

文章编号: 1001 - 4675(2009)03 - 0299 - 07

气候变化适应性研究综述 ——现状与趋向*

方一平¹, 秦大河², 丁永建²

(1. 中国科学院成都山地灾害与环境研究所, 四川 成都 610041;

2. 中国科学院寒区旱区环境与工程研究所, 甘肃 兰州 730000)

摘要: 在气候变化领域, 随着对气候变化本身不断的关注, 适应性研究不断涌现。因此, 理清气候变化适应性研究的脉络、把握国际适应性研究的发展趋势和动向, 对未来气候变化脆弱性的削减、针对性地提高人类适应和应对能力具有重要的意义。依据国际气候变化适应性研究的主要文献, 分析了气候变化适应性的概念及其应用, 适应性与适应能力、响应能力和恢复力之间的相互关系; 综述了气候变化适应性的情景模型测算、适应性选择、不同尺度适应能力、主动适应策略研究的 4 个集中领域; 总结了气候变化适应性社区尺度、自下而上手段、适应性过程研究的趋势。

关键词: 气候变化; 适应性; 发展态势

中图分类号: P467 **文献标识码:** A

以气候变暖为标志的全球气候变化已引起各国政府、国际组织和科学工作者的高度重视。政府间气候变化专门委员会 (IPCC) 的几次评估, 体现了关于气候变化对自然、管理和人类系统的影响、这些系统的适应能力及脆弱性方面的科学认识^[1-4]。评估表明, 气候变化对自然和人类环境所造成的影响清晰可辨^[1-4]。如何采取更广泛的适应措施降低对气候变化的负面影响, 成为人类社会持续性研究的重点和热点领域。

目前, 国内外学者正在不同领域、不同空间尺度上开展响应气候变化的适应性研究。因此, 理清气候变化适应性研究的脉络、把握国际适应性研究的发展趋势和动向, 对未来气候变化脆弱性的削减、针对性地提高人类适应和应对能力具有重要的意义。

1 适应性概念及其应用

适应性一词, 目前通常使用在气候领域, 起源于自然科学, 尤其是进化生态学。尽管适应性在自然科学中的定义有很多争议, 但泛指组织或系统为了生存、繁殖而增强应对环境变化的基因和行为特征^[5-7]。自然科学中适应性思考的尺度包含了从有机个体、到单个种群或整个生态系统^[8]。

适应性在人文系统的应用可追溯到人类学家、文化生态学家 Julian Steward, 他使用文化适应 (cultural adaptation) 描述核心文化 (cultural cores) 对自然环境的调整^[9]。Brien 等^[10]把适应性过程界定为组织、群体增进环境与文化磨合能力的方法, 认为适应性是在变化环境中通过文化实践而产生的行为选择结果。Denevan^[11]认为, 文化适应性是响应自然环境变化、人文内在环境变化 (如人口、经济和组织) 的过程, 因此, 大大拓宽了人文系统适应生物、物理环境压力的范畴。按照达尔文生物适应性的观点, 一个组织如果没有足够应对环境压力的办法, 对稀缺资源的获取就没有竞争力, 因而也难以持续生存。按照文化适应性的论述, 只有不断产生克服压力的能力, 文化实践才是真正意义的适应性, 不管是否属于进化产生的选择结果, 适应特点都允许社会在她们的环境中发挥应有的功能和作用, 因此, 自然科学中的基因特征与社会科学中的文化实践具有相似性^[10]。

生态系统和政治经济的关系往往也被认为是与政治、社会力量、资源使用、全球经济相关风险的适应性管理问题^[12-14]。政治生态领域适应性研究的

* 收稿日期: 2008 - 11 - 21

基金项目: 国家重点基础研究发展计划 (973 计划) 项目 (2007CB411507); 冰冻圈科学国家重点实验室开放基金项目 (SKLCS08 - 05)

作者简介: 方一平 (1965 -), 男, 浙江淳安人, 研究员, 博士生导师, 主要从事产业生态环境管理与区域可持续性研究。E - mail: ypfang@mde.ac.cn; ypfang2004@yahoo.ca

关键特点是在较大的尺度展开,个体、家庭的适应能力如何被社会、政治、经济过程所塑造和限制,并进行验证。相仿,全球环境、社会风险研究方面,在人文驱动力、生物物理限制、社会经济和政治风险的背景下,将调整 and 适应性研究放到了重要位置^[15-17]。

