (MDBMC 1995). In short, there is no more water to exploit from this basin, and further industry growth will need to come from more efficient and/or multiple water use, and a shift increasingly towards higher value production. An issue such as this effectively demonstrates the essential environmental imperatives of proposed IAAS development in Australia at a national level.

In summary, the scale of such resources and infrastructure which exists within the irrigated farming sector in Australia clearly offers considerable scope for diversification into aquaculture. However, in combination with the broader environmental imperatives, there is also clearly great potential for increasing the effectiveness and efficiency of irrigation water resources. Improving both economic return from this water and overall sustainability of the resource, by the development of multiple use strategies through integration of agriculture and aquaculture farming systems, has intrinsic merit for Australian primary industries and rural communities.

Global IAAS trends

The existing and potential integration of aquaculture and irrigation throughout developing nations is both recognised and well documented (eg. see Redding and Midlen 1991; Willman *et al.* 1998). As previously intimated, the rationale for such practice consistently centres on maximising the synergies and limiting the conflict between the relevant fisheries and agriculture sectors. Benefits are derived from recycling of nutrients and optimal use of water resources. Conflict may occur as a result of chemical residues, eutrophication of adjacent surface waters, and various other environmental impacts associated with inappropriate aquatic and land-based farming practices.

Arguably, the best models of IAAS development exist in Israel and throughout many Asian countries. The Israeli model is based very much on the need to obtain maximum economic advantage from the very limited, available water resources (both fresh surface and brackish groundwater), in what is largely a semi-arid or desert environment (eg. see Cohen 1997; also Appendix 10.2). The Asian experience is based largely on the need to utilise all available water, land and nutrient resources for both subsistence and commercial purposes (eg. see Huazhu *et al.* 1994). Both models dictate the need for multiple water use and integration of aquaculture with various other forms of agriculture eg. fish-rice-ducks in Asia, fish (multiple species)- land crops (multiple) in Israel.

Although relatively sophisticated, small-scale integrated aquaculture systems are also known to have been utilised in some eastern European countries for many years. More recently, the concept of IAAS has gained wider recognition within Europe. Indeed, the report of the Twentieth Session of the European Inland Fisheries Advisory Commission (EIFAC), in Praia do Carvoeira, Portugal, 23 June-1 July, 1998 (EIFAC 1998), which includes a summary of the EIFAC Symposium on Water for Sustainable Inland Fisheries and Aquaculture (23-26 June, 1998), states "...the possibility of integrating aquaculture into irrigated farming systems should be considered as an option for improved efficiency of water use..... However, a

flexible approach is suggested which uses all types of habitat created by existing agronomic practices, the hydrological cycle and the features of the landscape....". The same report indicates that globally, water extraction rates are occurring at 2.5x the rate of population growth with the irrigated agriculture sector exceeding both industry and domestic consumption.

Status of Australian IAAS Sector and Associated R&D

The development of IAAS in Australia has been undertaken on an opportunistic, somewhat *ad hoc* basis to date. For example, in Queensland silver perch development on sugar cane farms has been considered; in the New South Wales cotton industry the use of on-farm, turkey-nest water storages for various fin fish; in Western Australia, South Australia and more recently Victoria, the co-operational diversification into yabbie farming using existing on-farm water storages; in Western Australia, Victoria and New South Wales the use of inland saline, ground and surface waters for culturing finfish; in Victoria the use of cages to culture finfish in irrigation channels, on-farm storages and public reservoirs.

Many of these developments have included key research projects, including those funded by various State agencies and industry groups in association with the Rural industries R&D Corporation, Murray-Darling Basin Commission and the Australian Centre for International Agricultural Research (eg. see EIFAC 1998; Gooley *et al.* 1999).

This approach has resulted in varying degrees of experimental and/or commercial success, but from a national perspective is less than optimal, and it is clear that market opportunities in some cases may be lost and/or under exploited. Accordingly, if IAAS is to develop successfully in Australia, investors will need a comprehensive, well-coordinated R&D framework to enable them to proceed with confidence.

