Chapter 8

The Role of Information and Communications Technology in Research Capacity Building

Jane Grimson Professor of Health Informatics, School of Computer Science and Statistics, TCD, Ireland (Corresponding Author).
Email: jane.grimson@tcd.ie

Niamh Brennan Research Information Systems & Services, TCD, Ireland

Catherine Bruen Manager, National Digital Learning Repository, Ireland

Daniel Lete Murugarren Senior Network Engineer, HEAnet, Ireland

Margaret Ngwira Head, Secretariat at UbuntuNet Alliance for Research and Education Networking, Malawi

Vinny Wade Director of Intelligent Systems, School of Computer Science and Statistics, TCD, Ireland

Kondwani Wella Kamuzu College of Nursing, University of Malawi

Introduction
Reliable, accessible, high speed Internet and network connectivity is a fundamental requirement for the conduct of high-quality, high-impact research today. High speed communications are part of the basic infrastructure of a modern university, supporting efficient administration, ensuring a global presence on the web and helping with managing student information systems.

The focus of this chapter is on those elements of the Information and Communications Technology (ICT) infrastructure which are directly relevant to RCB; specifically National Research and Education Networks, Research Support Systems and Digital Repositories, and finally e-Learning technologies that support research-led teaching. A key theme running through this chapter is that of collaboration and the need for a cooperative approach both within and among institutions in order to deliver a robust and cost-effective ICT infrastructure.

National Research and Education Networks
A National Research and Education Network (NREN) is a network for a closed user group which has advanced connectivity requirements to support research and education needs. It provides the infrastructure for data communications and data services for the group. Commonly NRENs rent telecommunications lines from commercial providers, while owning the equipment required to route traffic through them. Traditionally, an NREN provides services to students, academic staff, researchers, administrative and support staff in the HE sector. A common feature of NRENs is that they are endorsed by national government and act as a single entity in their country. Typically, the government

department with responsibility for the NREN is the Ministry of Education or the Ministry of Communications.

NRENs play an important part in supporting research. Each is an independent organisation since its role is linked, not only to research, but also to education generally within a country. An NREN is an ICT / telecommunications network operated by and on behalf of the HE community in a single country. Examples of NRENs include HEAnet in Ireland <www.heanet.ie>, MAREN in Malawi <www.malico.mw/maren>, MoRENet in Mozambique <www.morenet. mct.gov.mz>, TERNET in Tanzania <www. ternet.or.tz/> and RENU in Uganda <www. renu.ac.ug>. The area of operation of an NREN does not extend beyond the country in which it has been established. In order to participate in and link to the global HE community, an NREN provides connectivity to a wider, usually continent-wide, Regional Research Education Network (RREN), such as, for example UbuntuNet in Africa <www. ubuntunet.net> or DANTE in Europe <www. dante.net>. A number of RRENs and NRENs, while formally established, are still at the early stages of construction and roll-out, particularly in Africa.

Why establish an NREN instead of simply using the services provided by a commercial Internet Service Provider (ISP)? The answer lies in the nature of the requirements of the HE sector which generally cannot be met by the commercial ISP market. Specifically, the discovery nature of education and

research requires more open access than that offered by commercial data services or corporate networks. Additionally, the amounts of data to be transported by the network and the performance of the network are significantly higher than for other user groups. Indeed new more collaborative forms of education and research are placing even greater demands on network connectivity both nationally and internationally. Research partners are just as likely to be on the other side of the world as in the university down the road. Video conferencing, for example, is now routinely used across the HE sector for everything from recruitment interviews to research collaboration. Furthermore, researchers may themselves be engaged in telecommunications research involving the development of new data protocols and services which a commercial ISP would be reluctant to service. These are some of the reasons for needing a dedicated / closed network to meet the needs of HE.

The first challenge in seeking to establish an NREN within a country is that of creating an initial association of HEIs to drive the establishment of an NREN forward. Generally this initial core group does not involve all HEIs within the country. Even if all HEIs are involved from the start then the principles of inclusivity and neutrality which underpin the NREN approach means that they must allow for the inclusion of new HEIs in the future. The association must also ensure that all members are treated equally and have equal representation in the governance structure. It is important to be clear at the

outset what the entry criteria should be, and usually this is defined by the funding model. For example, the typical European NREN community provides services to publicly funded institutions only, specifically excluding private institutions, and so, only publicly funded institutions are eligible for membership of the NREN. In general, European NRENs are exclusively and directly funded by national governments and they are explicitly precluded from receiving private funding. By contrast, the approach taken in the USA is more open and funding may come from different sectors; hence the criteria for access are more flexible. Both approaches have their advantages and disadvantages but it is essential to be clear from the outset and to incorporate these rules into the statutes of the newly formed NREN.