一些学者在研究物质、能量、信息流^[18]以及自然环境变化相关的恢复力、平衡和适应管理过程中也利用适应性这一概念^[19]。此外,尤其是在自然灾害方面,已经对适应性调整和环境灾害管理方面予以了极大地关注^[20]。

在很多社会科学著作中,基本达成共识的是,社会适应外部环境变化的范畴包括但不限于环境压力。具有快速响应能力、容易磨合外部快速环境变化的文化(或社会),被认为具有较高的适应能力(adaptability)^[11]。

在气候变化领域,随着对气候变化本身不断的关注,适应性研究不断涌现。早期的案例是Butzer^[21]依据可预测的气候变化和对世界食品供应的预期影响,考虑了文化适应(人类智慧,包括技术革新、长期规划),自此以来,为不同的目的,对气候变化进行适应性分析和研究逐步从广度和深度上得到拓展^[22-24]。

2 适应性和适应能力、响应能力、恢复力的相互关系

2.1 适应性(adaptation)与适应能力(adaptability)的关系

适应能力在生态学中意味着适应某种环境变化的能力,适应性是结构、功能和组织行为的特征^[25]。适应性是适应能力的反映,系统较好地处理暴露、敏感性的适应性反映了适应能力^[24]。按照不同的方式,可以划分许多适应性形式和层次。包括:按时机(预期的、现时的)、意图(自动的、规划的)、空间尺度(地方的、广域的)、形式(技术的、行为的、金融的、经济的、制度的、信息的)进行划分等^[23, 26-28],使原始系统按照调整程度来区分适应性成为可能^[29]。

适应能力涉及的类似概念包括应对能力(coping ability)、管理能力(management capacity)、稳定性(stability)、鲁棒性(robustness)、柔韧性(flexibility)等^[30-37]。适应能力的驱动要素、决定因子是影响系统适应性的关键^[15, 26, 38-41]。地方适应能力是

很多条件的综合反映^[42-43],通过诸如管理能力、经济金融条件、技术和信息资源、基础设施、制度环境等要素来体现^[12, 22, 44-51]。

Watts and Bohle等^[44]采用适应能力来表示短期的应对和长期的调整潜力。一般而言,通过改进环境条件,一个物种、种群或个体会更好地适应环境,由于人类系统具有认知能力和技术进步的支持,在人类领域甚至社会生态系统,适应的标准远远超出了生存和再生产能力,包括社会、经济活动的成果以及生活质量^[24]。人类系统的适应能力涵盖了在一定环境条件下,人类系统增加个体生活质量的能^[52],包括社会生态系统应对环境变化的能力以及促进与环境关系条件的能力^[30]。

在气候变化领域,适应性被定义为:自然、人文系统对现状、未来气候变化的响应和调整,包括预期的、自动的、瞬时的、规划的、公共的和私人的(IPCC, 2001)。不过, Kasperson等^[53]还把调整(adjustment)和适应性进行了区分,认为调整是系统对干扰或压力的响应,而没有根本改变系统本身,是短期的、相对较小的系统修正;适应性是系统对干扰或压力的响应,改变了系统本身,有时使系统状态发生了变化^[24]。

2.2 适应能力(adaptability)与响应能力(capacity of response)的关系

关于社会生态系统适应能力和响应能力的关系, IPCC同化了两者的概念,一般而言,适应能力内涵应该比响应能力要宽,不过,这些都取决于耦合社会生态系统研究对适应能力、响应能力的具体界定^[54]。Adger^[55], Smit^[24]和 IPCC^[3]等都将系统的应对能力^[56]或响应能力^[57]称为适应能力。而 Tumer等^[56]将响应能力与适应能力区别开来,认为两者都是系统恢复力的组成部分,把适应性作为系统响应后重建的表现。按照 Smit等^[24]的解释,一些学者应用“应对能力”表示短期能力或仅仅是生存能力,采用“适应能力”表示长期的、持续的调整能力^[54]。一般而言,响应能力是系统对干扰、缓解潜在破坏、利用机会、应对系统变化的调整能力,很明显,响应能力也是系统优先于干扰而存在的一种属性^[54]。