4. SWOT Analysis

An analysis of the strengths, weakness, opportunities and threats of a developing Australian IAAS sector was undertaken as part of the September, 1998, RIRDC Workshop held at Trawool, Victoria. The results are summarised thus:

Strengths

- It encourages the multiple use of water, thereby facilitating water conservation
- There are a lot of existing resources available within Australia suitable for adaptation to and utilisation within IAAS, eg. irrigation water and associated infrastructure (supply channels, storages, pumps, pipelines etc), land, shedding and general farming equipment etc
- Ambient weather conditions in Australia are generally conducive to at least seasonal IAAS production, albeit with variation from region/state to region/state
- There is much existing knowledge available within Australia on the principles of both agriculture and aquaculture production which could be readily accessed, including recent R&D focussing on the integration of the two disciplines
- There is a wide range of potentially suitable endemic and locally available exotic species available for utilisation within IAAS, including those typically suited to freshwater and inland saline conditions
- There is a large, existing domestic Australian and Asian export seafood market which potentially could be accessed, albeit one which is not well defined specifically for IAAS produce
- IAAS is readily perceived nationally and well established internationally as being an environmentally sustainable practice, based largely on utilisation of renewable resources
- There are low economic and resource requirement barriers to IAAS entry
- The multiple use of existing/available resources, particularly water and associated storage and reticulation infrastructure, provides logical opportunity to maximise economic returns from investments
- General farm management and associated intensive propagation and animal husbandry skills can to a large degree be readily adapted for IAAS
- IAAS is a flexible concept by definition and design and can therefore be accessed from multiple directions
- Potential exists with IAAS for relatively high returns on investment (and therefore profits) per unit of water consumption compared with more conventional forms of irrigated agriculture
- Aquaculture as a primary industry sector per se is exhibiting a relatively high rate of growth both nationally within Australia and internationally

- Some forms of IAAS, particularly those utilising otherwise wasted resources such as shallow saline groundwaters, have the potential to significantly offset environmental management costs associated with broader land and water resources
- IAAS practices promote an important image of environmental responsibility within industry and the broader community
- IAAS produce has the potential to reduce pressure on harvesting of wild fisheries and aquatic resources and also to contribute to replacing existing seafood imports
- There is considered to be significant latent investor interest in IAAS, both from existing farmers and new entrants
- IAAS has the potential to ensure a continuous supply of marketable produce, albeit subject to achieving appropriate levels of industry coordination and cooperation
- IAAS facilitates whole family involvement in the on-farm business, thereby offering broader socio-economic benefits to rural communities
- The interest in the IAAS concept is Australia wide.

Weaknesses

- Financial commitment is low and hence R&D activities lack economic planning
- The specific definition of both on and off farm benefits of IAAS is poorly defined, with an associated impact on general public perceptions
- IAAS production presently is extremely fragmented
- Specific markets for small producers have not been well identified and necessary production, processes, infrastructure and networks generally do not exist or are in only the embryonic stages of development
- IAAS produce in Australia is as yet of unknown quality and generally in limited supply for organoleptic testing and/or general market appraisal
- Specific aquaculture husbandry skills are largely lacking within the existing irrigated farming sector to readily extend their operations to include IAAS
- There is uncertainty over the downstream nutrient impacts by IAAS activities within surface irrigation systems such as on and off stream storages and associated supply channels
- There is a lack of government policy relating to environmental management of IAAS
- There is a lack of planning and administrative support for IAAS business development
- The definition and interpretation of what constitutes IAAS is inconsistent across government agencies and industry sectors

- There is a paucity of established endemic species suitable for targeting as part of IAAS operations, and a possible lack of acceptance of some potential exotic species
- The relative economic benefits of IAAS and associated multiple water use practices compared with more traditional farming and associated single water use practices are not well defined, and relevant cost-benefit data are lacking for necessary analyses
- Technical knowledge of suitable species and associated husbandry specific to IAAS practices is limited.
- Hatchery capacity for seedstock supply of many potential IAAS species is limited or non-existent at present
- Bureaucratic constraints to IAAS development exist at various levels of government
- Environmental regulations, often with little scientific validation, can also constrain IAAS development
- Conflicting and/or otherwise incompatible seasonal demands on water and other resources may exist between and/or by users when attempting to simultaneously address separate agriculture and aquaculture priorities
- There is a general lack of successful/working IAAS demonstration sites for extension purposes nationally
- There is a lack of regionally based infrastructure suitable specifically for post-harvest handling and storage of IAAS produce eg. purging, grading, live storage and transport etc.
- IAAS utilising surface waters have limited control over water quality, particularly where the initial supply is off-farm
- There is presently a lack of relevant and accessible background information and associated documentation on IAAS resources and practices in Australia
- Commodity prices are inherently variable in Australia such that price sensitivity on IAAS produce may well be significantly affected by rises and falls in other commodities independent of IAAS costs and markets