The operation and development of an NREN requires specialised personnel. It would be impractical and too expensive for each participating institution to have experts in all new or niche technologies. The NREN structure allows such highly skilled personnel to be based in the NREN organisation, acting as a shared resource so that the whole community shares the cost and can benefit from the expertise. This therefore leads naturally to the requirement for independence of the NREN from the institutions it serves in order to ensure the sustainability of the organisation. Given the variety of institutions in the HE sector in a country, conflicting demands and priorities are inevitable and hence the policies of the NREN must support all members equally and

avoid favouring those that are, for example, larger, better resourced, or more research-oriented.

The financial sustainability of the NREN is clearly of critical importance. Under the European model, funding comes from national governments and the HEIs. Governments are generally willing to provide capital as opposed to recurrent funding. However, ICT equipment has a limited lifespan and therefore each renewal cycle, typically 3-5 years, requires a significant capital investment. This needs to be built into the funding model from the start. The typical NREN rents bandwidth from the commercial sector and these rental costs also represent a recurrent charge. However, by joining together in an NREN, collectively the HEIs have much greater bargaining power in the market place than institutions acting alone. Furthermore, the longer the rental term procured, the more advantageous the price. Generally speaking, capital investments are provided by the Government, while recurrent costs are covered by member institutions. Hence long term commitment to funding both from government and from participating institutions ensures the sustainability of the NREN.

In addition to providing a physical infrastructure, the NREN can also have the role of representing the HE community both nationally and internationally. This representation can be to the Government as a means of articulating the needs of the HE community as a whole in a consistent

and coherent way, or as an advisory body to the Government on technical ICT issues related to education more generally. Equally, the NREN can act as a single point of contact with commercial providers of ICT goods and services. This allows the NREN to negotiate prices and conditions that a single institution could not do on its own. However, the position of an NREN with respect to commercial providers can be a difficult one, especially if it does not adhere to the closed user group model. Regardless of whether the telecommunications market is a monopoly or open and deregulated, the NREN can be perceived as a threat by the commercial ISP sector. This is a recurrent concern for the NREN community and should be managed through adherence to transparent procurement procedures and strict confinement of the use of the network to the closed group.

In the IAP programme, a key organisation is the UbuntuNet Alliance for Research and Education Networking, a pan-African RREN, with members currently in 12 African countries, including all the IAP partner countries. Ubuntunet is charged with providing high-speed connectivity to the African community. It aims to provide an African network to which the African NRENs connect. UbuntuNet member NRENs are currently renumbering, identifying African IP addresses so that they can have a discrete and identifiable set of traffic. This is routed through the UbuntuNet London router and on to the global RREN community.

It is only within the last two years that it is possible for this vision to become a reality due to developments in the telecommunications market in Africa, where before there was previously almost no option but to use satellite communications. Currently there are three submarine cables along the east coast of Africa linked to Europe, namely SEACOM, TEAMS and very recently, EASSy. This connectivity provides new options in the form of high-speed communications, as well as competition among service providers. At the national level, NRENs in the IAP are building dedicated telecommunications networks. FEAST, the EU funded feasibility study <www.feast-project.org> has shown that there is enough infrastructure and ready research and education communities to start the first phase of AfricaConnect, the continuation of the FEAST Project. This aims to deploy a network of sufficient capacity and affordability so that the Sub-Saharan countries have a digital connection for their students and researchers of the quality required to make them part of the global RREN community. A pan-African network would interconnect the African NRENs to Géant, the European fibre cable and to the global research and education network. This would increase collaboration and research output, as well as transforming curriculum and teaching methodologies to move more to learner centred and e-Learning methods.