2.3 适应能力(adaptability)与恢复力(resilience)的关系

由于观点的多样性和差异性,适应能力与恢复力的关系也不明确^[54],按照 Smit等^[24]所提到的,一

些学者将适应能力和恢复力、社会恢复力等同起来; Gunderson^[58]把适应能力作为系统对恢复力变化的有效性; Carpenter等^[59]把适应能力作为恢复力的组成要素,反映系统行为对干扰的响应; Walker等^[60]把适应能力作为人类活动者管理恢复力的集合能力,包括缩小或排除并不期望的因素、创建新的期望因素、促进目前系统朝向期望的状态转化等。

恢复力的概念源于生态学,应用于社会系统和生态系统,如 Adger^[61]把社会恢复力作为由于社会、政治、环境变化,群体、社区适应外部压力和干扰的能力。围绕恢复力和适应环(adaptive cycle),有很多不同的认识,生态系统的喻意后来扩展到社会以及生态系统方面,涉及跨尺度的动态性、巢式适应环之间的叠加概念^[62-63]。Holling^[64]把恢复力定义为:系统维持的一种手段,是系统同化、减轻变化和干扰、维持种群和状态变化原来关系的能力。Walker等^[60]认为,恢复力是系统减轻干扰、重新组织,促使系统返回到原来同样功能、结构和反馈的能力。

从景观稳定性的角度,恢复能力概念通常叫作生态恢复力,原则上讲,生态恢复力可以通过干扰程度来进行测度。相反,关注系统行为在平衡点或平衡轨迹的稳定能力,可以通过受干扰系统返回到稳定点或轨迹的速度来度量,这是由 Pimm^[65]和 Holling^[66]界定的恢复力的重要内容,相当于数学中关于局部稳定能力(local stability)的概念^[67-69]。

有时候也把脆弱性作为恢复力的反面或反义词^[70]。不过,十分明显的是,具有恢复力的系统其脆弱性要低于不具有恢复能力系统的脆弱性,恢复力与脆弱性要素中的响应能力明显有关,因此,它比脆弱性的反面范围要小^[54]。最基本的差异是,恢复力应用于系统行为的维持,脆弱性的反面应该是抗干扰、维持系统结构的能力^[54]。因而至少对社会生态系统的社会要素而言,恢复力似乎是响应能力的真子集。响应能力不仅包括系统的恢复力,而且还包括系统的应对影响、利用机会的能力^[54]。

3 气候变化适应性研究的现状与方向

3.1 气候变化适应性研究的目的

在气候变化领域,适应性研究的共同目的是通过适应性调整,评估缓与和削减气候变化负面影响、认识正面作用、避免气候变化对人类和生态系统产

生风险的程度^[71-73]。分析气候变化适应性,就是判断适应性对系统产生的可能效果,估计气候变化影响、筛选有效的适应性策略和途径^[24]。在联合国气候变化框架公约(United Nations Framework Convention on Climate Change, UNFCCC)第二条(Article 2)中^[74],强调了适应性,公约要求各个国家承诺削减温室气体排放,以便避免或抑制气候变化对人类产生危险的变化趋势,这些分析主要是从较大的尺度展开的,在适应和没有适应的条件下,用数学统计模型分别估计气候变化的影响程度,目的是要强调未来气候变化情景存在怎样的风险问题^[75-78]。

3.2 气候变化适应性研究的集中领域

从目前国际研究的主流文献看,气候变化适应性研究主要集中在以下4个方面^[24]:

(1) 研究主要采用适应性假设,按照气候变化情景模型测算的影响条件或参数变化,估计、预判不同适应性手段对气候变化趋势的不同效果^[79-80],这类研究没有对适应性进行实际调查、没有验证适应性或适应能力的实际过程、没有适应性决策的具体过程、也没有对气候变化的适应性机制进行探讨^[24]。

(2) 研究主要集中在气候变化条件下特殊系统的适应性选择和策略方面,在 UNFCCC 条款中(4.1)^[74],强调各个国家要承诺应用适当的气候变化适应性,构架和实施有效的应对策略,其目的是要评估替代适应性的优点和效用,确认最好的、较好的策略^[81-84],包括可能适应性的选择、通过研究者的观测、模拟、推断、分析筛选关键信息和因果关系,一些共同的分析工具包括成本效益、成本有效性、多标准过程等方法,对可能适应性的相对优点进行分类分级,其中常用的变量有:效益(benefits)、成本(costs)、可实施性(implementability)、有效性(effectiveness)、效率(efficiency)和平等(equity)^[83, 85-87]。