Opportunities

- IAAS investment, development and associated socio-economic benefits are primarily regionally based and therefore of most benefit to rural communities
- IAAS provides the opportunity to diversify operations and so enhance economic security
- The capacity exists to achieve multiple water use with no nett increase in consumption and overall water costs
- IAAS has the potential to capture and utilise farm generated nutrients and associated energy sources, to be used for nutrient stripping purposes in eutrophic wastewaters, and for utilisation of other waste resources such as shallow saline groundwaters

- IAAS may enable primary producers to shift towards higher value commodities with deregulation of the water industry, thus providing a potentially increased rate of return on investment
- IAAS is a concept which is conducive to vertically integrated business development and associated joint ventures, and regional business networks and clusters eg. lots of smaller operators achieving economies of scale through cooperative production and marketing to effectively tap into bigger and more lucrative markets
- Cost-effective entry for primary producers, in terms of capital outlay, to a more diversified farming enterprise through optimising the use of existing infrastructure and resources (eg. water, labour etc)
- “Windows of opportunity” such as seasonal irrigation flows and/or regional niche markets may be readily exploited
- Tangible means for promoting compatible environmental and economic sustainability imperatives for the primary industries sector
- Socio-economic multipliers, including enhancement of regional employment, resulting from development and facilitation of regional IAAS support industries such as feeds, freight, specialised harvesters etc
- Ready accessibility to freshly produced fisheries/aquaculture produce in regional centres
- Agri and/or eco-tourism experiences as an adjunct to core farm business eg. farm tours, sale of produce, recreational, “pay-as-you-catch, put-and-take” fisheries etc
- Any aquaculture production will reduce the pressures on already depleted wild fishery resources and will ultimately benefit aquatic biodiversity
- Any replacement of imported finfish will benefit the national balance of payments and therefore the local economy

Threats

- Lack of Quality Assurance Programs, food safety protocols and associated quality controls to ensure aquaculture produce is of both a high and consistent quality and safe to eat for consumers
- Off-flavours resulting from poor quality waters (eg. high turbidity, algal blooms etc) and limited water management control (noting however that such off-flavours can be readily removed through routine purging procedures)
- Negative perceptions of proposed IAAS developments and associated impacts by environmental regulators and lobby groups, local government and the community at large
- Possible impacts by (recently applied and/or residual) chemicals (eg. heavy metals, pesticides) and other extraneous contaminants (eg. blue-green algae) on IAAS
- Possible impacts by nutrients (N,P,K) and disease vectors from IAAS on natural aquatic biodiversity, ecosystems, resources and waterways

- Possible impacts from escape to natural waterways of translocated species/stocks used in IAAS (eg. impacts from competition with and genetic integrity of local endemic flora and fauna)
- On-farm system management conflicts as part of the integration process
- Increased cost of water as part of the combined effect of deregulation of the water industry and seasonal circumstances such as droughts and associated increased demand for secure reticulated water supplies
- Any new consumptive water use as part of IAAS would be problematic due to increasing caps by regulatory agencies on water allocations
- Lack of State and local government planning policy, schemes and processes to facilitate IAAS development
- Lack of industry sector level organisation and representation to facilitate meaningful government-industry consultation and liaison
- Unrealistic expectation of production levels causing stock crash from over intensification
- Impacts on IAAS by birds and other predators such as water rats, as well as from human intruders including vandals, thieves, poachers and other forms of irresponsible and/or anti-social behaviour (particularly in more public areas)

5. Key Industry Issues & Needs

The SWOT analysis identifies industry issues in the terms of five key industry needs which provide the basis for establishing national R&D priorities for the developing IAAS sector in Australia. These needs and issues are summarised here in priority order:

- 1) The need for relevant background information as an extension resource, including:
 - Identification and scoping of relevant IAAS resources and associated information in Australia; in the form of a resource inventory summarising available water resources (eg. location, accessibility, quality, quantity, reticulation and storage systems etc), climatic conditions (eg. ambient water and air temperatures), land accessibility and conditions (eg. present and historical usage, soil types, catchment condition, freehold/crown, salinisation, chemical residues, etc.) and infrastructure (eg. location and availability of storage, freight, transport, processing facilities etc)
 - Provision of an up to date literature review of IAAS developments both in Australia and around the world, with an emphasis on describing the successful Israeli and various Asian IAAS models; to include a checklist of recent/in progress Australian IAAS R&D
- 2) The need for an industry-wide economic development strategy to assist IAAS business planning for existing farmers and new investors, including:
 - An appraisal of potential domestic and/or export markets for IAAS produce, including an analysis of likely quality assurance standards/requirements, value-adding options and a general marketing strategy for such produce
 - A generic economic model with benchmark set-up and operating costings to enable objective cost-benefit analysis of various IAAS systems and associated levels of investment
 - The requirements for establishing regionally-based IAAS business networks/clusters, involving cooperative industry Codes of Practice, production, harvesting, post-harvest handling/processing and marketing
- 3) The need for a review, collation and, where appropriate, development of Federal, State and local government legislation, policy, planning and management guidelines relevant to IAAS implementation in Australia, including:
 - A broad review of state and local government and semi government/corporate agency permit/licensing, planning scheme and general policy guidelines and/or requirements relevant to IAAS development at a regional level
 - A broad review of state government and associated semi-government/corporate agency water and environmental legislation, policy, permit/licensing requirements as may apply to IAAS development
 - An analysis of environmental risks including potential downstream nutrient impacts, translocation of non-endemic species and transmission of exotic diseases

- Development of reliable and cost-effective Best Practice environmental management guidelines and associated environmental monitoring requirements such as nutrient mass balance models; includes provisions for industry Codes of Practice and/or Best Practice Environmental Management Guidelines etc
 - A review of water authority pricing policy and associated licensing requirements
 - A review and, where appropriate, development of food safety and associated HACCP and Quality Assurance Program requirements
- 4) The need for more biological and technical information relevant to development and implementation of IAAS in Australia, including:
- Information on species suitability, growth and survival, general husbandry, environmental, nutritional and health management requirements, and seedstock availability
 - Information on system design options and environmental impacts, such as fresh v saline waters, ponds v tanks v cages, surface v groundwater, agricultural production system linkages (eg. cotton, rice, horticulture, hydroponics, viticulture, dairy, agroforestry etc), polyculture v monoculture etc
- 5) The need for industry extension support, training and education for IAAS operators/investors and resource managers, regulators and legislators, including:
- The establishment/provision of regional training workshops and accredited, skills-based traineeships
 - The provision of industry extension services based on regionally-based dedicated extension officers with access to relevant extension resource materials and information, including recent research publications, technical reports, industry newsletters, resource maps etc
 - The provision of miscellaneous technical support and associated advisory services, such as fish pathology, water quality analysis, general engineering and farm planning

6. The R&D Plan for 1999-2004

The Plan is based on the key industry issues, needs and associated priorities, and is summarised below as a series of R&D tasks, together with indicative timelines and nominal % weighting for the necessary level of R&D investment relative to each of the listed priorities:

Prioritised Issue/R&D task	% Resources	Year				
		1	2	3	4	5
1. Resource Inventory & Information	5	■				
2. Business & Economics	20					
<i>a. Marketing & economics</i>		■	■	■		
<i>b. Quality assurance</i>			■	■	■	■
<i>c. Business development</i>			■	■	■	■
3. Policy and Planning	5					
<i>a. Legislation, licensing & permits</i>		■				
<i>b. Environmental management</i>			■	■		
4. Biology & Technology	50					
<i>a. Biology & husbandry</i>		*	■	■	■	■
<i>b. Technology & system design</i>		*	■	■	■	■
5. Education, Training & Extension	20					
<i>a. Education & training</i>		*	■	■	■	■
<i>b. Extension services</i>		*	■	■	■	■
<i>c. Support technical services</i>		*	■	■	■	■

* indicates tasks already partly in progress in most states either specifically for IAAS purposes and/or as part of other inland aquaculture R&D initiatives.

Specific details of each of the proposed R&D tasks, including objectives, background, strategies, targets and performance indicators are summarised in the following section.