The role of library and information services in supporting research

Supporting research is one of the core functions of library and information services

in education (Webb *et al.*, 2007). In recent years, libraries across the world have moved increasingly to the provision of electronic information, driven particularly by a surge in the number of academic journals available online. As a result of this, a number of access programmes have been established, such as INASP's PERii scheme <www.inasp.info>, eIFL <www.eifl.net> and domain-specific schemes such as HINARI <www.who.int/hinari> in health, AGORA <www.aginternetwork.org> in agriculture and OARE <www.oaresciences.org> in environment. These initiatives have enabled the negotiation of substantial discounts with publishers for HEIs in developing countries, sometimes as much as 98%, enabling African libraries to access more resources with limited budgets. In Malawi, for example, the establishment of the Malawi Library and Information Consortium (MALICO), has strengthened libraries and given them negotiating power. Contrary perhaps to common perception and thanks to the initiatives referred to above, many African universities do in fact have access to as broad a range of scientific journals as most western universities (Salanje and Ngwira, 2004). For this reason research activities and outputs have increased in quantity and quality in most Sub-Saharan African universities (Adams *et al.*, 2010), leading to increased demands for library and information resources (Musoke, 2008).

However, Harle (2010) has reported that African researchers, students and lecturers believe that their library did not subscribe to the journals they needed. Current evidence shows that this is not the case in Malawi, for example. So why are researchers not aware of what is available? Librarians frequently cite the lack of computers as an impediment to the availability of electronic journals to researchers. While this is true, the reality is that more and more students and lecturers own personal computers. This presents an opportunity for libraries to improve accessibility to electronic resources. 'Certainly, today's library will not serve the next generation client. As the continent is closing in on fast and affordable connectivity, librarians should drive ICT investment in their institutions. It is important to understand user needs other than speculating and using our prejudices. We too quickly say that the problem is lack of computers in our libraries. However, the ACU / Arcadia has shown that the problem is providing access to the electronic journals we subscribe to. Having computers in the library is one thing and providing wireless internet might be a worthwhile solution as the study recorded significant numbers of personal laptops' (Harle and Wella, 2010: 5).

Information management
Using the Internet, anyone can be an author and anyone can 'manage' information. There are many instances of researchers attempting to manage information themselves with or without the assistance of ICT personnel. It is increasingly common practice for authors to upload research onto personal or departmental web pages. While this provides a method for storing information, it does not make it readily

accessible. Information management is a specialised field with standard procedures and tools. It seeks to make the information easily accessible and searchable, as well as storing it for the future. The following cases from Malawi are examples of valuable information which has been generated in Malawi but which is managed in less than optimal ways, making it difficult or impossible to access.

Case 1: Accessibility of published journal articles
Research such as that shown in Figure 8.1 below, conducted at Bunda College of Agriculture in UNIMA, is of high value for national development. One would expect that this article published by college staff in *Aquaculture Research*, would be more easily accessible in Malawi than in any other country. Surprisingly, the modes of access to such articles are no different to those for other nationalities, with an average fee of US $52 per article. This is out of reach for many Malawians.

Figure 8.1: Journal article by Malawian researchers

Case 2: Theses and dissertations
The College of Medicine in UNIMA has established an international medical college. The College has the largest number of grants and research outputs in the university. Studies conducted at the College have informed health policy and practice nationally. However, the College lags behind in terms of the management of its research publications. Its webpage has links to theses and dissertations from the Master of Public Health programme. These important research outputs which contain evidence to inform public health policy are not readily searchable or accessible.

Case 3: Book chapters
A book entitled *Poverty in Africa* has been produced by two Malawian authors, one of whom works for The National Herbarium and Botanic Gardens of Malawi. While the entire book is of relevance to Malawians, a particular chapter 'Poverty and Maternal Health in Malawi' is of central importance, discussing maternal mortality, an issue which has haunted the country for a long time. It should be required reading for all researchers and policy-makers in the field. Yet with an average price for the book of £90 it is out of reach for most Malawians.

Some lessons can be learned from these cases. Case 1 and Case 2 are examples of information resources that are not fully accessible. The papers are available either from a publisher's website (Case 1) or they are deposited on a server with a link on a website (Case 2). Retrieval of these articles is serendipitous. Researchers need to realise that web design is not the same

as information management. There is a false perception that simply because the information is in electronic format on the web it is available worldwide, ignoring the tools developed by librarians over many years to describe documents and aid retrieval. Webb *et al.* (2007) contend that management of digital objects and long-term preservation of research may not occur if research output is posted on personal or departmental websites. All of this points to the urgent need for collaboration among researchers, librarians and ICT personnel to manage research publications and electronic resources.