(3) 研究主要集中于国家、区域、社区相对适应能力,选择一定的标准、指标、变量进行比较评估和分级^[22, 24, 88-92]。该类研究依据一定的因果关系和决定性因素进行测度,通过一些指标、分值、分级过程,评估一个国家、一个区域、一个社区的相对适应能力,将每一系统的适应能力要素进行累积加总,形成系统的总体评价分值^[24, 55]。

(4) 主要针对主动适应实践策略开展的相关研究,就目前而言,适应性实践过程的研究还不普遍,至少在适应性标签或框架之下直接进行的针对性研

究还不多,尤其是在区域层次和社区层次更为薄弱,尽管如此,不过在资源管理、社区发展、风险管理、区域规划、食品安全、生计安全、持续发展领域的许多学者均涉及适应性实践和过程的研究^[24, 93-96]。

3.3 气候变化适应性研究的主要方向

在气候变化适应性领域,主动利用适应性策略和自下而上的途径是该类研究工作的重要特点和重要方向,努力从社区实践中确认关键性的适应要素,关注社区的重要条件,采取实践经验、社区利益相关者的知识来刻画与适应能力相关的条件、战略、决策过程和气候变化适应之间的综合联系,采取自下而上的途径,而不是基于气候变化情景分析的自上而下的途径,提升社区层次的适应性^[24, 97-99]。

适应性过程是应用研究的主流,在实践水平上,适应性过程的焦点是在决策过程中强调了与气候变化相关的风险,仅仅依据气候变化,采取任何类型的适应行动都极端不可能,单一的手段和知识领域难以达到预期适应的效果,这是气候变化适应研究的最大发现^[24, 28, 47, 99-100]。需要多维知识和学科领域的联合,有大量的气候变化风险案例,都紧密结合了现有政策、规划以及与资源管理、社区发展、增进生计能力、持续发展和风险管理相关的决策过程,实践性的气候变化适应措施也不可避免地要与其他规划相结合,强化适应能力^[24]。

参考文献 (References):