Task 1

Resource Inventory & Information

Objective

To provide IAAS resource inventory and associated background information for industry extension purposes.

Background

Existing farmers, new investors, resource managers, policy makers, planners and regulators, financiers and extension personnel have a need for relevant, reliable, accessible and comprehensive (but otherwise concise) resource inventories and associated background information for the purposes of facilitating IAAS investment, development and implementation in Australia.

Strategy

- Review existing databases, collate information and summarise in both electronic and hard copy formats
- Establish electronic, internet-based R&D communication network at both national and international level
- Undertake literature review of current and recently completed IAAS R&D

Targets

- Complete complement of resource inventories and associated background information disseminated to all stakeholders by 2000
- Access to internet discussion forum made available to all stakeholders by 2000
- Published literature review disseminated to all stakeholders by 2000

Performance Indicators

- Distribution levels of relevant information
- Number of subscribers/postings on internet
- Rationale, design, quality and integrity of IAAS proposals and/or developments
- Accuracy, comprehensiveness and general accessibility of information

Task 2

Business & Economics

- a. Marketing & economics*
- b. Quality assurance*
- c. Business development*

Objective

To develop an industry-wide, economic development strategy for IAAS business planning purposes.

Background

There is a need for an industry-wide economic development strategy to assist IAAS business planning for existing farmers, new investors and financiers. Such a strategy needs to be cognisant of market opportunities and requirements (including product type and quantity, quality assurance and value adding issues), actual (capital and operating) costs of production and projected financial returns, and business development requirements for regional centres.

Strategy

- Undertake a current and future market appraisal of IAAS produce to determine demand/opportunities, quality assurance requirements, value-adding options and pricing structures.
- Develop a generic bio-economic model based on electronic/PC format for undertaking routine cost-benefit analysis of IAAS systems
- Design and document a regional business network/cluster concept for use as a model for the developing IAAS sector
- Develop and implement an extension program

Targets

- Identification of key IAAS market trends and opportunities, together with tentative pricing structure by 2000
- Completed bio-economic model by 2001
- Preparation of a strategic business development concept by 2002
- Utilisation of IAAS irrigation water resources to exceed 5% of total existing allocation and gross margin per ML of water as part of IAAS farming to achieve a significant increase over conventional single water use systems by 2004

Performance Indicators

- Proportion of market driven investment
- Increased rates of return on investment.
- Proportion of business plans incorporating aspects of cooperative industry development.

Task 3

Policy and Planning

- a. Legislation, licensing & permits*
- b. Environmental management*

Objective

To facilitate the understanding of farmers and other stakeholders of all relevant legislation and regulations, and planning, licensing and environmental management guidelines and, where appropriate, to assess risks and develop the necessary protocols.

Background

Due to the multiplicity of jurisdictions relevant to IAAS, there is a need to have ready access to all relevant Federal, State and Local Government legislation, policy, planning and management guidelines. Such information should specifically include local government planning scheme guidelines, food safety standards, and environmental regulations pertaining to effluent and species translocation policy. Where appropriate, the necessary protocols, including environmental management guidelines and associated monitoring tools may need to be developed.

Strategy

- Review and collate all relevant government legislation, policy and planning pertinent to requisite licensing, permits and associated regulations
- Review and collate food safety legislative requirements
- Review and collate environmental management guidelines
- Develop system-specific, conceptual nutrient mass balance models and associated nutrient budgets and monitoring techniques
- Review and collate translocation policy in relation to non-endemic species
- Implement on-going five year review process

- Where appropriate, assess risks and development appropriate management guidelines

Targets

- Complete summary of all relevant information in electronic and hard copy to all stakeholders by 2000
- Develop generic nutrient mass balance model by 2000
- Environmental risks assessed and management guidelines completed by 2004

Performance Indicators

- Distribution levels of relevant information.
 - Frequency of IAAS planning/licensing appeals.
 - Lead time between business planning and implementation.
 - Review process in place .
 - Process for determining nutrient budgets endorsed by relevant agencies
-

Task 4

Biology and Technology

- a. Biology & husbandry*
- b. Technology & system design*

Objective

To identify, develop and evaluate suitable IAAS species and technology.