Case 3 demonstrates a scenario where a Malawian student or researcher has to buy a book in order to access a chapter that is relevant to Malawi. The cost of the book is out of reach for many Malawians. Besides, since the book is published outside Malawi, other charges may apply. Globally, libraries are using open access institutional repositories to collect and provide access to local content. Many research publications in UNIMA are not accessible to students and other researchers. Important research outputs are locked away in offices or are poorly managed and hence inaccessible. This can lead to unnecessary duplication of research, limited local content in training programs at all levels of education and limited impact of research on public policy (Britz *et al.*, 2006).

Information management skills cannot be replaced by ICT skills. Rather, they complement each other. Librarians use metadata to describe documents. They also store the documents in repositories that have advanced and specialised tools designed to aid retrieval with precision. 'Librarians have embraced the new developments / advances in ICT and many have been trained and re-trained to be able to update their knowledge and skills. This enables librarians to competently implement ICT projects and to instruct and guide users.' (Musoke, 2008: 5). Librarians need to understand and respond to changing user needs and to engage proactively with the research community. In this way they will make themselves more relevant to the research world of the 21st century.

Research Support Systems and Digital Repositories: Research Infrastructure, Open Access and the IAP Portal
Integrated research information systems and open access digital repositories are a key component within national and institutional research infrastructures and are good examples of the applications that can be built according to Pehrson's Axioms (Pehrson, 2010).
- HEIs and research institutions are key actors in the creation of the knowledge society
- they need a common dedicated network infrastructure; non-connected institutions cannot effectively fulfil their missions
- African universities need to be connected to global resources like their peers on other continents
- connections are achieved through NRENs and RRENs using leased lines

The IAP has constructed a Current Research Information System (CRIS) and an integrated open access research repository within its Web Portal <www.irishafricanpartnership.ie>. Along with discussion forums, this 'Research Register' and 'Digital Repository' allow the IAP to collect, organise and disseminate the work of individual researchers, the partner institutions and related agencies, for access, impact, accountability, value for money, new knowledge and innovation, partnership building and translational research / evidence-based policymaking.

According to Chan *et al.* (2010) 'most new knowledge is largely reported from the richer countries, where spending on research and development is highest.... researchers in 8 countries – led by the United States, the United Kingdom, Germany and Japan - produce almost 85% of the world's most cited publications....163 other countries, mostly developing nations, account for less than 2.5%.... and.... only 10% of the global health research is undertaken in the developing world.' As emphasised in preceding sections of this chapter, and elsewhere in this book, the voice of the African researcher is often not heard, either internationally or locally. In response, the South African Research Universities Association (SARUA) bases its science and technology development programme on four fundamental needs, as described on their website <www.sarua.org/?q=content/science-and-technology-expert-advisory-group> and Belgarrab (2007). These are to encourage new scientists, especially women; retain and support leading African scientists; improve the quality and quantity of science and scientific publications; and build a vibrant knowledge economy in the region.

Open Access as part of the solution

According to Suber (2010), Open Access is 'putting peer-reviewed scientific and scholarly literature on the internet, making it available free of charge and free of most copyright and licensing restrictions and removing the barriers to serious research'. Publication details (or metadata) are available to search engines like Google, Google Scholar and harvesters like RIAN <www.rian.ie> and OAlster, thereby maximising impact and global reach. This explains why the number of institutional repositories around the world is increasing but their distribution is uneven, as shown in Information Box 8.1.

Open Access institutional repositories are already established in all of IAP HEIs in Ireland. Many of the African HEIs in the IAP either already have repositories up and running or have plans to construct one. To support those partners currently without an institutional repository and to manage additional content from other sources, the IAP has constructed an open access Digital Repository linked to a Research Register which is available through the IAP website <www.irishafricanpartnership.ie> and its content is accessible via Google and other search engines (Refer to Information Box 8.2 for further information).

Information Box 8.1: Distribution of repositories worldwide. Source: www.opendoar.org. Accessed July 11th 2010

Continent	Number of Repositories	% Of the Total
Europe	824	49
North America	434	26
Asia	221	13
South America	85	5
Australasia	78	5
Africa	41	2
Caribbean	7	0
Central America	6	0
Total	**1696**	**100**

Research shows that by making publications freely available on the web, an author can gain 50% to 250% more citations (Opcit Project, 2010). The rapidly-growing practice of academic authors allowing free and unrestricted access via the web to their research publications, research data and teaching and learning resources can help to provide a solution to the issue of the 'invisibility' of African research. The IAP repository provides a vital communication tool for its partners and the broader development community in making relevant publications available in full text and without