- [1] IPCC. Climate Change: The IPCC Scientific Assessment [M]. Cambridge: Cambridge University Press, 1990: 89 - 91.
- [2] IPCC. The Regional Impacts of Climate Change: An Assessment of Vulnerability [M]. Cambridge: Cambridge University Press, 1996: 20 - 100.
- [3] IPCC. Climate Change: Impacts, Adaptation & Vulnerability [M]. Cambridge: Cambridge University Press, 2001: 3 - 26.
- [4] Working Group. Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report Climate Change 2007: Impacts, Adaptation and Vulnerability [2007 - 04 - 23]. <http://www.ipcc.ch/SPM/Bapt07.pdf>
- [5] Futuyama D. J. Evolutionary Biology: 3rd Edition [M]. Sunderland: Sinauer Associates, 1998: 400 - 516.
- [6] Winterhalder G. Environmental analysis in human evolution and adaptation research [J]. Human Ecology, 1980, 8: 135 - 170.
- [7] Kitano H. H. Systems biology: a brief overview [J]. Science, 2002, 295: 1 662 - 1 664.
- [8] Krimbas C. B. On fitness [J]. Biology and Philosophy, 2004, 19 (2): 185 - 203.
- [9] Butzer K. W. Cultural ecology [C]//Gaile G. L., Willmott C. J. Geography in America. Columbus: Merrill Publishing Co., 1989.
- [10] O'Brien M., Holland T. D. The role of adaptation in archeological explanation [J]. American Antiquity, 1992, 57: 36 - 69.
- [11] Denevan W. M. Adaptation, variation and cultural geography [J]. Professional Geographer, 1983, 35 (4): 399 - 406.
- [12] Blaikie P. M., Brookfield H. C. Land Degradation and Society [M]. London: Methuen, 1987.
- [13] Sen A. Poverty and Famines: An Essay on Entitlement and Deprivation [M]. Oxford: Clarendon Press, 1981.
- [14] Walker P. A. Political ecology: where is the ecology? [J]. Progress in Human Geography, 2005, 29: 73 - 82.
- [15] Kaspersen J. X., Kaspersen R. E. Climate Change, Vulnerability and Social Justice [M]. Stockholm: Stockholm Environment Institute, 2001.
- [16] Kaspersen J. X., Kaspersen R. E. The Social Contours of Risk (vol 1) [M]. London: Earthscan, 2005.
- [17] Pidgeon N., Kaspersen R. E., Slovic P. The Social Amplification of Risk [M]. Cambridge: Cambridge University Press, 2003.
- [18] Odum H. T. Environment, Power and Society [M]. New York: Wiley, 1970.
- [19] Holling C. S. Resilience of ecosystems: local surprise and global change [C]//Clark W. C., Munn R. E. Sustainable Development and the Biosphere. Cambridge: Cambridge University Press, 1986.
- [20] Burton I., Kates R. W., White G. F. The Environment as Hazard [M]. New York: Oxford University Press, 1978.
- [21] Butzer K. W. Adaptation to global environmental change [J]. Professional Geographer, 1980, 32: 269 - 278.
- [22] Kelly P. M., Adger W. N. Theory and practice in assessing vulnerability to climate change and facilitating adaptation [J]. Climate Change, 2000, 47: 325 - 352.
- [23] Smit B., Burton I., Klein R., et al. An anatomy of adaptation to climate change and variability [J]. Climatic Change, 2000, 45: 223 - 251.
- [24] Smit B., Wandel J. Adaptation, adaptive capacity and vulnerability [J]. Global Environmental Change, 2006, 16 (3): 282 - 292.
- [25] Dobzhansky T. Adaptness and fitness [C]//Lewontin R. C. Population Biology and Evolution. New York: Syracuse Univ Press, Syracuse, 1968: 109 - 121.
- [26] Wilbanks T., Kates R. W. Global change in local places: how scale matters [J]. Climatic Change, 1999, 43: 601 - 628.
- [27] Smit B., Skinner M. Adaptation options in agriculture to climate change: A typology [J]. Mitigation and Adaptation Strategies for Global Change, 2002, 7: 85 - 114.
- [28] Huq S., Rahman A., Konate M., et al. Mainstreaming Adaptation to Climate Change in Least Developed Countries (LDCS) [M]. London: International Institute for Environment and Development, 2003.
- [29] Risbey J., Kandlikar M., Dowlatabadi H., et al. Scale, context and decision making in agricultural adaptation to climate variability and change [J]. Mitigation and Adaptation Strategies for Global Change, 1999, 4: 137 - 164.
- [30] Smithers J., Smit B. Human adaptation to climatic variability and change [J]. Global Environmental Change, 1997, 7: 129 - 146.