Background

With the range of target species potentially suitable for IAAS development including many classified as “new and developing” endemics, it will be necessary for there to be objective and comprehensive selection criteria established in order to maximise likelihood of success. Furthermore, where relevant information is not available for such criteria, R&D needs to be undertaken in order to fill the gaps. For commercially established species, including both endemic and introduced species, the requirement will be largely for a review and collation of existing information. Requisite information will include not only species suitability criteria but also specific technological details regarding production requirements on a species by species, system by system basis.

Strategy

- Review and collate all relevant literature in relation to potentially suitable IAAS candidate species
- Establish a concise and comprehensive set of key selection criteria for IAAS candidate species
- Prepare a regionally specific checklist of suitable IAAS species annotated with relevant technology and system requirements

- Evaluate priority candidate species in terms of growth and survival under IAAS conditions
- Through appropriate “in-situ” industry trials develop suitable husbandry, health management and nutritional protocols for IAAS operations on a system by system basis
- Through appropriate “in-situ” industry trials design and evaluate suitable system design requirements for IAAS operations on a species by species basis; to include evaluation of fresh and saline waters, pond, tank and cage-based systems, use of surface and ground waters, mono and polyculture systems
- Through appropriate “in-situ” industry trials design and evaluate suitable IAAS technical linkages to existing agricultural systems such as cotton, rice, sugar, fruit, dairy

Targets

- Complete summaries of all relevant information in electronic and hard copy to all stakeholders by 2004
- Completion of all relevant industry trials by 2004
- Finalisation of prioritised species and system checklists by 2004
- Established IAAS linkages with all key irrigated agriculture sectors by 2004

Performance Indicators

- Publication of results of relevant R&D trials in appropriate scientific journals and/or technical report series
- Rate of adoption by key irrigated industry sectors of recommended IAAS species and/or systems
- Proportion of irrigation industry sectors with tangible IAAS linkages and/or in principle commitment
- Ratio of farm income for established irrigation sectors derived from IAAS compared with conventional irrigation farm operations
- Nett water consumption and gross margin on water costs for IAAS farm operations compared with conventional farm operations

Task 5

Education, Training & Extension

- a. Education & training*
- b. Extension services*
- c. Technical services*

Objective

To facilitate access to education, training, extension and associated technical services.

Background

With any new technology-based, agri-business initiative it is necessary to draw on an appropriate skills base and to provide targeted training and education programs supported by effective, efficient and dedicated extension and associated technical support services.

Strategy

- Establish regionally-based demonstration sites
- Coordinate existing state-based agriculture and aquaculture extension programs
- Coordinate national dissemination of R&D outcomes to all stakeholders through formal extension network
- Collate relevant information and outputs from other R&D tasks (1-4) and disseminate through extension network
- Establish IAAS website and/or discussion list on internet and national newsletter
- Identify relevant training, education and associated technical service providers on a state by regional/state/national basis and summarise such information for distribution

Targets

- Complete summaries of all relevant information in electronic and hard copy to all stakeholders by 2004
- At least one successful IAAS demonstration site in each of key regional agricultural centres around Australia by 2001
- Establishment of a formal national network of extension, training and education service providers by 2004

Performance Indicators

- Proportion of farmers practising IAAS operations with formal training and education skills relevant to needs

- Enrolment in IAAS related courses at regional training and education institutions
- Proportion of such institutions offering IAAS relevant courses
- Diversity and level of demand on state-based extension services relevant to IAAS
- Improvement in indices of overall effectiveness and efficiency of IAAS operators

7. R&D Plan Implementation

Annual operating plans and allocation of funds by RIRDC for Integrated Agri-Aquaculture System (IAAS) R&D priorities will be based on this national R&D Plan for the period 1999/2000-2003/2004. Together with RIRDC, the FRDC is also recognised as a significant stakeholder in the development of an IAAS industry sector in Australia. Accordingly, to effectively and efficiently achieve common goals and outcomes, it is intended that this Plan provide a means by which the two agencies may establish a strategic alliance to jointly facilitate the funding and implementation of agreed IAAS R&D priorities. Overall direction of IAAS R&D Plan implementation will be facilitated by a national, expertise-based steering committee comprising the following disciplines/sectors:

- Marketing and economics
- Aquaculture, including at both the applied and policy levels
- Agriculture, including at both the applied and policy levels
- Research & Development, including funding agencies and service providers
- Environment
- Water resources
- Land/catchment management

Federal and State Government direction to the plan will also be facilitated by appropriate input from Aquaculture Committee of Standing Committee on Fisheries and Aquaculture.