Information Box 8.2: IAP Portal tools, services, resources and benefits

- Links Irish and African universities in virtual community
- Supports collaborative research with African universities
- Communications forum for members of the IAP
- Electronic consultation platform for the IAP
- Digital repository (Open Access)
- Research register (Publicly Accessible)
- Promotion of researchers' outputs
- A reciprocal facility for finding research partners
- Automated generation of electronic curricula vitae
- Personal URL links from your business card or website
- A means of creating and maintaining up-to-date publications lists
- Upload publications onto the IAP Portal and open access digital repository and thereby maximise audience and impact on the web.
- Compliance with funders' mandates for dissemination of research outputs

restrictions. It simultaneously supports RCB by maximising the exposure and impact of the research outputs of the IAP partnership. This is particularly important as most research evaluations use bibliometrics as one indicator of research excellence. Also important to funders and researchers is compliance with the Open Access mandates of funding councils, such as the Wellcome Trust, NIH, all UK research funding councils, almost all Irish research funding councils, the EC, European Research Council and others. All of these agencies require, as a condition of funding, open access to the publications arising from that funding within a specified period of time. A database of funder mandate policies is available at <www.sherpa.ac.uk/juliet/>. There are currently some 24,000 peer reviewed research journals, so there is an issue of getting access to research, especially if resources are only available through expensive subscriptions. Surveys show that 92% of journals permit lodging of some version of a paper in an open access repository <www.sherpa.ac.uk/romeo>. Some allow deposit of the publisher's PDF, and most allow open access to the author's post-peer review version of a paper ('post-print').

There are many misconceptions about Open Access. Some researchers erroneously believe that open access runs counter to peer review standards or that it may breach copyright or put publishers out of business or cause libraries to cancel subscriptions. Open Access supports peer review and favours the

increased impact of peer reviewed papers; it operates in accordance with publishers' copyright policies; papers in open access repositories link directly to the publisher's 'official' version and provide citations to that version. Open Access provides ongoing public access to publicly-funded research outputs, supports interdisciplinary scholarship and evidence-based policy-making. Additional information is available at MIT Libraries' 'Dispelling Myths About Open Access' <www.info-libraries.mit.edu/scholarly/open-access-initiatives/ faq/dispelling-myths-about-open-access-2/> and in Jessani and Reid (2008). Details on how to use the IAP register and repository can be found in Information Box 8.3 at the end of this chapter.

Enhancing teaching and research through e-Learning

e-Learning or technology-enhanced learning is the development and effective use of digital technologies to support learning, teaching and research. Learning technologies can consist of multimedia / animations, virtual worlds, video, podcasts, games, simulations, mobile learning, virtual learning environments (VLEs), content management systems (CMSs) and web 2.0 technologies. They range from supported learning such as making slides available on the web, through blended or hybrid learning to learning that occurs 100% online (Figure 8.2). Sound e-Learning is based on instructional design principles that take into account learning theories and the outcomes for the learner.

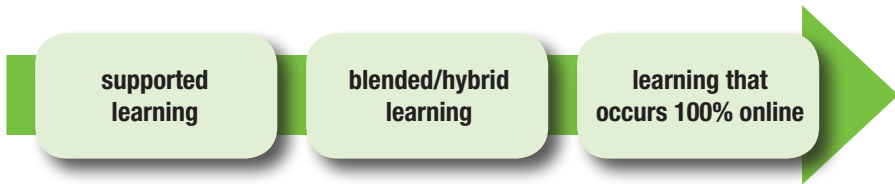| supported learning | blended/hybrid learning | learning that occurs 100% online |

Figure 8.2: The spectrum of e-Learning

Given its nature, online distance education is well-matched with e-Learning and flexible learning but is also used for in-class teaching and blended learning.