- [31] Adger W N, Kelly P M. Social vulnerability to climate change and the architecture of entitlements [J] *Mitigation and Adaptation Strategies for Global Change*, 1999, 4: 253 - 266.
- [32] Smit B, Burton I, Klein R J T, et al. The science of adaptation: a framework for assessment [J] *Mitigation and Adaptation Strategies for Global Change*, 1999, 4: 199 - 213.
- [33] Jones R. An environmental risk assessment/management framework for climate change impact assessments [J] *Natural Hazards*, 2001, 23: 197 - 230.
- [34] Fraser E, Mabee W, Slaymaker O. Mutual vulnerability, mutual dependence: the reflective notion between human society and the environment [J] *Global Environmental Change*, 2003, 13: 137 - 144.
- [35] Tompkins E I, Adger W N. Does adaptive management of natural resources enhance resilience to climate change? *Ecology and Society*, 2004, 9 (10) (online) <http://www.ecologyandsociety.org/vol9/iss2/art10>.
- [36] Brooks N. Vulnerability, Risk and Adaptation: A Conceptual Framework [C]//Working Paper 38, Tyndall Centre for Climate Change Research Norwich: University of East Anglia, 2003.
- [37] Flüsel H M, Klein R J T. Climate change vulnerability assessments: an evolution of conceptual thinking [J] *Climatic Change*, 2006, 75: 301 - 329.
- [38] Adger W N. Social aspects of adaptive capacity [C]//Smith J B, Klein R J T, Huq S. *Climate Change, Adaptive Capacity and Development* London: Imperial College Press, 2003.
- [39] Turton A R. Water scarcity and social adaptive capacity: towards an understanding of the social dynamics of water demand management in developing countries [C]//MEWREW Occasional Paper No. 9. London: University of London School of African Studies, 1999.
- [40] Walker B, Carpenter S R, Anderies J, et al. Resilience management in social-ecological systems: a working hypothesis for a participatory approach. *Conservation Ecology*, 2002, 6 (online) <http://www.ecologyandsociety.org/vol6/iss1/art14/print.pdf>
- [41] Blaikie P, Cannon T, Davis I, et al. *At Risk: Natural Hazards, People's Vulnerability, and Disaster* [M] London: Routledge, 1994.
- [42] Smit B, Pilifosova O. From adaptation to adaptive capacity and vulnerability reduction [C]//Smith J B, Klein R J T, Huq S. *Climate Change, Adaptive Capacity and Development* London: Imperial College Press, 2003.
- [43] Yohe G, Strzpek K, Pau T, et al. Assessing vulnerability in the context of changing socioeconomic conditions: a study of Egypt [C]//Smith J B, Klein R J T, Huq S. *Climate Change, Adaptive Capacity and Development* London: Imperial College Press, 2003.
- [44] Watts M J, Bohle H G. The space of vulnerability: the causal structure of hunger and famine [J] *Progress in Human Geography*, 1993, 17: 43 - 67.
- [45] Handy A, Abu-Zeid M, Lacirignola C. Institutional capacity building for water sector development [J] *Water International*, 1998, 23: 126 - 133.
- [46] Adger W N. Social vulnerability to climate change and extremes in coastal Vietnam [J] *World Development*, 1999, 27: 249 - 269.
- [47] Handmer J W, Dovers W, Downing T E. Societal vulnerability to climate change and variability [J] *Mitigation and Adaptation Strategies for Global Change*, 1999, 4: 267 - 281.
- [48] Toth F L. *Fair Weather? Equity Concerns in Climate Change* [M] London: Earthscan, 1999.
- [49] Smit B, Pilifosova O. Adaptation to climate change in the context of sustainable development and equity [C]//Chapter 18 in *Climate Change 2001: Impacts, Adaptation, and Vulnerability-Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change* Cambridge: Cambridge University Press, 2001.
- [50] Wisner B, Blaikie P, Cannon T, et al. *At Risk* [M] London: Routledge, 2004.
- [51] Adger W N, Kelly P M, Ninh N H. *Living with Environmental Change: Social Resilience* [C]//Adaptation and Vulnerability in Vietnam. London: Routledge, 2001.
- [52] Gallop G C, Gutman P, Maletta H. Global impoverishment, sustainable development and the environment—A conceptual approach [J] *International Social Science Journal*, 1989, 121: 375 - 397.
- [53] Kasperson J X, Kasperson R E, Turner B L, et al. *Vulnerability to global environmental change* [C]//Kasperson J X, Kasperson R E. *Social Contours of Risk* (vol II). London: Earthscan, 2005: 245 - 285.
- [54] Gallop G C. Linkages between vulnerability, resilience, and adaptive capacity [J] *Global Environmental Change*, 2006, 16 (3): 293 - 303.
- [55] Adger W N. Vulnerability [J] *Global Environmental Change*, 2006, 16 (3): 268 - 281.
- [56] Turner B L, Kasperson R E, Matson P A, et al. A framework for vulnerability analysis in sustainability science [J] *Proceedings of the National Academy of Sciences of the United States of America*, 2003, 100 (14): 8 074 - 8 079.
- [57] Gallop G C. A systemic synthesis of the relations between vulnerability, hazard, exposure and impact, aimed at policy identification [C]//Economic Commission for Latin American and the Caribbean (ECLAC). *Handbook for Estimating the Socio-Economic and Environmental Effects of Disasters* ECLAC, LC/MEX/G S, Mexico, D. F., 2003: 2 - 5.
- [58] Gunderson L H. Resilience in theory and practice [J] *Annual Review of Ecology and Systematics*, 2000, 31: 425 - 439.
- [59] Carpenter S R, Walker B H, Anderies J M, et al. From metaphor to measurement: resilience of what to what? [J] *Ecosystems*, 2001, 4: 765 - 781.
- [60] Walker B, Holling C S, Carpenter S R, et al. Resilience, adaptability and transformability in social-ecological systems [J] *Ecology and Society*, 2004, 9 (2) art 5 [online], URL: <http://www.ecologyandsociety.org/vol9/iss2/art5>.
- [61] Adger W N. Social and ecological resilience: are they related? [J] *Progress in Human Geography*, 2000, 24 (3): 347 - 364.
- [62] Gunderson L H, Holling C S. *Panarchy* [M] Washington: Island Press, 2002.
- [63] Folke C. Resilience: the emergence of a perspective for social-eco-