8. Benefit and Investment

A cost/benefit analysis of the IAAS R&D Program will direct RIRDC and associated funding bodies on the level of investment on behalf of the Federal Government. The analysis used will be one which is accepted by other R&D funding organisations and in use for other RIRDC Programs.

9. Further Reading

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- Willmann, R., Halwart, M. and Barg, U. (1998)** Integrating fisheries and agriculture to enhance fish production and food security. *FAO Aquaculture Newsletter, December 1998 – No. 20*: 3-8.

10. Appendices

10.1 Delegates, both present and invited, to the *Farmer-Operated Integrated Aquaculture, National R&D Planning Strategy Workshop*, conducted by the Rural Industries Research and Development Corporation and held at Trawool, Victoria, from 15-16 September, 1998.

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10.2 Abstract of Keynote Address by Professor Sam Appelbaum at the FOIA R&D Workshop:

Multiple use of geothermal, brackish water in the southern part of Israel

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ABSTRACT

Two thirds of Israel is covered by desert, which is inhabited by only 2-3% of the population. Beneath this desert are large aquifers containing huge quantities of fossil, geothermal saline water. For the last 30 years this brackish water has been successfully used for irrigation of agricultural crops (e.g., tomatoes, melons, wheat, cotton, olives, etc.). In the past ten years, investigations have shown the significant potential of the geothermal, brackish water for the successful culture of aquatic organisms (fish, crustaceans, algae, etc.). In order to improve the economic viability of both sectors - aquaculture and agriculture - it is obvious that a chain of users of the desert water is needed.

Ramat Negev Highlands is a district in the Israeli desert with a community of 4000 inhabitants and a current use of 4.5 million m³ brackish water per annum. Seven drillings, to a depth of between 550-1000m, supply the brackish water at a salinity of between 2680-4360 TDS, at temperatures of between 39-41° for aquaculture/agriculture.

A practicable, efficient chain of users is illustrated below:

Several wells, possibly linked, continuously supply brackish water to both first users - greenhouses (for heating) and thermal baths (medicinal or recreational). Water from the first two users runs to an environmentally controlled fish polyculture system.

Water, rich with suspended organic material, leaves the fish culture system and enters a reservoir which stores the water to meet the demand of the next user - irrigation of agricultural crops, which supply, among other items, fodder for dairy cows, sheep, ostriches etc.

Furthermore, a proportion of the original saline water can be cost-effectively desalinated and used as freshwater for human consumption. Our efforts are being directed towards optimization of such models, for maximizing economic viability.

10.3 IAAS Farmer Opportunities

As a general rule, preliminary IAAS farmer opportunities as identified by FOIA R&D Workshop delegates are seen to potentially include (but not exclusively) access to and/or use of the following resources/systems:

- Existing and/or purpose built ponds (eg. farm storages, rice ponds etc), tanks (flow-through and/or recirculating systems), and cages/pens (in both public and private waters)
- Surface and ground waters, both ambient and geothermal, fresh and saline
- Public water storages, including both on and off river impoundments
- Public and private irrigation channels/canals using purpose built cages and/or pens
- Natural lakes and wetlands, both fresh and saline
- Saline evaporation basins and storages

10.4 Preliminary list of potential IAAS species

A preliminary list of species with potential for IAAS development within Australia, as determined by FOIA R&D Workshop delegates, includes:

- Rainbow trout, *Oncorhynchus mykiss*
- Atlantic salmon, *Salmo salar*
- Yabbies, *Cherax destructor*
- Redclaw, *Cherax quadricarinatus*
- Silver perch, *Bidyanus bidyanus*
- Murray cod, *Maccullochella peelii peelii*
- Golden perch, *Macquaria ambigua*
- Sleepy cod, *Oxyeleotris lineolatus*
- Barramundi, *Lates calcarifer*
- Snapper, *Pagrus auratus*
- Mulloway, *Argyrosomus hololepidotus*
- Black bream, *Acanthopagrus butcheri*
- Eels, various spp.
- Prawns, various spp.
- Sea weed, various spp.