e-Learning is not a panacea for teaching and learning but can be harnessed in combination with pedagogical good practice to achieve effective student-centric learning (Reigeluth, 1999; Kizza, 2008). However, e-Learning and digital technologies are having a significant impact on the way teaching and research is done. There is evidence to show that students value being in a research-rich environment. Today's graduates must be able to analyse and contribute to research. Understanding how knowledge is created and developed is critical in today's knowledge society. For academic staff, forging productive links between teaching and research helps them to manage better what would otherwise be conflicting demands. In strong research departments, students appreciate the value of the research focus. For departments with limited access to research funds, developing the research-teaching nexus can help engender a research profile (ibid.). Internationally, there is a growing demand for third level education with dramatic

increases in participation rates from much more heterogeneous groups of students (COIMBRA, 2001). HEIs have moved their strategic direction towards more inclusive curricula that are relevant to national economic and social goals. An increasingly diverse student population results in different expectations, motivations, skills and learning models where students can take courses for credit from other institutions and providers. Against this background, there are two major forces at work. Firstly, there is a push towards de-institutionalisation and "market-led" education which is associated with increased autonomy for the student who can choose from a wide range of learning opportunities. This model is not really supported by the traditional HE sector. The second relates to innovation as a result of education, including for example, life-long learning and the switch from teacher-centric to learner-centric education with increased autonomy for learners.

Best practice dictates that there are three key areas which institutions seeking to build effective capacity in e-Learning must address. First is the e-Learning strategy which should be aligned with institutional strategies for teaching and learning (Carroll

et al., 2003). Given the need to create a strong synergy between teaching and research, it should also integrate with the research strategy (Somekh and Lewin, 2005). The e-Learning strategy should indicate which pedagogic approaches are favoured, for example, blended learning, self-learning resources, or self-assessment. Second is to develop the skills base amongst their staff. A small dedicated team of learning technology and pedagogic experts is required to work with and support academics in the development of learning resources and to ensure best practice. By keeping abreast of the latest developments, the team will also ensure that the institution is well placed to take advantage of the latest technologies / paradigms, for example leveraging social networking tools to enable learner collaboration. Third is the need to put in place the appropriate technical infrastructure of servers and networks and associated software (VLE, Learning Management System). There are excellent open source VLE solutions, such as Moodle, now available.

TCD, with almost 16,000 students, of whom approximately 4,000 are postgraduates, has adopted many of these technologies. Most students are full-time and small group teaching is a feature of undergraduate education in TCD. The Centre for Learning Technology (CLT) <www.tcd.ie/CAPSL/clt/index.php> was established in 1999 and offers a range of services and supports through a small team of educational technologists under the direction of the Centre for Academic Practice and Student Learning. CLT acts as a one-stop shop for staff wishing to enhance teaching and research through new media and technology. By funding a number of innovative projects on a competitive basis each year through the National Digital Learning Resources (NDLR) service, CLT built capacity across all departments and schools in the use of learning technology. It also acts as the TCD node in the NDLR network through which it promotes collaboration and partnership with other HEIs.

The NDLR service <www.ndlr.ie> is an Irish HE sector service funded by the Irish HEA to enable the sharing of digital learning content and associated teaching experience across all HEIs. The NDLR mission is "to promote and support HE sector staff in the collaboration, development and sharing of digital learning resources and associated teaching practices". Staff from different disciplines can share effort and expertise as they raise the bar collectively for how they support their students' learning. They can embed research into their teaching and potentially embrace partnership with research and industry, both in Ireland and internationally. The NDLR achieves these objectives by supporting staff in sharing digital learning resources / associated teaching practices through funded local and national projects. The outputs and activities of these projects feed back into the activities of the SMARTCoPs (SMART Communities

of Practice) (Maguire and McAvinia, 2009). Local and National learning resource development projects supported by the NDLR can be accessed from <www.ndlr.ie/resources/about.php>. NDLR's SMARTCoP homepages can be accessed from <www.ndlr.ie/communities.php>. Find and share NDLR teaching and learning resources via the NDLR repository, which can be accessed at <www.dspace.ndlr.ie/jspui/>.

Information Box 8.3: How to use the IAP Research Register & Digital Repository

Register with the system via <www.irishafricanpartnership.ie>. Complete the details, upload your photograph and agree to the terms presented on-screen. In order to access the Research Register, you will have to wait until you receive an email with your username and password. As soon as you receive these login details, complete your Research Profile via the Research Registry. Full details on how to work with the Research Registry and upload your publications to the Digital Repository are available from the website. If your institution has its own repository, insert a link to your publication in that repository on your Research Profile publication list.

Those members of the IAP who have agreed to act as a subject specialist or a thematic leader for the IAP are identified on the website. They will help to identify key people and content associated with the IAP thematic areas, and will welcome any additional information from users. Please include the appropriate IAP thematic areas on your Research Registry profile in the 'Research Interests' area and in the key words associated with your publications in your local or IAP repository.

72