- logical systems analyses [J] *Global Environmental Change*, 2006, 16(3): 253 - 267.
- [64] Holling C S Resilience and stability of ecological systems [J] *Annual Review of Ecology and Systematics*, 1973, 4: 1 - 23.
- [65] Pimm S L. The complexity and stability of ecosystems [J] *Nature*, 1984, 307 (26): 321 - 326.
- [66] Holling C S Engineering resilience versus ecological resilience [C]//Schulze P C. *Engineering within Ecological Constraints* Washington: National Academy Press, 1996: 31 - 43.
- [67] Hahn W. *Stability of Motion* [M] Berlin: Springer, 1967.
- [68] Tu P N V. *Dynamical Systems: An Introduction with Applications in Economics and Biology: second ed* [M] Berlin: Springer, 1994.
- [69] Nicolis G, Prigogine I. *Exploring Complexity* [M] New York: Freeman, 1989.
- [70] Folke C, Carpenter S, Elmqvist S, et al Resilience and sustainable development building adaptive capacity in a world of transformations [C]//Report for the Swedish Environmental Advisory Council 2002 I Ministry of the Environment Sweden: Stockholm, 2002.
- [71] Parry M. Scenarios for climate impact and adaptation assessment [J] *Global Environmental Change*, 2002, 12: 149 - 153.
- [72] Mendelsohn R, Morrison W, Schlesinger M E, et al County-specific market impacts of climate change [J] *Climatic Change*, 2000, 45: 553 - 569.
- [73] Fankhauser S. *The Costs of Adapting to Climate Change* [M] Washington: The Global Environmental Facility, 1998.
- [74] United Nations Framework Convention on Climate Change (UNFCCC). <http://unfccc.int/resource/docs/convkp/conveng.pdf>
- [75] Dessai S, Adger W N, Hulme M, et al Defining and Experiencing Dangerous Climate Change [M] Norwich: University of East Anglia, 2003.
- [76] Tubiello F N, Donatelli M, Rosenzweig C, et al Effects of climate change and elevated CO₂ on cropping systems model predictions at two Italian locations [J] *European Journal of Agronomy*, 2000, 13: 179 - 189.
- [77] Winters P, Murgai R, Sadoulet E, et al Economic and welfare impacts of climate change on developing countries [J] *Environmental and Resource Economics*, 1998, 12: 1 - 24.
- [78] Parry M, Amell N, McMichael T, et al Millions at risk: defining critical climate change threats and targets [J] *Global Environmental Change*, 2001, 11: 181 - 183.
- [79] Tol R S J. The damage costs of climate change towards a dynamic representation [J] *Ecological Economics*, 1996, 19: 67 - 90.
- [80] Amell N W. Climate change and global water resources [J] *Global Environmental Change*, 1999, 9: S31 - S49.
- [81] Dolan A H, Smit B, Skinner M W, et al *Adaptation to Climate Change in Agriculture: Evaluation of Options* [M] Guelph: Department of Geography, 2001.
- [82] Klein R J T, Nicholls R J, Minura N. Coastal adaptation to climate change: can the IPCC Technical Guidelines be applied? [J] *Mitigation and Adaptation Strategies for Global Change*, 1999, 4: 239 - 252.
- [83] Fankhauser S, Smith J B, Tol R S J. Weathering climate change: some simple rules to guide adaptation decisions [J] *Ecological Economics*, 1999, 30: 67 - 78.
- [84] Niang-Diop I, Bosch H. Formulating an adaptation strategy [C]//Lin B, Spanger - Siegfried E. *Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures* Cambridge: Cambridge University Press, 2004.
- [85] Feenstra J F, Burton I, Smith J B, et al *Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies* [M] Amsterdam: UNEP/Vrije Universiteit, 1998.
- [86] Smith J B, Ragland S E, Pitts G J. A process for evaluating anticipatory adaptation measures for climate change [J] *Water, Air and Soil Pollution*, 1998, 92: 229 - 238.
- [87] Adger W N, Amell N W, Tompkins E L. Successful adaptation to climate change across scales [J] *Global Environmental Change*, 2005, 15: 77 - 86.
- [88] Van der Veen A, Logmeijer C. Economic hotspots: visualizing vulnerability to flooding [J] *Natural Hazards*, 2005, 36: 65 - 80.
- [89] O'Brien K, Leichenko R, Kelkar U, et al Mapping vulnerability to multiple stressors: climate change and globalization in India [J] *Global Environmental Change*, 2004, 14: 303 - 313.
- [90] Adger W N, Brooks N, Bentham G, et al *New Indicators of Vulnerability and Adaptive Capacity* [C]// Technical Report 7, Tyndall Centre for Climate Change Research Norwich: University of East Anglia, 2004.
- [91] Brooks N, Adger W N, Kelly P M. The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation [J] *Global Environmental Change*, 2005, 15: 151 - 163.
- [92] Rayner S, Mabne E L. Climate change, poverty, and intergenerational equity: the national level [J] *International Journal of Global Environmental Issues*, 2001, 1: 175 - 202.
- [93] Sanderson D. Cities, disasters and livelihoods [J] *Risk Management: An International Journal*, 2000, 2: 49 - 58.
- [94] Gittel R J, Vidal A. *Community Organizing: Building Social Capital as a Development Strategy* [M] Sage: Thousand Oaks, 1998.
- [95] Aikwang J, Siegel P B, Jorgensen S L. *Vulnerability as Viewed from Different Disciplines* [M] Washington: World Bank, 2001.
- [96] Haines Y Y. *Risk Modeling, Assessment, and Management* [M] Hoboken: Wiley, 2004.
- [97] Pahl-Wostl C. Participative and stakeholder-based policy design, evaluation and modeling processes [J] *Integrated Assessment*, 2002, 3: 3 - 14.
- [98] Moss S, Pahl-Wostl C, Downing T. Agent-based integrated assessment modelling: the example of climate change [J] *Integrated Assessment*, 2001, 2: 17 - 30.
- [99] Morduch J, Shama M. Strengthening public safety nets from the bottom up [J] *Development Policy Review*, 2002, 20: 569 - 588.
- [100] Huq S, Reid H. Mainstreaming adaptation in development [J] *Institute for Development Studies Bulletin*, 2004, 35: 15 - 21.

A Review about the Research on Adaptability in Climate Change —Present Situation and Tendency

FANG Yi-ping¹, QIN Da-he², DING Yong-jian²

(1. Institute of Mountain Disaster & Environment Research, Chinese Academy of Sciences, Chengdu 610041, China;

2. Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, Lanzhou 730000, China)

Abstract: Analyses on adaptability in climate change field emerge concurrently with the growing awareness to climate change itself. It is of important significance for reducing the vulnerability of climate change and increasing the adaptability and adaptive capability of human beings to understand the research approaches, analysis content under present situation and international tendency of research on the adaptability in climate change based on literature review in this field. In this paper, the concept of adaptability in climate change and its application as well as the relations between the adaptability and the adaptive capability, and between the response capability and the resilience are analyzed. Moreover, the four focus research fields including the effect of the assumed adaptability, specific adaptation options, relative adaptive capability of different countries, regions or communities, and practical adaptation initiatives are reviewed, and a general summary of adaptability research orientation (e.g. community-based adaptability, bottom-up approach and adaptation processes) is carried out.

Key words: climate change; adaptability; tendency of research

拾零

新疆艾丁湖区发现大型煤田

从新疆维吾尔自治区国土资源厅了解到,经过数月勘探,截至目前,新疆煤田地质部门在我国陆地最低点(-154.31 m)——新疆艾丁湖区发现储量 3.0×10^9 t的大型煤田。

据了解,今年2月新疆煤田地质局156勘探队在新疆吐鲁番地区的伊拉湖至艾丁湖区域内全面启动煤炭资源勘查项目,截至3月底,共设计施工17个钻孔,发现东西长约16 km、南北宽约10 km,厚10~22 m的煤炭资源带,初步预计煤储量在 3.0×10^9 t以上。

据目前获得的地质样本预测,艾丁湖周围地区可能还存在煤炭资源带,伊拉湖至艾丁湖煤炭资源勘查项目完成后,预计可获得煤炭资源量 2.7×10^{10} t以上,提交大的煤炭产地1~2处。

王燕如